636 -Trinity County Resource Conservation District, West Weaver Creek - Channel and Floodplain Rehabilitation

Trinity County Resource Conservation District Technical and Scientific Documentation Table		
Technical and Scientific Document Name	**Document Description**	**Relevant page #**
ESA PWA/Trinity County Resource Conservation District. West Weaver Creek Channel and Floodplain Rehabilitation - 30% Preliminary Design Plans, 2012.	Title Sheet, Existing Conditions Plan View, Proposed Conditions Plan View and Profile, Proposed Conditions Design Details	entire document
ESA PWA/Trinity County Resource Conservation District. West Weaver Creek Assessment and Action Planning, 2012	• A general overview of the watershed's geography, land use and ownership, hydrologic and geomorphic setting. • The history of the watershed as it concerns the existing physical and ecologic conditions of the channel. • A review of initial field reconnaissance efforts and description of observations sufficient to focus more-detailed field surveys. • A review of more-detailed surveys and field observations • A summary of hydrologic and hydraulic analyses for a focused reach of creek, including fish passage at Highway 299. • A summary of key issues and recommendations for next steps, including provision of potential restoration design concepts.	entire document
Supporting Documents provided digitally via the BMS upload and by CD		
United States Forest Service. Weaverville Watershed Assessment, 2004	This document reports on vegetation condition as it relates to fuel loading, water quality, aquatic habitat, wildlife habitat, and soil productivity for watersheds that are administered by the Shasta Trinity National Forest. The document provides information on the current condition in these watersheds as well as the desired condition based on the Land and Resource Management Plan (LRMP).	3,13,14,17,19, 22,23,24,25, 26,31,51,82
Environmental Protection Agency. Trinity River Sediment Total Maximum Daily Load, 2001	The Trinity River Total Maximum Daily Load (TMDL) for Sediment is being established in accordance with Section 303(d) of the Clean Water Act, because the State of California has determined that the water quality standards for the Trinity River are exceeded due to excessive sediment.	pg. 24, 25, 39, 50, 53, 61
Ebasco Environmental/United States Department of the Interior Bureau of Reclamation. West Weaver Creek Fish Habitat Assessment, 1990.	This document reports on quantifying physical aspects of existing salmon and steelhead habitat and recommending habitat enhancements where habitat deficiencies may limit salmon and steelhead production for West Weaver Creek.	entire document

WEST WEAVER CREEK

CHANNEL AND FLOODPLAIN REHABILITATION

WEAVERVILLE, TRINITY COUNTY, CALIFORNIA

Trinity County Resource Conservation District

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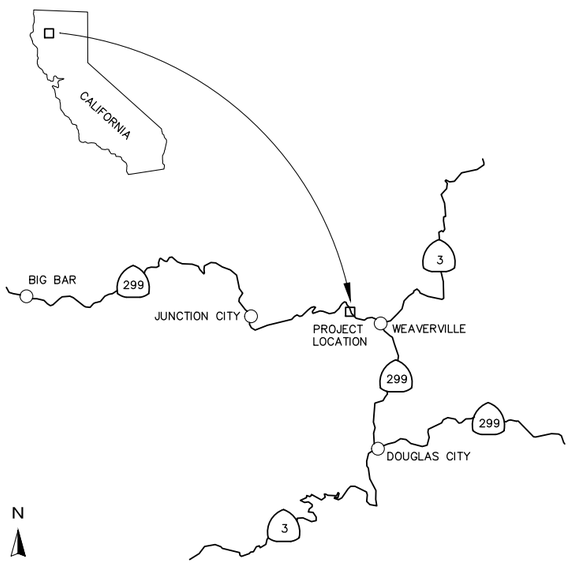

LOCATION MAP

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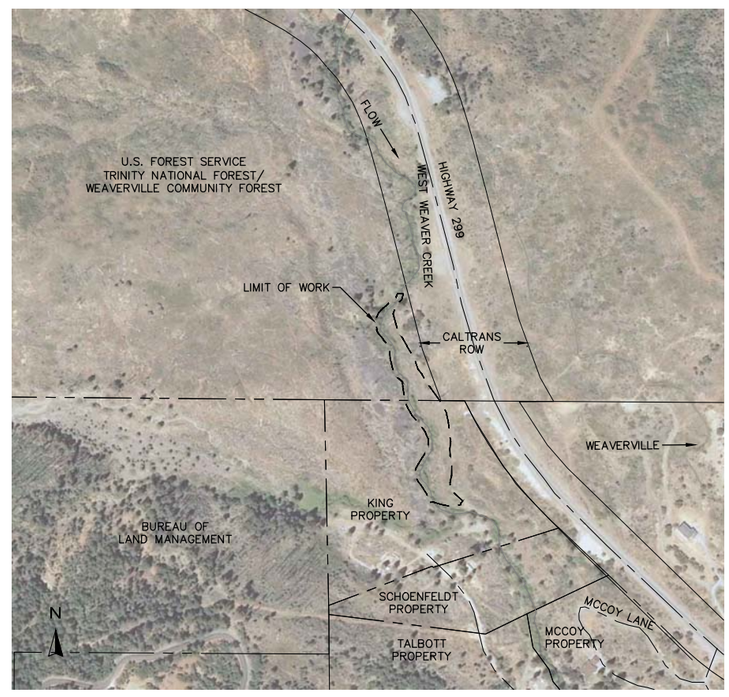

VICINITY MAP

SCALE:1" = 300'

SHEET INDEX

G01	TITLE SHEET
G02	EXISTING CONDITIONS
C01	PROPOSED CONDITIONS SITE PLAN
C02	DETAILS

ABBREVIATIONS

APPROX	APPROXIMATE
℄	CENTERLINE
ELEV	ELEVATION
WSEL	WATER SURFACE ELEVATION
(E)	EXISTING
FT	FOOT, FEET
MAX	MAXIMUM
MIN	MINIMUM
NTS	NOT TO SCALE
STA	STATION
3:1	SLOPE, HORIZONTAL:VERTICAL
TYP	TYPICAL

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SHEET TITLE: TITLE SHEET

PROJECT: WEST WEAVER CREEK CHANNEL AND FLOODPLAIN REHABILITATION

PREPARED FOR: TRINITY COUNTY RESOURCE CONSERVATION DISTRICT 1 HORSESHOE LANE WEAVERVILLE, CA

APPROVED	
DESIGNED	J. WHITE
DRAWN	J.WHITE
INCHARGE	P. LUECKING
SCALE	AS NOTED
DATE	FEBRUARY 4, 2013
SHEET	G01

01 OF 04

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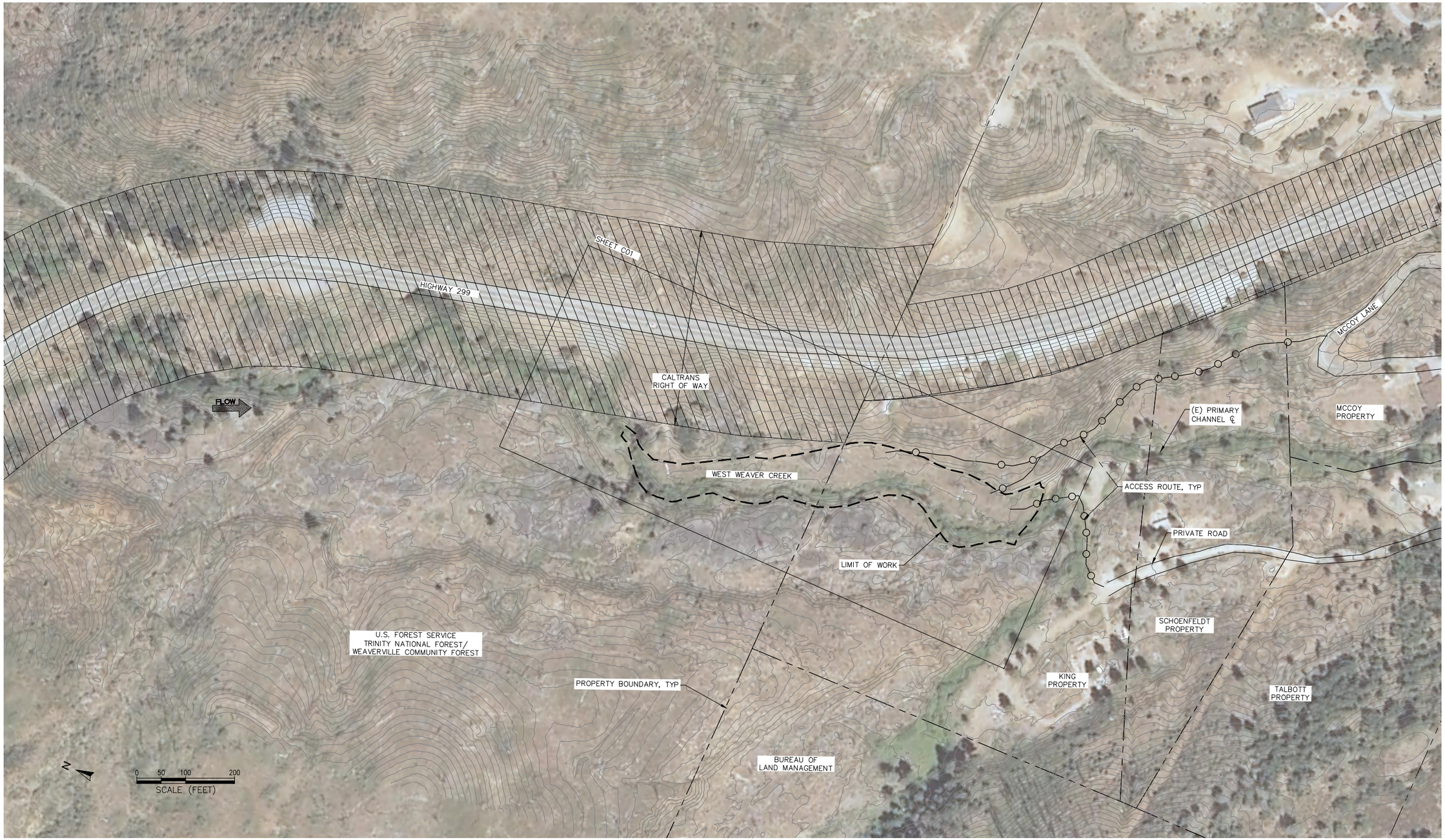

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SHEET TITLE
EXISTING CONDITIONS
SITE PLAN

PROJECT
WEST WEAVER CREEK
CHANNEL AND FLOODPLAIN
REHABILITATION

PREPARED FOR:
TRINITY COUNTY
RESOURCE
CONSERVATION DISTRICT
1 HORSESHOE LANE
WEAVERVILLE, CA

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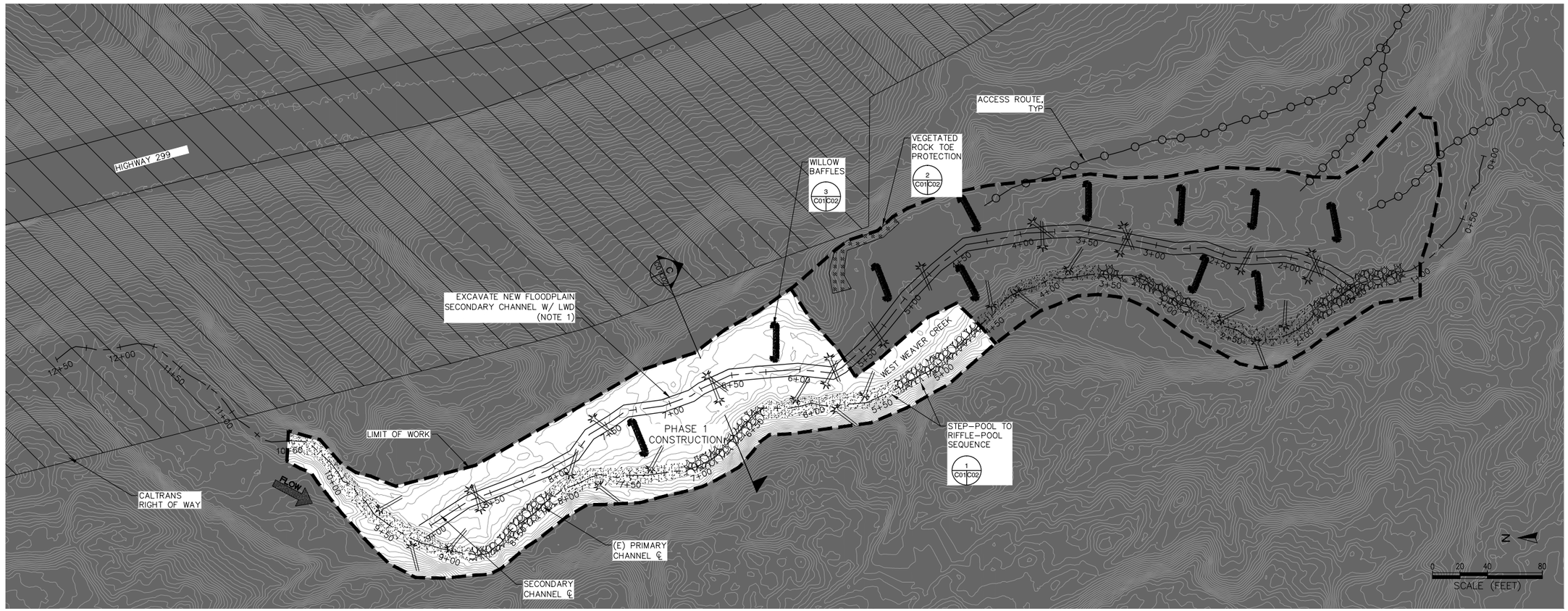

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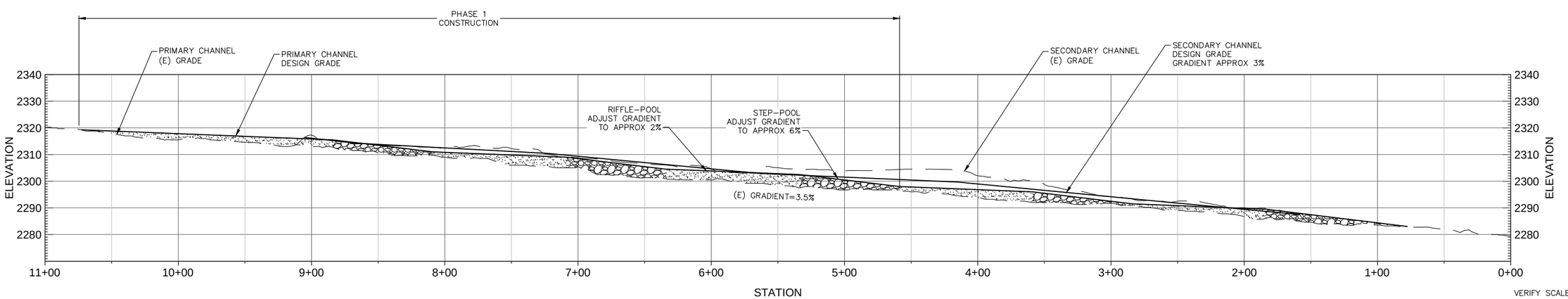

PROPOSED CONDITIONS
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SHEET TITLE
PROPOSED CONDITIONS SITE PLAN

PROJECT
WEST WEAVER CREEK CHANNEL AND FLOODPLAIN REHABILITATION

PREPARED FOR:
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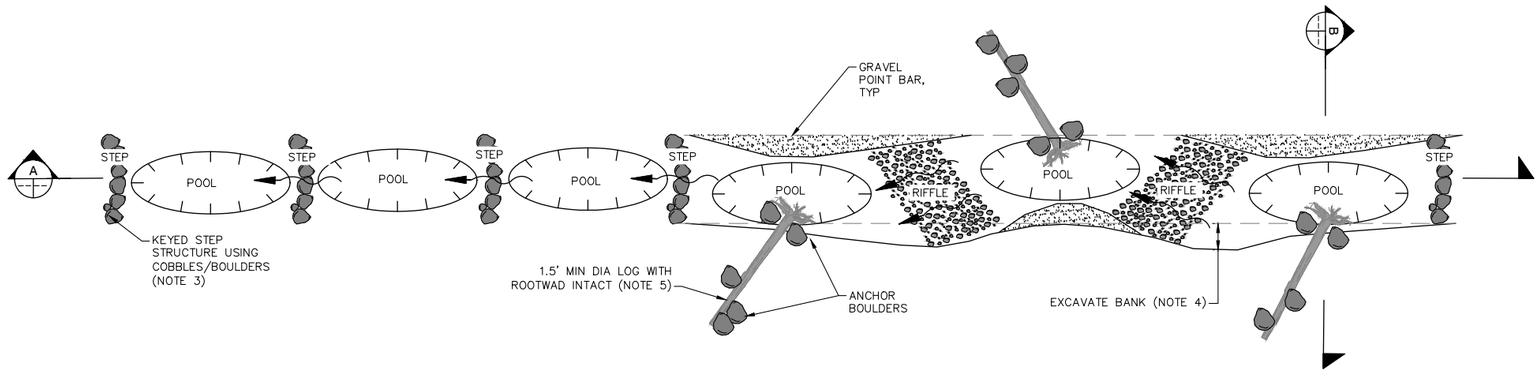

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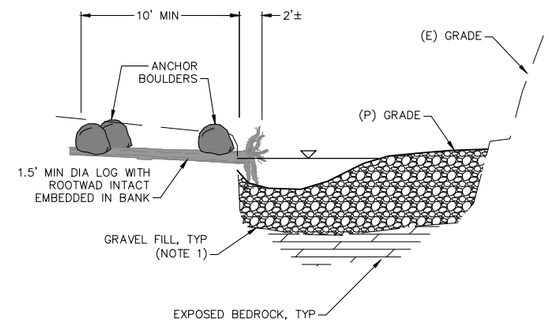

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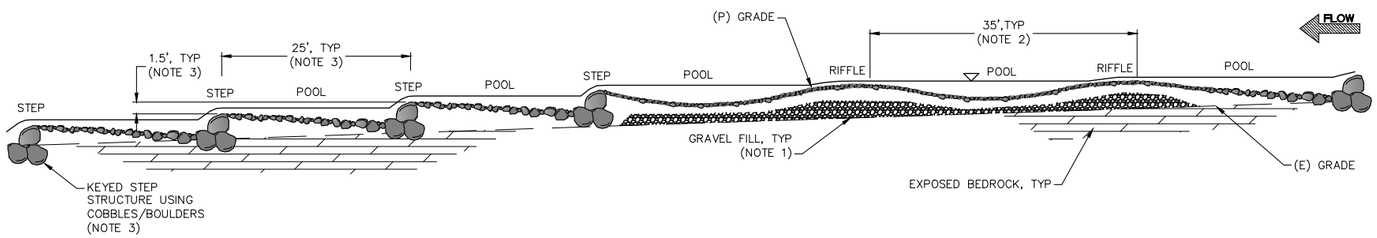

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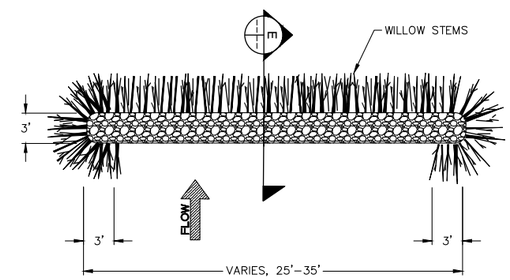

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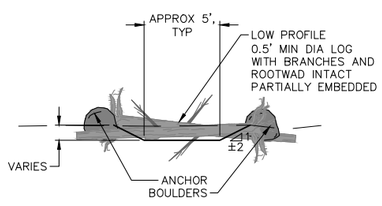

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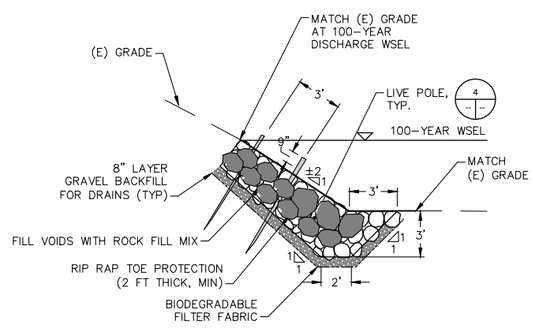

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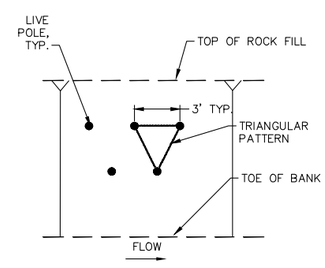

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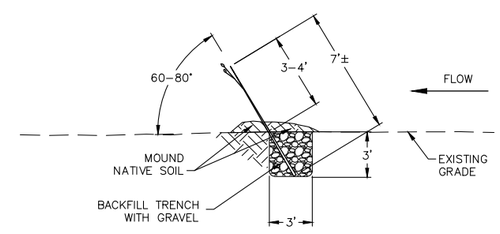

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NOTES:
1. AUGMENT CHANNEL WITH GRAVEL FILL.
2. RIFFLE CRESTS TO BE SPACE 35 FT FROM CREST TO CREST. THE ELEVATION DIFFERENCE BETWEEN RIFFLE CRESTS TO BE APROX. 0.7 FT TO ACHIEVE A GRADIENT FROM CREST TO CREST OF 2%.
3. STEP CRESTS TO BE SPACED 25 FT FROM CREST TO CREST. THE ELEVATION DIFFERENCE BETWEEN STEP CRESTS TO BE APROX. 1.5 FT TO ACHIEVE A GRADIENT FROM CREST TO CREST OF 5%.
4. EXCAVATE BANK TO WIDEN CHANNEL AT RIFFLE CREST AS NEEDED.
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PROJECT: WEST WEAVER CREEK CHANNEL AND FLOODPLAIN REHABILITATION

PREPARED FOR: TRINITY COUNTY RESOURCE CONSERVATION DISTRICT
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WEST WEAVER CREEK

Assessment and Action Planning

Prepared for
Trinity County Resource Conservation District

August 2012

ESA PWA

WEST WEAVER CREEK

Assessment and Action Planning

Prepared for
Trinity County Resource Conservation District

August 2012

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1 INTRODUCTION

1.1 Overview of the Assessment

Rivers are comprised of their contributing tributaries and upstream watersheds. These tributaries contribute more than water—they provide important contributions of sediment, organic material, and also serve as habitat for resident and anadromous aquatic species. The tributaries of the Trinity River, downstream of Lewiston Dam, are perhaps even more important than in other basins, given the exclusion of anadromous habitat in the river's watershed upstream of the dams. These tributary watersheds may also contribute to fine sediment loading of the river and habitat within the tributary streams themselves. The Trinity River Restoration Program includes the Watershed Restoration Program and Watershed Coordinator Program to assess, plan and implement tributary watershed restoration actions for an improved Trinity River. These watershed restoration activities require a combination of actions that: 1) (re)establish natural physical processes that create and maintain high-quality aquatic habitat, and 2) improve spawning and rearing conditions downstream of the dams that best compensate for lost habitat upstream.

Over the past century West Weaver Creek, a tributary and contributing watershed of the Trinity River, has experienced a number of land use stressors including hydraulic mining, fire, timber harvest, road construction, and urbanization. Fortunately, West Weaver Creek exhibits strong potential for improved spawning and rearing conditions given the appropriate rehabilitation effort.

This report provides:

- A general overview of the watershed's geography, land use and ownership, hydrologic and geomorphic setting.
- The history of the watershed as it concerns the existing physical and ecologic conditions of the channel.
- A review of initial field reconnaissance efforts and description of observations sufficient to focus more-detailed field surveys.
- A review of more-detailed surveys and field observations
- A summary of hydrologic and hydraulic analyses for a focused reach of creek, including fish passage at Highway 299.
- A summary of key issues and recommendations for next steps, including provision of potential restoration design concepts.

The work completed to assess West Weaver Creek and prepare this report focused on providing information and recommendations to guide restoration funding to the most appropriate locations and issues, relative to improving aquatic habitat for important fish species of concern. This work also sought to recommend a specific set of prioritized actions to help apply restoration funding in

a manner that addresses key stressors and reinvigorates the physical and ecological processes that create and maintain desirable habitat conditions in the West Weaver Creek.

1.2 Goals

The Trinity River receives fine sediment from its watersheds at levels above that which is considered acceptable for the protection of the aquatic ecosystem (US EPA, 2001). The Trinity River Watershed Council, the Trinity County Resource Conservation District, and the Trinity River Restoration Protection, and other natural resource management agencies at the state and federal level all want to reduce the fine sediment entering the mainstem river from the West Weaver Creek watershed. *Reducing West Weaver Creek's fine sediment yield to the Trinity River is an important project goal.*

As a tributary to the Trinity River, West Weaver Creek provides valuable spawning and rearing habitat for endangered salmonids in the Trinity River basin. A number of anthropogenic stressors (mining, timber harvest, urbanization, water diversion) in the watershed may affect the quality of salmonid habitat. *Another project goal is to improve quantity, quality and access to salmonid habitat in this tributary to the Trinity River.*

1.3 Objectives

The objectives of this assessment focused research and evaluation first at a broad, regional scale, then sequentially refined the focus downward until issues related to salmonid habitat and sediment yield were identified at a local, reach scale. *Issues that span the entire basin, and/or are at a broad, landscape-level, such as forest road erosion or background sediment yield from timber harvest, were not considered in this assessment.* For the purposes of this assessment, watershed stressors/habitat issues were defined at the discrete and/or reach-scale and also present an opportunity for execution of manageable rehabilitation efforts to address the goals of the project. The specific objectives of the assessment were:

- Understand the general setting of watershed
- Review historical conditions (primarily the disturbance history), previous studies and past rehabilitation efforts
- Conduct a field reconnaissance effort to assess existing watershed channel/floodplain conditions as they pertain to salmonid habitat and sediment yield
- Identify and prioritize issues related to salmonid habitat and sediment yield
- Recommend actions to address these issues

1.4 Conclusions

- The reach of West Weaver Creek that deserves immediate attention, in terms of focused rehabilitation effort, begins just upstream of Grub Gulch (RM 1.8) and ends just downstream of Highway 299 (RM 2.3).

- Future rehabilitation efforts should develop a design that includes reconfiguration of the channel's width, slope, and its ability to connect with the adjacent floodplain.
  - This includes increasing in-channel substrate in areas currently scoured to bedrock, and the expansion of the channel and floodplain width in key locations sufficient to support hydraulic conditions that will maintain desirable riffle-pool channel morphology.
  - The design process should consider sorting and grading of the floodplain to create beneficial conditions for revegetation and long-term geomorphic processes (such as sediment sorting and deposition on the floodplain; and in the long term allow for channel avulsion).
  - Small side channels, the augmentation of large woody material, and revegetation in riparian and hillslope areas may also be key components of the proposed design.
  - All restoration actions should be synergistically designed (and validated, via hydraulic modeling) to provide and improve the sorting and storage of spawning-sized substrate, sustain new pools for holding habitat, and increase channel complexity and low-flow refugia.
  - Increased sediment retention in the channel will provide increased potential for spawning, increased colonization surfaces for macroinvertebrates, and may help regulate temperature through increased hyporheic flow.
  - The re-connected floodplain areas will a) improve sediment retention and sorting in this reach, increasing the storage of fine sediment that would otherwise be transported to the Trinity River, and b) provide high-flow refugia.
- A detailed fish passage and remediation assessment of the Highway 299 culvert is recommended, as is partnering with Caltrans to conduct this assessment and consider management actions to address passage based on the results of the study.
- Implementation of restoration designs will require satisfactory completion of environmental compliance documentation and the requisite permitting.
- The recommended rehabilitation actions would provide benefits beyond the reach targeted for action. These actions would provide:
  - Restored watershed-scale sediment dynamics, including the sorting and storage of sediment that may currently be routed quickly to the Trinity River.
  - Continuity with intact spawning habitat upstream and provide improved rearing conditions for resident fishes, outmigrants from upstream reaches, and juveniles spawned in the restored reach.
- Grub Gulch should be assessed and confirmed as a sediment source before any implementation actions to address sediment in this tributary are developed.

2 SETTING

2.1 Geography and Land Ownership/Management

The West Weaver Creek watershed is located in the Klamath Mountain physiographic province of California, more specifically in the Trinity Mountains in Trinity County, California (Figure 2.1). West Weaver Creek is a branch of Weaver Creek, which itself is a tributary to the Trinity River with its confluence located downstream of Lewiston Dam at Trinity River Mile (RM) 93.8. The West Weaver Creek watershed lies just west of the town of Weaverville, in township 33N, range 10W, sections 2 and 11. The creek headwaters start northwest of Weaverville, flow south until the creek crosses under Highway 299, and then flow in a southeasterly direction as the creek skirts the southwest side of Weaverville, connecting with East Weaver Creek just southeast of Weaverville, where the two become Weaver Creek (Figure 2.2). The West Weaver Creek watershed outlet and confluence with East Weaver Creek is located at latitude 40° 44’ 43” and longitude -122° 58’ 05” (NAD83).

Much of the watershed is located on public lands (Figure 2.3). The majority of the watershed is federally owned land (U.S. Forest Service [USFS] and Bureau of Land Management [BLM]) with the remaining land privately owned and with a portion of that land designated as timber production zone harvested by Sierra Pacific Industries (SPI). Of the federally-owned lands, half of the basin is in the Trinity Alps Wilderness, a quarter of the basin is in the Trinity National Forest, and the remaining land is owned and managed by the BLM. An important additional management overlay in West Weaver Creek is that portions of the Trinity National Forest and BLM land have also been designated as the Weaverville Community Forest (quarter of the basin). The Weaverville Community Forest, which includes West Weaver Creek, is jointly managed by the Bureau of Land Management (BLM), US Forest Service (USFS) and the Trinity County Resource Conservation District (TCRCD), and is comprised of 13,000 acres of excellent timber land, historic and prehistoric resources, and recreational uses and provides high visual quality for the Weaverville Basin. Community input is gathered by the managers to help promote and develop projects that meet the vision of the Community Forest. Potential aquatic habitat rehabilitation efforts on West Weaver Creek would meet the goals outlined in the strategic plan of the Weaverville Community Forest. More information on the Weaverville Community Forest is available at http://www.tcrcd.net/wcf/index.htm.

2.2 Infrastructure

West Weaver Creek is crossed by four roads and has one major water district diversion. Additionally, rural homes and associated driveways, outbuildings, and private diversions are scattered throughout the watershed downstream of RM 2.

Roads cross West Weaver Creek at Mill Street (RM 0), Rock Road (RM 0.9), Oregon Street (RM 1.4) and Highway 299 (RM 2.3). Mill Street and Rock Road are bottomless culverts, with no indication of fish passage issues. Prior to November 2000, Oregon Street was a fish passage barrier (CalFish, 2011; 5C, 2012, Contech, 2010). The perched corrugated metal pipe that was barrier to fish passage was removed and a bottomless culvert installed by the Trinity County Department of Transportation in cooperation with 5 Counties Salmonid Conservation Program (5C, 2012). The Oregon Street bottomless culvert, has since been assessed (by Caltrans) as not a barrier (CalFish, 2011). The Highway 299 box culvert with baffles, owned by Caltrans, has been assessed as not a barrier by the California Department of Fish and Game (CDFG) using "professional judgment" (CalFish, 2011); though, according to the USFS, the culvert presents a barrier to Coho (but not Steelhead) migration (USFS, 2004).

A diversion operated by the Weaverville Community Services District through the Moon Lee Ditch is located at RM 3.2, at an elevation of 8,070 feet. Downstream of Oregon Street, numerous homes are located on parcels that have "creek front" access, many of which utilize the stream (confirmed via field reconnaissance).

2.3 Topography and Land Cover

The topography of West Weaver Creek is typical of northern California's Klamath Mountains, characterized by steep, highly-dissected ridges and mountain slopes, transitioning to isolated valleys (i.e., the one in which Weaverville is located) and river canyons. The highest point in the West Weaver Creek watershed is 7,362 feet (NGVD29), and the outlet connects with East Weaver Creek at an elevation of 1936 feet (ft). The general profile of West Weaver Creek (extracted from USGS 7.5 minute topographic maps) is that of a typical concave-up mountain stream (Figure 2.4) over the course of 8.3 miles from headwaters to its confluence with East Weaver Creek. The creek's slope at the headwaters (starting at RM 7.7) is 22 percent, transitioning to 3 percent at the outlet (RM 0). The adjacent hill slopes range in slope from 39 to 52 percent in the headwaters to 13 to 26 percent near the outlet.

The majority of the watershed land cover was delineated in 2002 by the California Department of Forestry and Fire Protection (CDF) as conifer forest consisting of ponderosa pine, digger pine, douglas fir, interspersed with hardwood forest and shrub (Figure 2.5). It should be noted, however, a significant portion of the watershed downstream of RM 3 was recently (2006) impacted by fire turning that portion of the watershed from conifer forest to barren/herbaceous/shrub succession (see Section 3.2). Most of the intact forest lies in the upper watershed (upstream of RM3). The basin in is 4.7 percent urban cover with 0.2 percent impervious area.

2.4 Geology, Soils and Hillslope Processes

The topography and geology is such that the steep terrain of the upper watershed (upstream of RM 3) produces a sediment supply that is deposited in the lower watershed (downstream of RM 3). The upper portion of the watershed has shallow soils underlain by igneous bedrock, and is prone to shallow mass wasting. The lower portion of the watershed is conglomerate bedrock overlain by alluvium in the channel and surrounding floodplains and shallow soils in the hill slopes. The watersheds of Weaver and Rush Creeks were analyzed as a subset of the analysis area for the Trinity River for a total maximum daily load (TMDL) assessment (Strauss, 2001). According to the Trinity River TMDL, fine and coarse sediment originating from these watersheds need to be reduced 42 percent combined to meet water quality objectives (Strauss, 2001).

The underlying bedrock of the West Weaver Creek upper watershed is Salmon Hornblende Schist, as shown in Figure 2.6 (Irwin, 2010). The lower watershed is mostly Weaverville Formation, with sections of Abrams Mica Schist, Serpentinized periodite, and mudstone/sandstone conglomerate (Irwin, 2010). Below is a description of each major formation (Madej, 2007):

- Salmon Hornblende Schist: Amphibolite-grade hornblende schist and gneiss; locally includes lenses of micaceous schist.
- Abrams Mica Schist: Schistose metasedimentary rocks; generally micaceous and quartzitic; discontinuous lenses of micaceous marble near base.
- Weaverville Formation: Lacustrine facies occur at the base of the Weaverville sequence and are overlain by alluvial floodplain sediments which include coarse channel fill deposits and bar conglomerates. Floodplain sediments and fluvial conglomerates are intercalated with debris flow deposits. The diverse assortment of clasts consists primarily of hornblende schist, mica schist, greenstone, serpentized periodotite, gabbro, sandstones and siltstones, with smaller percentages of granodiorites. The Weaverville Formation produces abundant fine material (0.5 to 3 millimeters [mm]) upon weathering (within the size range of concern for Trinity River TMDL).
- Alluvium: Unconsolidated silt, sand, and gravel in modern stream channels and on associated floodplains and low terraces.

The soils in the watershed consist of Chawankee, Neuns, Forbes, and Deanwood soil series (USFS, 2004). The upper watershed (upstream of RM 3) is primarily Chawankee soil series, with Forbes and Neuns soils in the lower portion of the upper watershed (RM 3 to RM 4). Chawankee is a soil of shallow depth (10-20 inches), granitic parent material, low rock fragment and high erosivity. Forbes is a very deep (>60 inches), non-marine sediment, loam, high clay, low rock fragment, moderately highly erosive soil series whereas Neuns is a moderately deep (20-40 inches), metavolcanic, low clay, moderately high rock fragment, moderately erosive soil series. Small landslides are common on Forbes soils when at field capacity. The lower watershed (downstream of RM 3) is primarily Deadwood soil series. Deadwood is a shallow (10-20 inches), very gravelly loam, high rock fragment soil series that is moderately erosive.

The upper watershed (RM 3 and upstream) is prone to shallow mass wasting and contains failure-prone slopes (USFS, 2004). The typical mass wasting process in this area is rotational/translational slides. Moderate to high hazards are defined for some translational/rotational areas, with a high probability of initiating some 1,000 to 10,000 cubic-yard landslides. Downstream of RM 3 in the area surrounding the channel (~250 to 1000 feet across) is a mass wasting deposit.

2.5 Hydrology

2.5.1 Climate

West Weaver Creek has a Mediterranean climate of hot, dry summers and cool, wet winters. Mean annual precipitation in the watershed ranges from approximately 40 to 60 inches, with an average of 48.8 inches. Most of the precipitation falls between October and May. In this geographic region, snow frequently accumulates above 4,000 feet, and elevations between 3,000 and 4,000 feet are frequently subject to rain-on-snow events (USFS, 2004). Figure 2.4 shows the West Weaver Creek basin is above 4000 feet starting at RM 6.5, indicating the head waters regularly experience rain-on-snow events.

2.5.2 Basin characteristics

The West Weaver Creek basin area is approximately 8.2 square miles. West Weaver Creek has an elongated, dendritic basin shape with about 8.5 river miles. There are no major tributaries entering West Weaver Creek, just a few “gulches” including Grub Gulch (RM 1.8), Bear Gulch (RM 4.7), and Austrian Gulch (RM 5.8). Currently there is no operating flow gauges on either West Weaver Creek or Weaver Creek. Previously, discharge data was collected from Weaver Creak a mile upstream from the confluence with the Trinity River by the USGS from 1958-1969, then again 3 miles upstream of the confluence 2000-2005. Recently, flows have been measured 2008-present at RM 2.5 by the USFS Redwood Sciences Laboratory. As an example, a typical annual peak storm (February 4, 2010) from the time series had a time-to-peak of approximately 14 hours, lag time of approximately 15 hours, and a time of concentration of approximately 36 hours.

2.5.3 Flows

As mentioned, there has never been an operational flow gauge on West Weaver Creek. The data collected by the Redwood Sciences Lab is not extensive enough for flow frequency analyses. Typically, for ungauged streams, the first option is to find a nearby gauged basin of similar size and shape for comparison. If a suitable basin does not exist, the next best option is to use regional regression equations. The closest gauged basins to the West Weaver Creek basin are the Weaver Creek gauge with ten years of data from 1958-1969, and Rush Creek with seven years of data from 2004 to present. Given the basin area at the outlet of West Weaver Creek is 8.2 square miles, it is not advisable to use the flow data from the Weaver Creek gauge which covers a basin area of 48.4 square miles. With a basin area, 22.3 square miles, and elongated shape, Rush Creek

makes a better basin for comparison. However, given it only has seven years of flow data, it was decided to also use regional regression equations for the estimating return intervals for the basin, and average the two for analysis purposes.

Event flows at the watershed outlet were estimated for 2-, 5-, 10-, 25-, 50-, and 100-year return intervals using two different methods. First, event flows were estimated using USGS's Streamstats, an internet-based tool that will estimate streamflow statistics for un-gauged streams. For the California North Coast, Streamstats uses the Wannanen and Crippen regression equations. Next, event flows for the gauged Rush Creek (a neighboring basin with a similar elongated basin shape, but at 22.3 square miles is nearly three times the size of West Weaver Creek) were estimated from 7 years of discharge records using the HEC-SSP software utilizing the method B of Bulletin 17B (USGS, 1982). This method provides water yield as a unit-of-discharge per area, so that while the total area in the "paired basin" being compared is potentially different from the target basin, a unit-runoff per area can be generated. From these values, discharge levels for the West Weaver Creek outlet were estimated using the method outlined by Waananen and Crippen (1977) for paired basin discharge estimation. The estimated 2-, 5-, 10-, 25-, 50-, and 100-year return interval discharges are shown in Table 2.1. The results for each method were close (within a magnitude), especially for the larger flows. In most cases, it is preferable to use a paired-basin estimation; however, with the large difference in basin area between Rush Creek and West Weaver Creek, the average of the two methods was selected for use in this assessment's hydraulic analyses.

TABLE 2.1 ESTIMATED RETURN INTERVAL DISCHARGES AT WEST WEAVER CREEK BASIN OUTLET.

Return Interval	Discharge estimated from Streamstats' Waananen and Crippen regression equation (cfs)	Discharge estimated from Rush Creek Bulletin 17B results (cfs)	Percent Difference
2-year	431	171	60%
5-year	751	389	48%
10-year	1070	657	39%
25-year	1510	1233	18%
50-year	2300	1918	17%
100-year	2500	2935	-17%

Notes: cfs = cubic feet per second

3 WATERSHED HISTORY

3.1 Land Use Practices

The West Weaver Creek watershed has experienced a suite of Euro-American land use practices including but not limited to mining, timber harvest, residential land development, road construction, fire suppression, and flow diversion. The most prominent and disturbing of the land use practices in the watershed was hydraulic gold mining, occurring in the late 1800s and early 1900s. Hydraulic mining consists of the diversion of water (in this case, from an adjacent watershed, the Stuart Fork of the Trinity River) and focused discharge of that water onto hillslopes to scour soil and rock to uncover deposits thought to contain gold. The water was frequently delivered to the mining locations through pipes from upslope locations, resulting in high-pressure discharge through "hydraulic monitors"—essentially large nozzles that were powerful enough to rapidly erode soil and rock. Major hillslope scarps and mounds of coarse debris are found throughout the watershed, most notably near the channel downstream of RM 3. The BLM indicates the West Weaver Creek mining landscape in the Weaverville Community Forest downstream of RM 1.5 is an interpreted cultural site (BLM, 2003).

The watershed has undergone both clear-cut and selective-cut timber harvest in relatively small areas of the watershed. All of the residential growth has occurred in the lower two miles of the creek, most of which is on river-left between RM 0.5 and 1.0. A number of country roads exist throughout the basin in support of timber harvest (most of which are upstream of RM 2.3). All paved roads exist downstream of RM 2.3, the most notable and likely having the most affect, State Highway 299.

3.2 Recent Fire History

In the past 80 years, the West Weaver Creek watershed has been influenced by four significant of fires (Figure 3.1). The most recent fires, the Oregon and Junction Fires, occurred in 2001 and 2006, respectively. One portion of the watershed (generally bounded by RMs 2 to 3) was influenced by both of these fires, meaning the same watershed area was hit twice over a short period of time. An aerial photograph time series from 1998 to 2010 (Figure 3.2) illustrates the changes in vegetation cover during a time period that bounds these two fires. In the 2003 aerial photo, two years after the Oregon Fire, there is evidence of vegetation survival/recovery on the hillslopes adjacent to the creek. However, in the 2010 aerial photo, four years after the Junction Fire, the hillslope landscape appears to be completely cleared of vegetation.

3.3 Past Stream Assessments

Several previous efforts to assess West Weaver Creek were identified as a part of research on the watershed. Overviews of those efforts are presented below.

3.3.1 West Weaver Creek Fish Habitat Assessment (1990 Ebasco)

In 1990, Ebasco Environmental conducted a fish habitat assessment of West Weaver Creek from RM 0 to RM 4.4 (identified natural fish barrier) for the U.S. Bureau of Reclamation. The Ebasco assessment quantified the habitat types using a habitat classification with 22 habitat types and the investigation assessed substrate and habitat utilization. The most frequent habitat types throughout the survey reach were classified as step runs, pocket water, and low-gradient riffle and step run-pocket water complexes, and plunge pools estimated to be the dominant pool type. Substrates were "visually" estimated to be dominated by cobble and gravel, 38 percent and 33 percent, respectively. About 5 percent of the channel area was determined suitable for spawning. It was observed that 0+ age Steelhead preferred runs, trench pools, and step runs, and avoided riffles and pocket water over the studied reach. The report recommended instream enhancements including: low-stage check dams, bank-placed boulders, floating or half-log cover structures, submerged large woody debris and boulder clusters series, log or boulder weirs, and log or boulder wing deflectors.

3.3.2 Weaverville Watershed Analysis (2004 USFS)

Published in 2004, the USFS Shasta-Trinity National Forest, Trinity River Management Unit conducted an assessment of the Weaver Creek watershed in context with other Weaverville-area creeks to provide a baseline for evaluating existing conditions in terms of desired future conditions. The focus of this assessment was vegetation condition as related to fuel loading, water quality, aquatic habitat, wildlife habitat, and soil productivity (USFS, 2004). Upstream of RM 5 the West Weaver Creek watershed condition was rated high. Downstream of RM 5, the watershed condition was rated low, and was noted to exhibit low-levels of geomorphic, hydrologic, and biotic integrity relative to natural potential condition and the majority of the drainage network. The poor rating downstream of RM 5 was mostly attributed to the 2001 Oregon Fire, but also to increased roads and urban development. Adverse conditions of the stream were reported as insufficient large wood material (e.g., most wood material was of small diameter; <1 foot), shallow pools (average=1.4 feet), and 51 percent of the banks were assessed as unstable.

The report recommended actions to reduce cumulative watershed impacts and restore a more-natural system, including a road maintenance program, decommissioning of roads (especially near stream reaches occupied by anadromous fishes), and management of vegetation to promote tree growth and maintain riparian function. The report also recommended using in-stream habitat structures to create complexity and stabilize the channel. These recommended structures include log and rock check dams, head-cut mitigation structures, and structures to create pool habitat.

3.4 Past Stream Restoration Efforts

Since the 1980's several habitat improvement projects have been completed in the West Weaver Creek watershed. Some of these projects included the installation of structures, with some of the structures still persisting and providing complex habitat in West Weaver Creek (USFS, 2004). One such example is that of log weirs tacked to the bed with 1 inch rebar, intended to stabilize stream substrate and improve pool formation.

Prior to 2000, the culvert at Oregon Street (at RM 1.4) was a perched, corrugated metal pipe that was considered an upstream migration barrier for Coho salmon (Ebasco, 1990). The perched Oregon Street culvert was upgraded with a 24-foot wide, modular precast concrete bottomless culvert/bridge in November of 2000. This replacement came after previous retrofits with baffles failed subsequent to the 1997 flood. The replacement project was funded by the "5C" Five Counties Salmonid Conservation Program.

In 2010, the USFS considered placing in-stream boulders and large woody debris structures to provide in channel sediment storage (Lynsky, 2010) as a part of the Weaverville Community Forest - Riparian and Stream Channel Improvement Project. However, because of unforeseen timeline issues and consultation issues with National Marine Fisheries Service (NMFS), the habitat structures were not included in the project at the time, and only riparian and upland plantings were completed.

4 EXISTING CHANNEL CONDITIONS

4.1 Water Quality

In West Weaver Creek, high water temperature and low flows can be limiting factors to fish, especially mid-summer to autumn (USFS, 2004). Water quality is generally very good in streams of the Weaverville watersheds (USFS, 2004); however, the cumulative watershed effects on West Weaver Creek water quality are above the threshold of concern downstream of RM 2 mostly because of recent fire damage but also because of urbanization and increased road density. Also of concern are the water diversions from West Weaver Creek by the Weaverville Community Service District. Stream temperatures for West Weaver Creek in late July-early Aug (as reported in the 1990 Ebasco report) averaged 66.6 degrees F, with a range from 52 to 76 degrees F. The high end of the observed range exceeds 68 degrees F, the recommended maximum temperature for maintaining healthy rainbow trout. High temperatures were most frequently observed in unshaded reaches of the creek, including those impacted by hydraulic mining and fire damage. The warmest temperatures were observed at the lowest portion of the watershed from RM 0 to RM 0.7 RM, a reach adjacent to mine tailings, and surrounded by increased urbanization. Recent measurements of water temperature indicate water temperature is of high quality from RM 2 upstream, likely due the undeveloped nature of the watershed upstream of RM 2 (personal communication: Wiseman, 2011). Aside from water temperature, no notable water quality problems were reported by the 1990 Ebasco report.

4.2 Stream Classification

A second order perennial stream, the West Weaver Creek watershed drains mountainous terrain and confluences with East Weaver Creek in a mountain valley. A useful stream classification system for “channel-reach morphology in mountain drainage basins” is provided by Montgomery and Buffington (1997). Among other measureable parameters, the classification system organizes stream morphology into various classifications based in part on reach slope: cascade morphology is typified by slopes greater than 6.5 percent, step-pool morphology, 3-6.5 percent; plane-bed morphology, 1.5-3 percent; and riffle-pool morphology with slopes less than 1.5 percent. Plane bed is often found to be the transition bedform between step-pools and riffle-pools, and some variation can be expected around these averaged and generalized slopes and morphologies.

Based on this classification criteria and using the slope of the valley profile (Figure 2.4) as a surrogate for stream slope, the reach of creek from RM 5 and upstream would be classified as cascade morphology. According to the classification scheme, the typical bed material for this segment would be boulders, the pool spacing would be less than one channel width, the channel would typically be confined by the adjacent hillslopes, and the dominant sediment source would be hillslope, fluvial, and debris flows. Field reconnaissance efforts, described further in Section 5,

support this classification. Using the same valley slope measure, the reach from RM 0.5 to RM 5 would be classified as step-pool. In this reach the typical bed material would be mixed cobble and boulders, the pool spacing would be one to four channel widths, the channel would be confined, and the dominant sediment source would also be hillslopes, fluvial, and debris flows. Again, field observations generally confirm this classification.

4.3 Riparian Vegetation

Dense riparian vegetation provides a number of valuable attributes to sustain healthy salmonid fisheries streams including shade, large wood, root-wad cover, and detritus. Willows (*Salix spp.*), alder (*Alnus rubra*), blackberry (*Rhubus vitfolius*) are the dominant riparian species lining the stream banks (Ebasco, 1990). The hillslopes above the creek are typically covered by ponderosa pine, digger pine, doulas fir, buckbrush and Manzanita (USFS, 2004). As part of the approved USFS "Weaverville Community Forest Riparian and Channel Improvement Project" (Lynsky, 2010), there are plans to re-plant 6 acres of West Weaver Creek watershed contained within Oregon Fire burn area, which includes the reach from Highway 299 (RM 2.3) downstream to the boundary of the Trinity National Forest (RM 2). The proposed action is to plant 1.8 acres adjacent to the stream with douglas fir seedlings, and 6 acres adjacent to the stream with ponderosa pine, in order to provide increased stream cover, increased long-term large wood recruitment, and decreased fine sediment from upslope (Lynsky, 2010).

4.4 Fish Ecology and Habitat

Information on the fish ecology of West Weaver Creek is relatively limited, and this summary of existing conditions is compiled from a relatively-small set of available documents and from interviews with local agency scientists. The list of fish species that have been observed in West Weaver Creek includes coho (*Oncorhynchus kisutch*), steelhead (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), speckled dace (*Rhinicthys osculus*), three spined stickleback (*Gasterosteus aculeatus*), and Klamath small-scale sucker (*Catostomus rimiculus*).

For fish migrating upstream on Weaver Creek to the confluence of West and East Weaver Creeks, there are no migration barriers. The downstream-most natural fish barrier on West Weaver Creek has been identified as a 7 ft waterfall near Bear Gulch at RM 4.4 (Ebasco, 1990; USFS, 2004). Recent video recording has documented adult and juvenile coho and salmonid redds upstream of the Oregon Street culvert (Wiseman, personal communication, 2012).

Adult coho and steelhead have been observed spawning on Trinity National Forest lands, which places these observations upstream of RM 2 (USFS, 2004; NMFS, 2012). Juvenile coho and juvenile steelhead (0+), have both been sampled in the creek in recent history (Ebasco, 1990). As recent as the past few years USFS Redwood Sciences has sampled Steelhead and Brown trout (but not Coho) upstream of Highway 299 near the diversion. Species that have also been sampled in the creek are speckled dace (*Rhinicthys osculus*), three spined stickleback (*Gasterosteus aculeatus*), and Klamath small-scale sucker (*Catostomus rimiculus*) (Ebasco, 1990).

For both steelhead and (more so) coho, run size is highly variable and appears to depend on stream flow (i.e., greater flow enabling more upstream passage and/or attraction). Though coho have not been observed above RM 1.5 in any sampling, during a wet season it is expected that coho would be found above RM 1.5 (personal communication: Wiseman, 2012).

Sampling from two decades ago (Ebasco, 1990) found juvenile steelhead were the most abundant species observed in West Weaver Creek. Of the sampled habitat units, 2107 were steelhead and 15 were coho. Of the steelhead sampled, 93 percent were zero-plus year aged steelhead (0+), 6 percent were 1+ steelhead, 0.7 percent were 2+ steelhead. The sampled density of 0+ Steelhead was steady between 40 to 50 fish per 1000 sq ft from RM 0.75 to RM 3.25 with a spike of 90 fish per 1000 at RM 2.25 just downstream of the Highway 299 culvert (RM 2.3). This suggests that the Highway 299 culvert at the time was (may still be) a barrier to fish passage, particularly smaller fish less than a year in age, and resulted in the observed concentration of fishes downstream of the culvert.

The coho salmon of West Weaver Creek are Southern Oregon Northern California Coast (SONCC) coho salmon and are listed as threatened under the Endangered Species Act (ESA) by the National Oceanic and Atmospheric Administration (NOAA). All streams accessible to anadromous fish have been listed as critical habitat (USFS, 2004).

The coho and steelhead life stage histories and habitat needs are well described by the Trinity River Restoration Program (http://www.trrp.net). Coho salmon ascend the streams by late November or early December and spawn November through January. Emergence of coho salmon fry begins in February and continues through March. In the summer, coho parr reside in pools and near instream cover, such as large wood, overhanging vegetation, and undercut banks. Overwintering habitat is essential for coho salmon because juvenile coho salmon remain in the Trinity River Basin for their first winter and into the following spring. Preferred overwintering habitats are pools containing large woody debris, undercut margins, and debris near riffle margins. Outmigration of 1+ Coho salmon smolts begins in February and continues through May.

Steelhead enter reach by December and hold in deep pools until they spawn in February. Spawning begins in February and ends in early June. Key winter habitat for steelhead are areas with boulder-rubble stream margins that are approximately 12 inches deep with low to near zero water velocities. Outmigration of steelhead smolts begins in early spring of their second or third year.

Additional habitat requirements include sufficient migration depths, quality spawning gravel, and abundant overwintering habitat. The minimum depth required for upstream migration of coho is about 0.56 feet and for steelhead is about 0.8 feet (Everest et al. 1985). Successful spawning occurs in gravels with a low percentage of fine sediment. Riffles often provide such ideal gravel conditions-spawning commonly occurs on the upstream side of riffle crests. SONCC Coho and steelhead require abundant overwintering habitat composed of low-velocity pools and interstitial cobble spaces.

5 FIELD RECONNAISSANCE AND ASSESSMENT

5.1 Field Reconnaissance

5.1.1 Initial Reconnaissance

The initial field reconnaissance (recon) of the West Weaver Creek watershed began about 1,000 feet upstream of the Moon Lee Ditch diversion at RM 3.1 and ended at the confluence of West Weaver Creek and East Weaver Creek just downstream of Mill Street. The purpose of the initial field recon was to familiarize ESA PWA with the watershed and review/identify stressors and impacted reaches in order to focus subsequent, more-detailed recon visits. Observations from the initial recon are shown in Figure 5.1.

Much of the stream observed is in relatively-good condition. There is minor evidence of hydraulic mining upstream of RM 2.7, with most of this former land use limited to reaches downstream of the RM 2.7. An old road or skid trail influences the creek upstream of RM 2.7; however, this reach is found to be in generally good condition as compared to downstream reaches (discussed more, below): there is an available sediment supply; the channel exhibits an expected channel morphology and substrate caliber; the channel includes some elements of structural habitat complexity; channel incision is minor and intermittent depending on the presence of the old roadway; and the stream is shaded and includes available cover (Figure 5.1). In this reach the channel is relatively confined with limited floodplain width caused by the hillslopes terminating very close to the edge of the channel. Channel morphology is a mixture of step-pool and boulder cascade. The Moon Lee Ditch diversion is located near RM 3.0 (Figure 5.1). No major effects on hydraulics or geomorphology because of the diversion were noted. No assessment was made on the effects of the diversion on flow, temperature, or fish passage. It should be noted, however, current fish and water quality monitoring is being conducted by the Redwood Sciences Laboratory concerning the diversion. The results of that work are pending.

West Weaver Creek between RM 1.7 to RM 2.7 exhibits signs of being more-impacted by anthropogenic activities than the reaches of creek upstream. This reach of creek flows through an area that was extensively hydraulically-mined and was likely mined again resulting in coarse tailings piles and highly disturbed substrate conditions on the floodplain and channel banks. This area was also impacted by fire twice in the past decade.

Noteworthy in this reach of creek is the incision of the channel into the anthropogenic floodplain, and the occasional exposure of bedrock in the channel. Based on our understanding of the watershed's geology, it is most likely that the exposed bedrock is Weaverville Formation. This exposure of Weaverville Formation bedrock in the channel was not observed upstream of RM 2.7 or downstream of RM 1.4 (Oregon Street culvert). At one location in this reach, a log weir was identified, likely installed as a part of previous restoration efforts to stabilize and build up sediment in this reach (this theory is supported by the Ebasco 1990 report).

The Highway 299 culvert was observed to be a potential fish passage barrier and subsequent survey and investigation of this structure was deemed merited. Downstream of the Highway 299 culvert the channel remains incised and occasional bedrock is exposed for about the first 1000 feet, at which point (at RM 2.1) the majority of the channel bed becomes comprised of exposed bedrock. The adjacent hillslopes in this reach are anthropogenic, as are the floodplains, comprised of material deposited through hydraulic mining operations and hillslope colluvium derived from that material. The hillslopes in this reach are recovering from recent fires (similar to the reach immediately upstream of Highway 299) and large trees are lacking. Most of the regeneration of vegetation is early-secession, chaparral-type species and is particularly lacking in conifer recruitment.

Grub Gulch joins West Weaver Creek at RM 1.8. This is apparently an ephemeral tributary, and upstream reaches of this creek are similarly impacted by hydraulic mining. Downstream of Grub Gulch there is another significant exposure of Weaverville Formation bedrock in the channel, and in places the incision into this material has formed narrow chutes.

One item of interest at RM 1.4, just upstream of the upgraded Oregon Street culvert, was a tall (about 12 feet) bank of fine sediment, possibly deposited from hydraulic mining activities (Figure 5.1). The channel appeared to be eroding into this deposit creating a possible source of fine sediment. Downstream of RM 1.4, the Oregon Street culvert, the channel is in relatively-good condition. Between RM 1.4 and about RM 0.8 portions of the creek flow through parcels containing single-family homes that are adjacent to the creek, influencing the vegetation of the streamside and upslope areas. The morphology in this reach is riffle-pool. Downstream of about RM 0.8, the creek flows through the Weaverville Community Forest and despite hydraulic mine tailings on the broad, right-bank floodplain, the existing channel morphology is comprised of glides, pools and riffles. We noted the channel bed was comprised of gravel and cobble substrate (as opposed to exposed bedrock), channel incision was relatively minor, and for a creek recovering from past mining appeared to have reasonable amounts of cover and shade.

5.1.2 Detailed Reconnaissance

As mentioned in the project objectives, we aimed to refine our focus downward until issues related to salmonid habitat and sediment yield were identified at a local, reach scale. From the initial recon, it was determined that the of the reaches examined, a more detailed recon field visit would focus on the reach from Highway 299 culvert (RM 2.3) downstream to just below Grub Gulch (RM 1.8). This “focus reach” (RM 1.8 – 2.3) was chosen based on the facts that: 1) fish passage at Highway 299 is questionable, with no definitive passage assessment completed and some evidence suggesting this barrier is limiting the distribution of juvenile, and perhaps adult, fish; 2) of the reaches examined, this reach (and the reach immediately upstream of Highway 299) are the most impacted and in need of rehabilitation efforts to increase the physical processes that create and maintain habitat and ecosystem functions required by native fish species; and 3) without treatment of the Highway 299 culvert to ensure unimpeded fish passage, the reach upstream of that culvert is a slightly lower-priority section of creek in terms of rehabilitation planning and implementation.

As part of the detailed field reconnaissance the following data was collected:

1. dimensions of the Highway 299 culvert
2. detailed longitudinal topographic profile of the channel, capturing nick points and significant slope breaks
3. topographic cross sections of the channel, illustrating channel incision, channel width, and channel size and elevation relative to floodplain width
4. GPS delineation of the channel centerline location and floodplain width
5. geomorphologic unit mapping, based on field observations and topographic data review
6. LiDAR topographic data, captured via sensors mounted on a fixed-wing aircraft platform

Additionally, the recon team collectively developed a general concept of the site's geomorphic character (key geomorphic processes, changes through time, and likely future trajectories) and brainstormed ideas for conceptual designs to rehabilitate key forms and functions missing from the site.

The culvert under Highway 299 is comprised of a box culvert that was extended with round corrugated metal pipe (CMP) at the upstream end, apparently when the highway was widened. The majority of the culvert is comprised of a concrete box culvert with the walls including natural stone and is retrofitted with steel baffles to enable fish passage. The dimensions of the downstream box culvert are 8 feet wide by 8.5 feet tall and 110 feet long. The 35 foot long CMP has a diameter of 8 feet and also contains alternating steel baffles.

The overall slope of the culvert is 5 percent; however, there is a slope break in the culvert where the culvert transitions from the CMP to box culvert. The CMP is at the same slope as the channel (3.6 percent) which makes the box portion (5.5 percent) steeper than the overall slope. The box culvert portion of the culvert contains 1-foot tall alternating baffles designed for fish passage (Figure 5.2). Looking downstream, the left baffles (which extend 3 feet, 5 inches) are perpendicular to flow. The right baffles angle upstream at an angle of 28 degrees from the wall and a length of 7 feet, extending 3 feet, 5 inches feet into the channel (measured normal to flow). The baffles on the right appear to be filled in with coarse sediment providing limited refuge from high velocity flows.

The first 1000 feet of creek downstream of Highway 299 (station 2500 downstream to station 1500; Figure 5.3) can give the casual observer the appearance of relatively good habitat conditions. The channel profile is rather steep and the channel is dominated by armored step-pool units with occasional exposure to bedrock (Figure 5.3). Several locations contain racked-up wood debris that provides complex habitat and forces hydraulics that sort sediment. In such occasions the racked wood often functions as sediment dams, creating localized reduction in slope which seems to force riffle-pool morphology (Figure 5.3). Surrounding the channel is dense, young cottonwoods and willows and in many locations groundwater seepage from banks above the creek's water surface was observed. However, there are clues to a lack of the natural (and desirable) geomorphic processes that ultimately create and sustain the disturbance-driven habitat conditions in the channel and on the floodplain. For example, a number of the step-pools terminate into pools with exposed bedrock and the large, substrate that forms these pools is

comprised of a relatively- thin veneer, based on the bedrock exposure. The shallow substrate (within the channel itself) and tall channel banks indicate the channel in this reach is incised. Additionally, the channel does not appear to be migrating laterally, probably because the bank is armored by coarse mine tailings and/or exposures of the Weaverville formation, and there is a significant lack of undercut banks because of the bank composition. There are some slight expansions in the valley width in some areas that would allow high flows to spread and disperse energy, but generally the channel is located tight against the toe of the adjacent hillslopes. These hillslopes do not appear to be providing a local sediment supply, leaving the only sediment input being that supplied by transport into the reach from upstream.

Downstream, from station 1500 to station 0 at Grub Gulch (Figure 5.3), the channel is in very poor condition. The channel has incised down to the Weaverville bedrock formation in much of the reach and much of this bed length is devoid of alluvial substrate. Only two isolated sections of creek include channel morphology that does not include exposed bedrock. The riparian zone is the thinnest in the entire watershed. There is very little large wood or channel complexity. The banks and floodplain are comprised of coarse mine tailings, and this reach lacks undercut banks and potential for lateral channel migration. One positive attribute of the reach is that the left-bank side of the creek includes a floodplain throughout the reach that is relatively wide, illustrated in Figure 5.4, cross section 3 and 4. However, as was demonstrated through analysis detailed later in this report, the creek is largely disconnected from the floodplain and any low areas on the floodplain (perhaps ancient secondary channels or areas used for drainage during mining) up to and including the 10-year peak discharge. There is no evidence to suggest that the channel has or will migrate through the expanded floodplain, and appears to be locked in place.

Grub Gulch is an ephemeral tributary that enters on the right bank at RM 1.8, and anecdotally this stream has been indicated as a potentially-significant source of fine sediment. Such anecdotal accounts were given by the land owners at the confluence of Grub Gulch and West Weaver Creek, suggesting that Grub Gulch discharges “muddy water” into West Weaver Creek during storm events. The lower portion of Grub Gulch consists of course tailings vegetated by Ponderosa pine, Manzanita, Buckbrush (Figure 5.4). There are two channels in this area, one channel hugging the right hillslope that is dense with willow and black berries, and a second, deeper ephemeral channel down the center of the gulch that has signs of erosion into a silt/clay substrate. As an ephemeral stream, any fine sediment transport in Grub Gulch would occur primarily during storm events, and possibly derived from the upper hillslopes. Additional future reconnaissance during the wet season/storm events may be merited.

Downstream of Grub Gulch the West Weaver Creek channel becomes steeper and is a series of bedrock exposed reaches and step-pool reaches with occurrences of exposed bedrock until the slopes reduce and the channel turns to plane bed at RM 1.7.

5.2 Analysis

5.2.1 Examination of Profile

The surveyed profile covers 2500 feet of channel from the upstream end of the Highway 299 culvert down to Grub Gulch (Figure 5.3). The culvert at the upstream end of the reach has a gradient of 5.1%. The entire focus reach has a gradient of 3.6%. Aside from fine-scale, local changes in slope associated with bed forms, there is no noticeable break in gradient of the focus reach until the very end of the reach. Here it appears the creek becomes steeper; however, this was only confirmed for the first 100 feet, after which is based on visual assessment. Within the upper reach (station 1200 to 2500 in Figure 5.3), there were three low gradient stretches of channel (1.0%, 1.0%, and 0.9%) located upstream of sediment impediments that gave way to riffle-pool morphology. Such forced riffle-pool morphology was not found in the downstream half (station 100 to 1200 of Figure 5.3) of the focus reach. The steepest stretch was a well-structured step-pool reach with a gradient of 5.9%. This step-pool reach had steps with an average distance of 26 feet from upstream crest stone to downstream crest stone, and a 1.8 foot average difference in height from upstream crest stone to downstream crest stone (these dimension did not vary much for the four measured steps).

5.2.2 Analysis of Cross Sections

A hydraulic analysis was performed for the four cross sections surveyed on the focus reach (locations shown on Figure 5.4). Cross section 1 (XS1) is located in the reach just downstream of Highway 299, where the banks are comprised of substrate with a broad distribution of sizes. Cross section 2 (XS2) is located at the beginning of the reach that is dominated by exposed bedrock, with some floodplain area and former side channel to the right of the channel. Cross section 3 (XS3) and cross section (XS4) are both located in the reach with exposed bedrock and a floodplain on the left-bank side of the channel.

Using these cross sections (and surveyed gradient data) we assessed the ability of various flows to transport sediment using hydraulic analysis. Hydrology was estimated at the site using the same methods as described in Section 2.5.3 (for assessment of the entire basin), with the exception that the basin area was reduced to 6.1 square miles, corresponding to the location of these cross sections. As described in section 2.5.3, the average of the two methods was used in the hydraulic analysis (Table 5.1).

The flows used for the hydraulic analysis at the cross sections were the 2-, 5-, and 10-year discharges. These were chosen because channel forming flows are generally considered to be anywhere from the 2- to 10- year flow event, and the 2-year flow is also often used as the surrogate bankfull discharge, the discharge at which flow begins to break out of the channel at the top of bank.

The hydraulic analysis was performed in HEC-RAS using the Hydraulic Design Uniform Flow module. This module calculates normal depth using the chosen equation. For the analysis,

Manning's equation was chosen using roughness values from Chow (1959) and a slope of 3.7% for XS 1, and 3.6% for XS 2, 3, and 4.

TABLE 5.1 RETURN INTERVAL DISCHARGES AT THE FOCUS REACH FOR THE METHODS USED

Return Interval	Discharge estimated from Streamstats' Waananen and Crippen regression equation (cfs)	Discharge estimated from Rush Creek Bulletin 17B results (cfs)	Percent Difference
2-year	329	131	230
5-year	583	299	441
10-year	844	506	675
25-year	1200	953	1077
50-year	1640	1483	1561
100-year	2030	2269	2149

Notes: cfs = cubic feet per second

The depth and velocity results from the hydraulic analysis are about the same for all cross sections (Table 5.2). The depths for the three recurrence intervals are shown for each cross section are illustrated in Figures 5.5a-d. As shown, bankfull for XS1 is just below the 5-year discharge (Figure 5.5a), for XS 2 it is just above the 5-year (Figure 5.5b), for XS 3 it is just above the 5-year (Figure 5.5c), and for XS 4 bankfull is well above the 10-year (Figure 5.5d). Generally, in this geomorphic setting we'd expect to see water surface elevations at or above the top of bank for discharges at or just larger than the 2-year flow event. This suggests that the channel in this area is incised and/or the floodplain morphology is highly altered.

TABLE 5.2 VELOCITY DEPTH RESULTS FROM THE HYDRAULIC ANALYSIS FOR XS1-4

	depth: 2-year (ft)	depth: 5-year (ft)	depth: 10-year (ft)
cross section 1	2.4	3.7	4.8
cross section 2	2.6	3.8	4.5
cross section 3	3.4	4.6	5.2
cross section 4	3.5	4.7	5.7
	velocity: 2-year (ft/sec)	**velocity: 5-year (ft/sec)**	**velocity: 10-year (ft/sec)**
cross section 1	6.0	6.8	6.7
cross section 2	8.3	7.9	8.8
cross section 3	6.7	7.5	7.8
cross section 4	6.8	8.0	8.9

Based on the velocity results from the hydraulic analysis, significant sediment transport is likely occurring during flood events. According to the Hjulstrom diagram (Knighton, 1998), beds with grains sizes of 30 mm and smaller is likely to be eroded for the 5-year discharge for XS1 and XS2, and the 2-year discharge for XS3 and XS4. Beds with grains sizes of 30-400mm may be in transport for the 5-year discharge for XS1 and XS2, and the 2-year discharge for XS3 and XS4.

Table 5.3 presents the critical shear stress required to entrain certain particle sizes for comparison to estimated open channel shear stress calculations. Table 5.4 presents estimated open channel shear stress using the hydraulic radius-slope product equation for open channel shear stress. These values can be compared to those in Table 5.3 to assess the potential for entrainment of sediment under current conditions and for 2-, 5-, and 10-year discharges.

TABLE 5.3 CRITICAL SHEAR STRESS REQUIRED TO ENTRAIN CERTAIN PARTICLE SIZES

	max spawn gravel size	typical step-pool D50*	large cobble
diameter (mm)	35	64	128
entrainment critical shear stress (lb/sq ft)**	0.5	1.1	2.3

*SOURCE: Montgomery and Buffington (1997)
** SOURCE: Fischenich (2001)

TABLE 5.4 RESULTS OF OPEN CHANNEL SHEAR STRESS CALCULATIONS FOR XS1 THROUGH XS4

recurrence interval	2-year	5- year	10- year
cross section 1 shear stress (lb/sq ft)	4.1	5.6	8.1
cross section 2 shear stress (lb/sq ft)	3.5	5.4	5.9
cross section 3 shear stress (lb/ sq ft)	4.0	5.2	5.3
cross section 4 shear stress (lb/ sq ft)	4.0	5.3	6.3

*SOURCE: Montgomery and Buffington (1997)
** SOURCE: Fischenich (2001)

Currently, it appears West Weaver Creek from Highway 299 to Grub Gulch has the competency to transport large-caliber sediment, which when considered with the resistant banks and confined channel morphology explains the shallow in-channel sediment depths and significant bedrock exposure. Based on Parker's (2007) bankfull geometry relationships, while the actual bankfull width (average of 27 feet) is about the same as expected by the relationship (30 feet), the actual bankfull *depth* is more than 3 times that which is to be expected (6.0 feet vs. 1.7 feet). This is further confirmation the channel is significantly incised in this reach.

5.2.3 Analysis of Culvert Hydraulics for Fish Passage

The CDFG "Culvert Criteria for Fish Passage" (2002) was used to assess fish passage for the Highway 299 culvert that is currently retrofitted with baffles. There are four scenarios under which passage was assessed:

1. Passage for adult salmon with minimum depth at the low design flow.
2. Passage for adult salmon with maximum velocity at the high design flow.
3. Passage for juvenile salmon with minimum depth at the low design flow.
4. Passage for juvenile salmon with maximum velocity at the high design flow.

For the high flow scenarios, 50% of the 2-year recurrence interval flow was used for adult salmon and 10% of the 2-year recurrence interval flow for juvenile salmon. For the low flow scenarios a 50% annual exceedance flow was used for adult salmon, and 95% annual exceedance flow was used for juvenile salmon. The low flow annual exceedance was determined from the hydrologic data provided by the Redwood Sciences Laboratory.

The configuration of the fish passage baffles made it difficult to analyze flow hydraulics for low flows (such as those shown in Figure 5.2). To address this complexity we examined hydraulics for the low flow criteria at two locations that appeared to confine flow and control flow hydraulics (Figure 5.6). The first location, shown in Figure 5.6 is through the left side of the culvert (looking downstream). The second location, shown in Figure 5.6, is through the right side of the culvert (looking downstream). The hydraulic analysis was performed in HEC-RAS using the Hydraulic Design Uniform Flow module. This module calculates normal depth using the chosen equation. For the analysis, Manning's equation was chosen using roughness values from Caltrans (2009) for the baffles (ranging from 0.039 to 0.076 based on depth/baffle height ratio) and Chow (1959) for the culvert wall (roughness of dressed stone in mortar = 0.017), a slope of 5.5% for the entire culvert cross section and location 1 and 5.0% for location 2. The results from that analysis are presented in Table 5.5.

Based on the hydraulic modeling, adequate depth and high velocities is a concern for both adult and juvenile salmon. Admittedly, the analysis is an approximation of hydraulic conditions owing to the complexity of flow though the baffle structures and the simplification of this complexity in the modeling. However, because the baffle height is only 1 foot, even a conceptualization of flow dynamics suggests that flow must be overtopping the baffles to meet or exceed the CDFG adult salmon passage criteria of 1 foot depth. Our field work was conducted during the fish migration time period (December), and although the exact discharge is unknown, photos of the culvert that we took during the visit (Figure 5.2) show that flows are less than the height of the top of the baffles (flows unknown).

TABLE 5.5 COMPARISON OF CDFG PASSAGE CRITERIA TO RESULTS OF HYDRAULIC ANALYSIS FOR FISH PASSAGE THROUGH THE HIGHWAY 299 CULVERT

	California Department of Fish and Game (CDFG) Fish Passage Requirement		
		min depth (ft)	**max velocity (ft/s)**
Adult salmon		1	4
Juvenile salmon		0.5	1
	Hydraulic Analysis Results		
	Modeled discharge (cfs)	**min depth (ft)**	**max velocity (ft/s)**
Low Flow			
Adult salmon	6	0.5	-
Juvenile salmon	1	0.2	-
High Flow			
Adult salmon	115	-	10.0
Juvenile salmon	23	-	4.2

5.3 Summary of Field Assessment, Modeling and Analysis

The reach of the West Weaver Creek between RM 1.7 and 2.7 was significantly impacted by hydraulic mining and recent forest fires. The fish passage assessment suggests that the present configuration of the culvert provides insufficient depth for adult steelhead and coho migration. In terms of geomorphic form and function, the creek is incised into hydraulic mine debris and shows little if any sign of lateral migration or the potential for it given the existing morphology. The depth of in-channel sediment is very limited and large sections of the reach are scoured to the underlying bedrock (Weaverville Formation), most prevalently RM 1.8 to RM 2.1. Fish passage at the Highway 299 culvert is dubious and fine sediment production from Grub Gulch is a potential concern. Riparian vegetation appears to recovering in some areas after being repeatedly subjected to recent fire, though many areas are still in the early stage of recovery and source material for large wood is absent. The floodplain area adjacent to the reach of creek with the greatest amount of bedrock exposure has sufficient width to provide a valuable opportunity to enhance floodplain inundation, if enhancement actions are taken to properly reconnect the channel to this floodplain. The stream's longitudinal topographic profile shows no major slope breaks, but does show a few localized reductions in gradient caused by sediment dams (formed by wood), and these locations are presently characterized by riffle-pool morphology. The cross sectional hydraulic analysis shows the channel is currently incised, creating hydraulic conditions with high sediment transport competency.

Without the forcing of wood, riffle-pool channel morphology is not expected in the focus reach, at least based on the valley profile. For riffle-pools reaches, the typical bed material is expected to be gravel (finer than is presently the case), the pool spacing 5 to 7 channel widths, the channel unconfined, and the dominant sediment sources from fluvial, bank failure, and debris flow sources. Many of these conditions are not present in the focus reach.

Obstructions such as large woody material can force local morphology variations that differ from the free-formed morphology that might be expected in higher gradient reaches (Montgomery and Buffington, 1997). In forested mountain drainage basins, such as the West Weaver Creek basin, large wood may cause local scour and sediment impoundment that form pools and steps, respectively. Log jams have even been observed to form (or "force") alluvial bed forms in otherwise bedrock reaches of mountain channel networks. Forced pool-riffle and step-pool channels are the most common obstruction-controlled morphologies in forested mountain drainage basins. Therefore, in West Weaver Creek, it is to be expected that riffle-pools may form in steeper morphology as a result of large wood or other forcing agents.

5.3.1 Top 5 Priority Issues

5.3.1.1 Issue 1 – Exposed bedrock and shallow in-channel substrate depth in the focus reach

The most-significant issue identified and reviewed is the extensive exposure of bedrock found in the focus reach. The majority of the reach is comprised of channel with a bed of exposed bedrock, interspersed with the occasional step-pool and plane bed unit. The extensive and uniform presence of bedrock limits spawning, holding refugia for juvenile salmonids, and macroinvertebrate production. Additionally, the exposed bedrock is Weaverville Formation, which is soft and friable and erosion by flow may cause it to be a small but constant source of fine sediment easily flushing into the downstream system.

In the areas of this reach where the bed is not scoured to bedrock, the substrate comprising the bed is abnormally-shallow (i.e., the thickness of stream alluvium atop bedrock is less than in other reaches of the creek and less than expected absent disturbance). It is unknown, but these areas with some remaining alluvial substrate may be on a trajectory similar to the dominantly exposed bedrock portions of the reach. What may be limiting this trajectory—and serves as an indication of what types of design concepts may be appropriate in addressing this issue—is that localized wood debris/sediment dams are forming what appear to be stable step-pools, with occasional riffle-pool and plane-bed formations.

5.3.1.2 Issue 2 – Lack of lateral channel migration in the focus reach

Somewhat linked to Issue 1—at least in terms of the anthropogenic disturbances that resulted in the abnormally-coarse bank material and disturbed floodplain conditions—the lack of lateral

channel migration or avulsion has resulted in a positive feedback loop whereby all available stream energy remains focused on the bed and banks. At a minimum, were the channel afforded an opportunity to lose flood flows to side channels and/or floodplain areas, there is a chance that more sediment would deposit in the channel, improving hyporheic conditions and spawning habitat, and increasing benthic substrate. In addition, if the banks and floodplain were comprised of smaller material that could be eroded, through time lateral migration of the channel, and even avulsion events, would increase channel complexity and would afford the channel additional flow paths within which to disperse energy—reversing the existing positive feedback loop that perpetuates channel incision and simplification.

5.3.1.3 Issue 3 – Lack of floodplain connectivity in the focus reach

The incised nature of the channel restricts relatively-large flood flows from accessing the floodplain, and in many places even the 10-year flood event is confined within the channel. This lack of connectivity precludes the dispersal of high-energy flood waters and limits the creek's ability to deposit sediment. Additionally, when flood waters leave a channel and travel across floodplain surfaces, they are able to recruit to the stream important nutrients and biotic and abiotic materials that are vital to the good health of aquatic ecosystems. Lower floodplain surfaces and/or changes to the channel invert and bank profile would allow flood flows to interact with the floodplain and gain the aforementioned beneficial functions and inputs.

5.3.1.4 Issue 4 – Fish passage at Highway 299 Culvert (RM 2.3)

Fish passage at the Highway 299 culvert is in question. It was assessed by CDFG as passable using professional judgment. The USFS (2004) suggest it is a barrier to coho, but not steelhead. The hydraulic analysis performed as a part of this effort indicates the culvert has insufficient depths during times of adult migration, and this is supported by our field observations and related photographic evidence. Full volitional passage for all species and life stages is highly desirable in terms of enabling true habitat connectivity and allowing access to all parts of the watershed to help support populations of key fish species of concern.

5.3.1.5 Issue 5 – Fine sediment from Grub Gulch (RM 1.8)

Anecdotally, Grub Gulch is a source of fine sediment. The specific sources of fine sediment in the Grub Gulch watershed are still uncertain. The hydraulic mine debris/tailings that fill the lower portion of Grub Gulch and comprise adjacent floodplain and hillslopes may comprise a source, or it is possible that the headwater hillslopes which have been cleared by recent fires are (another) source. Regardless, additional efforts to understand the role of this tributary in aquatic habitat conditions downstream of the focus reach should be taken after other, higher-priority issues have been addressed.

6 OPPORTUNITIES AND CONSTRAINTS

There are number of opportunities and constraints that exist related to addressing the priority issues. Land ownership in this area is favorable in terms of there being just two landowners (one private, the other the USFS). Most of the land that surrounds the focus reach is a part of the Trinity National Forest or the Weaverville Community Forest, and both are managed by the USFS an agency that is eager to see rehabilitation of aquatic habitat in this area. While the channel itself is incised and lacks connectivity with the floodplain during frequent flood events, the topography of the floodplain (where it is present) is relatively-well configured. Most portions of the floodplain do not have impediments to flow and are gently graded to flat (measured laterally, across the valley). Given these potential floodplain areas, and an understanding of the configurations necessary to allow the formation of "forced riffle-pools", there is substantial opportunity to alter the morphology of the creek channel in the focus reach to enhance holding/rearing pools and spawning riffles. Additionally, construction staging and access to the creek corridor is available via an older logging road, landing, and skid trail, located off Highway 299 on the stream's left bank.

The last detailed study of fish ecology in West Weaver Creek was conducted over twenty years ago. A number of major disturbances (Oregon and Junction Fires) have occurred since that time and may have affected the stream's ecology. At this time, the best data available are simple "presence observations" of a few key species at different locations within the West Weaver Creek watershed. Fortuitously, the USFS Redwood Sciences Laboratory (RSL) is presently conducting a comprehensive study (albeit of a short reach of stream) related to the affects of the Moon Lee diversion, in a reach of creek upstream of Highway 200 and outside the focus reach. The RSL staff working on this study wish to collaborate with any restoration efforts that may lead from this stream assessment. This is a substantial opportunity because this would provide post-restoration project monitoring at site, but also, the RSL study includes the use of monitoring data to calibrate a spatially explicit, individual-based model for stream salmonid populations that could be crafted to help assess restoration success, as based on hypotheses that would be developed during the design process. This would be a great opportunity to demonstrate the potential restoration benefits of tributary restoration relative to improving fish ecology in the Trinity River basin.

There are also a number of constraints related to addressing these issues. One major constraint is related to the proximity of the channel's left bank to the toe of the Highway 299 embankment, limiting the potential to expand the channel or establish a floodplain via grading. Another possible constraint is the tailings on the right bank of the channel. While grading of the tailings is possible, such activities may be prohibited due to the need to protect historical resources (though based on previous reviews [Lynsky, 2010], this may not be an issue). A historical resources inventory and analysis would resolve this uncertainty and would be completed concurrent with the design process. As noted above, the floodplain topography is relatively-well configured (flat, free of major flow impediments), but the caliber of the substrate itself is coarse and may require

sorting or other processing to support floodplain desirable vegetation and to allow for future channel migration and supply of appropriate-sized sediment to the stream (i.e., spawning gravel).

Access to the existing road and skid trail, as well as rehabilitation efforts in the downstream-most 500 feet of the focus reach, will require the permission of private land owners. This is not considered a constraint, and these individuals have participated in this project by providing access for field reconnaissance and have provided anecdotal information on channel conditions and observed watershed dynamics. Similarly, the Highway 299 culvert can be considered both an opportunity and constraint. Currently, the fish passage issues at Highway 299 suggest that work should be limited to areas downstream of the culvert, due to the segregation of habitat. However, the culvert is also an opportunity in that retrofitting the culvert would open up habitat that is currently inaccessible as well as give cause for habitat rehabilitation efforts in the creek upstream of Highway 299.

7 RECOMMENDED ACTIONS

As detailed in the subsections above, there are numerous reasons to focus rehabilitation actions on the portion of West Weaver Creek located in the focus reach. Further, there are five priority issues identified for West Weaver Creek that are associated with the focus reach. In this section we provide a set of recommended actions that if implemented will result in the creation of channel morphology that is beneficial to key aquatic species of concern and the rehabilitation of the important geomorphic processes that create and maintain these channel forms and habitats and sort and sequester sediment within the watershed—reducing transport into the mainstem Trinity River. These actions are focused on addressing the top three priority issues; with the last two issues relegated to subsequent efforts where the spatial scope of rehabilitation efforts can expand beyond the focus reach, and partners such as Caltrans (i.e., for the Highway 299 culvert) can become involved in identifying solutions. Indeed, if the top three issues are addressed, the habitat in the focus reach will benefit from rehabilitated geomorphic processes that have been demonstrated to sustain the habitat necessary to support the native aquatic species present in the West Weaver Creek watershed.

Generally, the recommended actions can be encompassed within the single term “physical habitat rehabilitation”—an activity that involves the physical manipulation of the bed, banks, floodplain and associated vegetation to create a morphology that results in flow dynamics and geomorphic and ecologic processes that create and maintain desired habitat. This work is typically completed through the use of heavy machinery, hand labor, and can include the import of materials such as alluvium and larger rock, many forms of vegetation (live plants, cuttings, seeds), and erosion control materials such as biodegradable geo-textiles or other natural materials.

In the exposed bedrock reach we recommend creating riffle-pool channel morphology, a form expected in this reach based on the valley profile. (Details of how this could be accomplished are provided below). We recommend augmenting the channel (certainly in the exposed bedrock sections, and perhaps also injected at the upstream end of the focus reach during the first storm event after construction) with appropriately-sized substrate that will improve fish spawning and rearing habitat conditions, as well as provide a medium through which hyporheic flow can pass and benthic invertebrates can colonize. Additionally, we recommend that portions of the floodplains be graded and the sediment caliber manipulated such that the floodplain is of a configuration that mitigates for the potential that any new channels that are created (over the long term, through channel avulsion or migration) are not subjected to the same risk of developing the very issues our recommended actions seek to mitigate. Lastly, we recommend augmentation of large wood debris within the channel and floodplain and the planting of native species within the riparian zone/floodplain and adjacent hillslopes. These “habitat focused” actions are indeed “multi-objective solutions” because the natural processes that they restore are the same processes that sort and sequester fine sediment on floodplains—helping achieve both project goals.

To create riffle-pool habitat the longitudinal profile of the creek must be broken up such that there are areas of reduced gradient within the reach, allowing the formation of riffles and stabilizing the augmented sediment. We recommend accomplishing this in two possible ways (Figure 7.1). The first concept is to adjust the slope using step-pools constructed out of large cobble/small boulders (sourced on-site from the floodplain) topped with finer stream alluvium, in combination with widened channel banks coincident with the riffle locations to allow for flow expansion during channel-forming flows. These flow expansion areas sustain the topographic riffle relief through reversal of flow velocities (i.e. the water slows down across the riffles at higher discharges) as documented in White *et al.* (2010). In conjunction with these constructed riffles, bed topography would be built up sufficient to connect the creek to the adjacent floodplain

The second concept is simpler in terms of the design and construction, and has been implemented elsewhere in Northern California; however, it carries increased risk of failure. This concept is to create wood-formed sediment dams, similar to those presently located in the focus reach. Sediment would be augmented behind the dams to increase floodplain connectivity and enhance the substrate for ecological processes. Natural channel forming processes (i.e., initial flood flows after construction) would be allowed to shape the channel. This concept would require less design effort, a different set of imported materials (i.e., wood debris, though some could be sourced on-site), and similar equipment to the first concept. However, there is no guarantee the desired morphology will develop, the wood sediment dams may inhibit fish passage, and ultimately they may blow out, negating the rehabilitation effort. Although a formal design process has not been completed, our initial recommendation is to favor the constructed riffle approach in most locations, and perhaps include the second, wood-formed riffle concept in a more-limited extent, particularly where there is not an adjacent floodplain within which to expand flood flows and sustain the riffle morphology.

A detailed fish passage and remediation assessment of the Highway 299 culvert is recommended, as is partnering with Caltrans to conduct this assessment and consider management actions to address passage based on the results of the study. We recommend that Grub Gulch be assessed and confirmed as a sediment source before any implementation actions to address sediment in this tributary are developed. This need not be complex study, and determining the extent and source(s) of sediment in Grub Gulch appears a logical first step. Subsequently, assessment of downstream transport and affect on aquatic organisms may be merited to inform the worth of any remediation action planning.

8 REFERENCES

5 Counties Salmonid Conservation Program (5C), 2012, West Weaver Creek at Oregon Street Large Wood Management.

California Cooperative Anadromous Fish and Habitat Data Program (CalFish), 2011. California Fish Passage Assessment Database Project (PAD). http://www.calfish.org/tabid/83/Default.aspx

California Department of Fish and Game (CDFG), 2002. Culvert Criteria for Fish Passage.

California Department of Transportation (Caltrans), 2009. Fish Passage Design for Road Crossings: Appendix F – Hydraulic Baffles.

Contech Construction Products Inc. (Contech), 2010. West Weaver Creek, Weaverville, California Stream and Wetland Crossing

Ebasco Environmental, 1990. Trinity River Basin Restoration Program West Weaver Creek Fish Habitat Assessment. Prepared for U.S. Bureau of Reclamation (USBR).

Environmental Protection Agency (EPA), 2001. Trinity River Sediment Total Maximum Daily Load. U.S. Environmental Protection Agency (EPA) Region IX.

Everest, F. H., N. B. Armantrout, S. M. Keller, W. D. Parante, J. R. Sedell, T. E. Nickelson, J. M. Johnston, and G. N. Haugen, 1985. Salmonids. Pages 199-230 in E. R. Brown, editor. Management of wildlife and fish habitats in forests of western Oregon and Washington. Part 1—Chapter narratives. U. S. Forest Service, Portland, Oregon.

Fischenich, C., 2001. Stability Thresholds for Stream Restoration Materials. EMRRP Technical Notes Collection (ERDC TNEMRRP-SR-29), U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes.army.mil/el/emrrp

Irwin, W.P., 2010. Geologic Map of the Weaverville 15' Quadrangle, Trinity County, California: U.S. Geological Survey Scientific Investigations Map 3095, scale 1:50,000

Knighton, D., 1998. Fluvial Forms and Processes: A New Perspective. New York, Oxford University Press Inc.

Lynsky, T., 2010. Weaverville Community Forest – Riparian and Stream Channel Improvement Project. Decision memo by Tina Lynsky, District Ranger, Trinity River Management Unit. U.S. Forest Service: Shasta-Trinity National Forest.

Madej, M. A., 2007. A Strategy to Reduce Fine Sediment from Tributaries in the Trinity River Basin. A Report in Fulfillment of the Trinity River Restoration Project Agreement #

04AA202062. U.S. Geological Survey Western Ecological Research Center Redwood Field Station. Arcata, CA.

Montgomery, D.R. and Buffington, J.M., 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin 109 (5), 596-611.

National Marine Fisheries Service (NMFS), 2012. Public Draft Recovery Plan for Southern Oregon/Northern California Coast Coho Salmon (*Oncorhynchus kisutch*). National Marine Fisheries Service. Arcata, CA.

Parker, G., P. R. Wilcock, C. Paola, W. E. Dietrich, and J. Pitlick (2007), Physical basis for quasi-universal relations describing bankfull hydraulic geometry of single-thread gravel bed rivers, J. Geophys. Res., 112, F04005, doi:10.1029/2006JF000549.

Strauss, A., 2001. Trinity River Total Maximum Daily Load for Sediment. U.S. Environmental Protection Agency Region IX.

U.S. Department of the Interior Bureau of Land Management (BLM). 2003. America's Priceless Heritage: Cultural and Fossil Resources on Public Lands—California. Bureau of Land Management,Washington, DC.BLM/CA/GI-03/021+8111. 10pp.

United States Forest Service (USFS), 2001. Burned-Area Report: Reference FSH 2509.13.

United States Forest Service (USFS), 2004. Weaverville Watershed Analysis. Shasta-Trinity National Forest, Trinity River Management Unit

U.S. Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency, Bulletin 17-B of the Hydrology Subcommittee: Reston, Virginia, U.S. Geological Survey, Office of Water Data Coordination, [183 p.]. [Available from National Technical Information Service, Springfield VA 22161 as report no. PB 86 157 278 or from FEMA on the World-Wide Web at http://www.fema.gov/mit/tsd/dl_flow.htm]

Waananen, A.O. and Crippen, J.R., 1977. Magnitude and frequency of floods in California: U.S. Geological Survey Water-Resources Investigations Report 77-21, 102p

White, J. Q., G. B. Pasternack, and H. J. Moir, 2010. Valley width variation influences riffle-pool location and persistence on a rapidly incising gravel-bed river, Geomorphology, 121, 206–221, doi:10.1016/j.geomorph.2010.04.012.

Wiseman, E, 2012. Fish Biologist. Shasta-Trinity National Forest, Trinity River Management Unit, Fisheries. Personal Communication. 1/9/2012.

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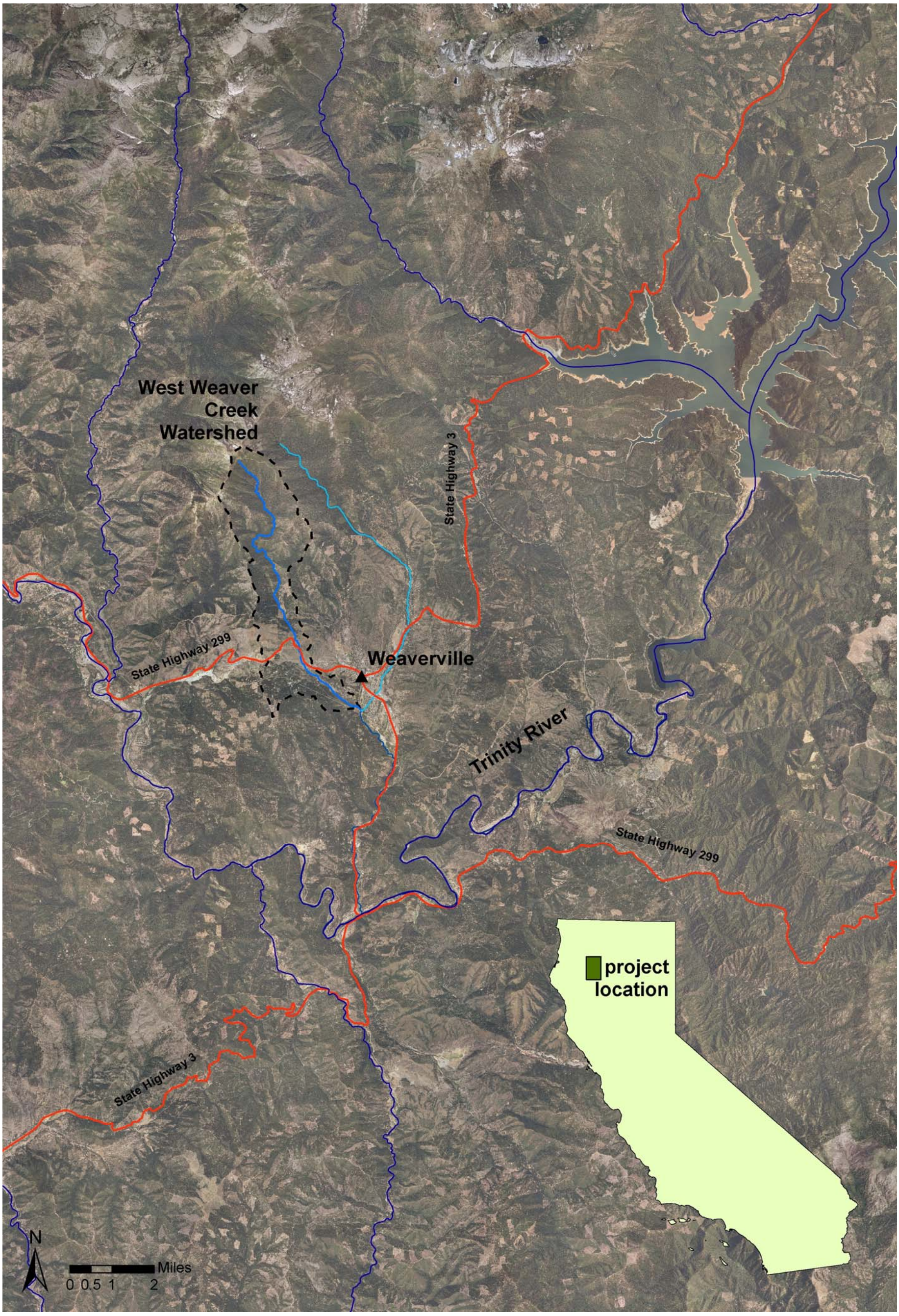
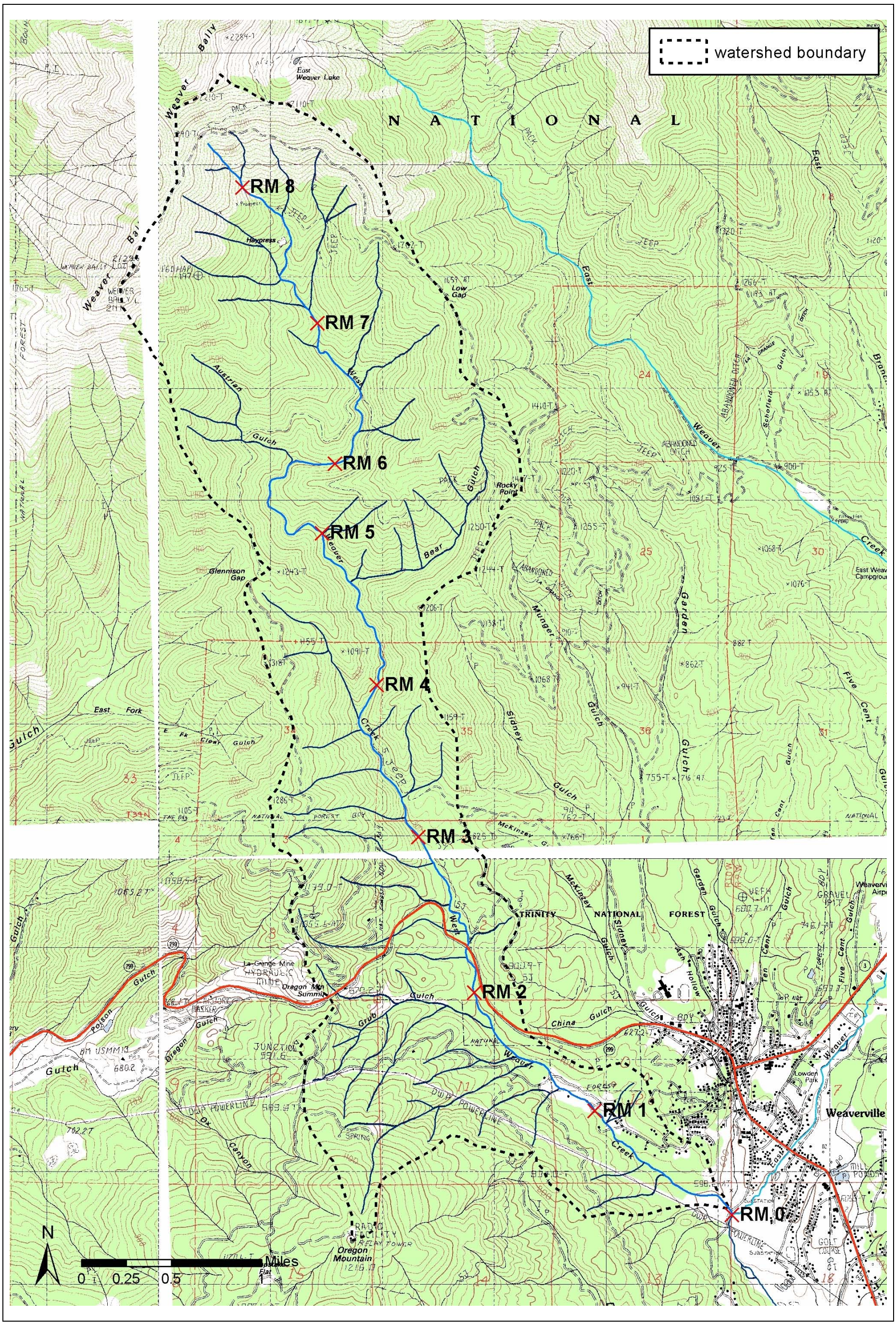


SOURCE: 2010 NAIP Aerial Photo

West Weaver Creek Assessment and Action Planning

Figure 2.1

West Weaver Creek Setting

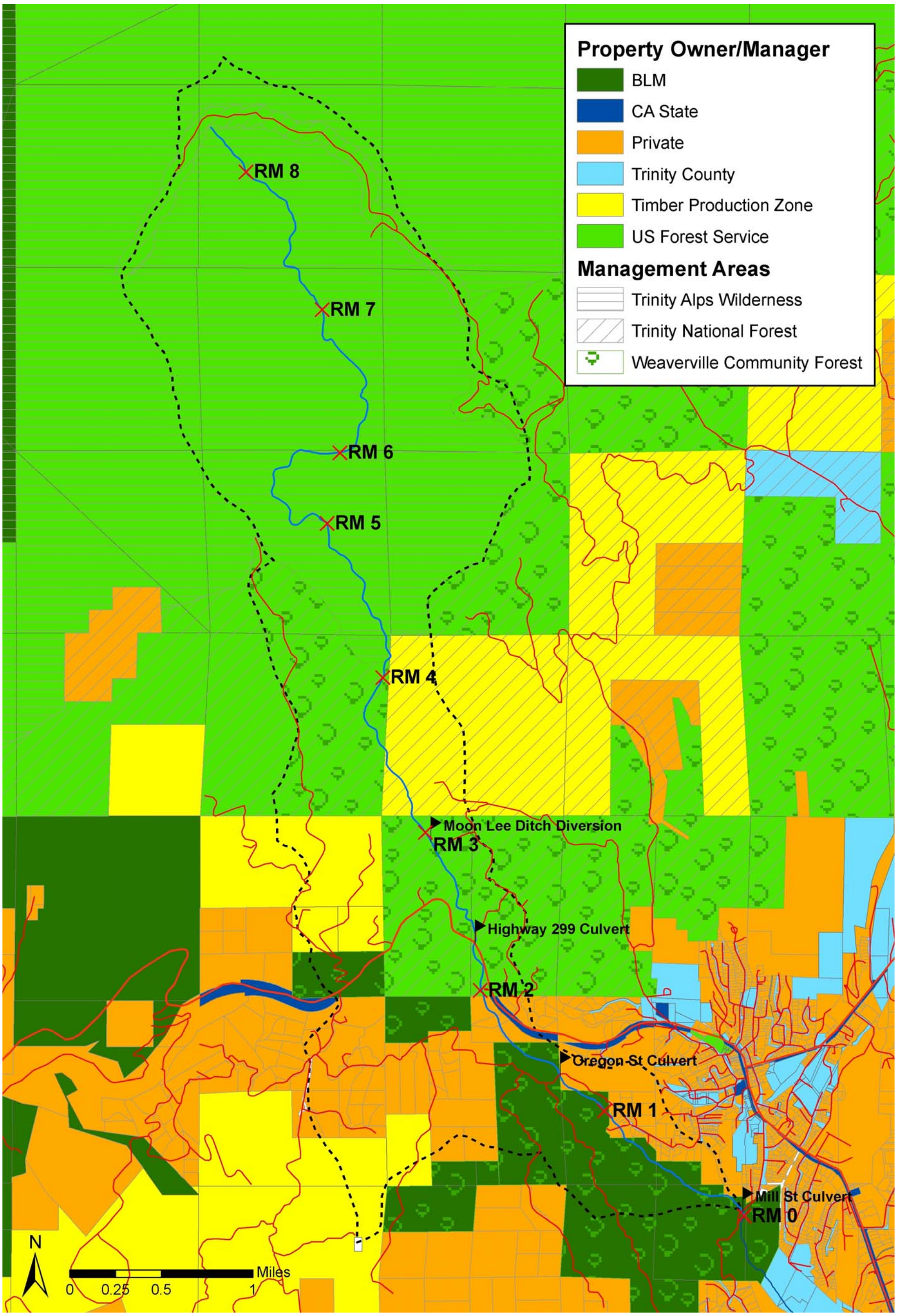


SOURCE: USGS 7.5 Minute Quadrangles (updated 1982); contour intervals in meters.

West Weaver Creek Assessment and Action Planning

Figure 2.2

West Weaver Creek Geography

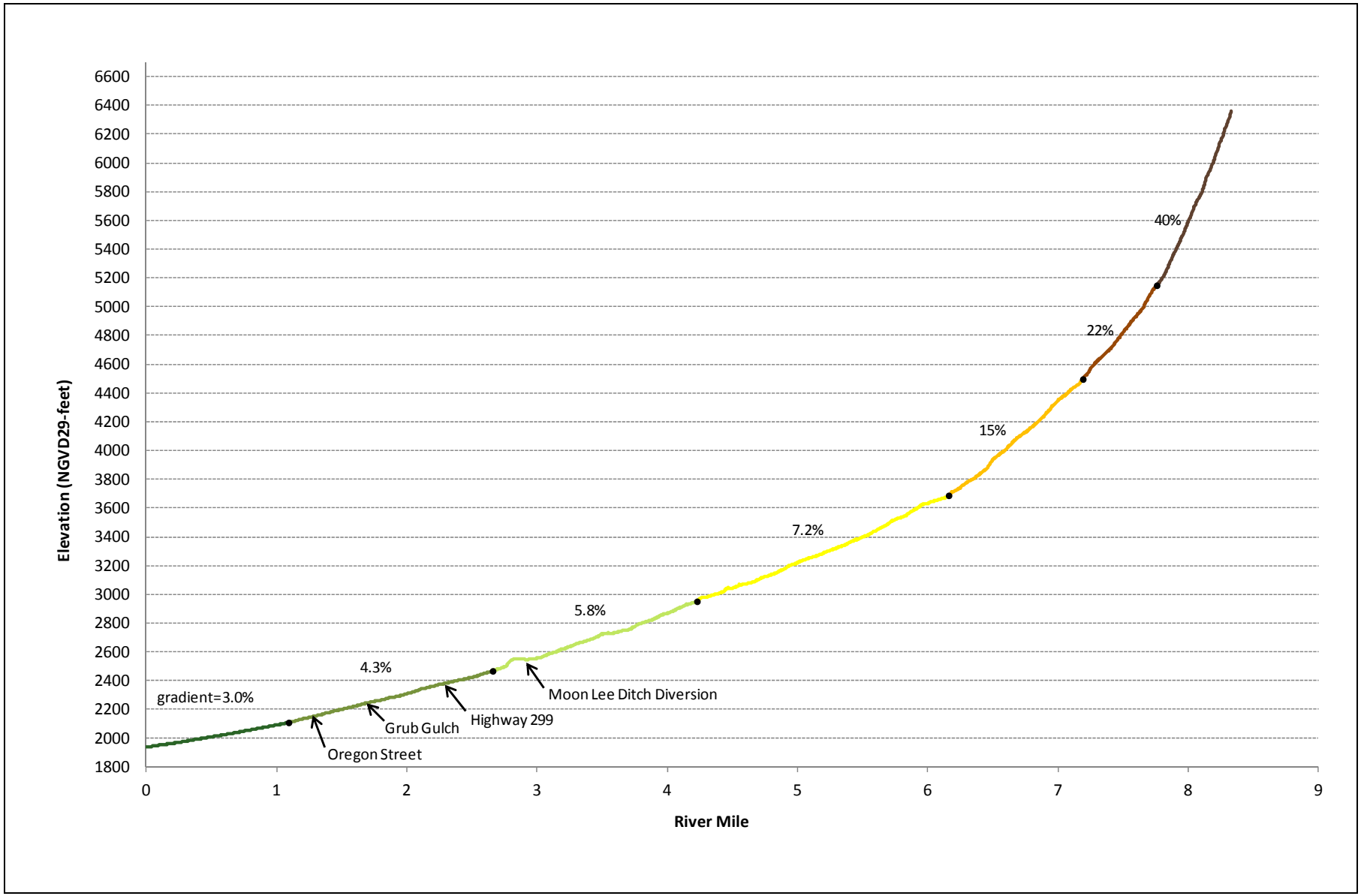


SOURCE: Parcel data provided by TCRCD

West Weaver Creek Assessment and Action Planning

Figure 2.3

West Weaver Creek Land Ownership/Management and Infrastructure



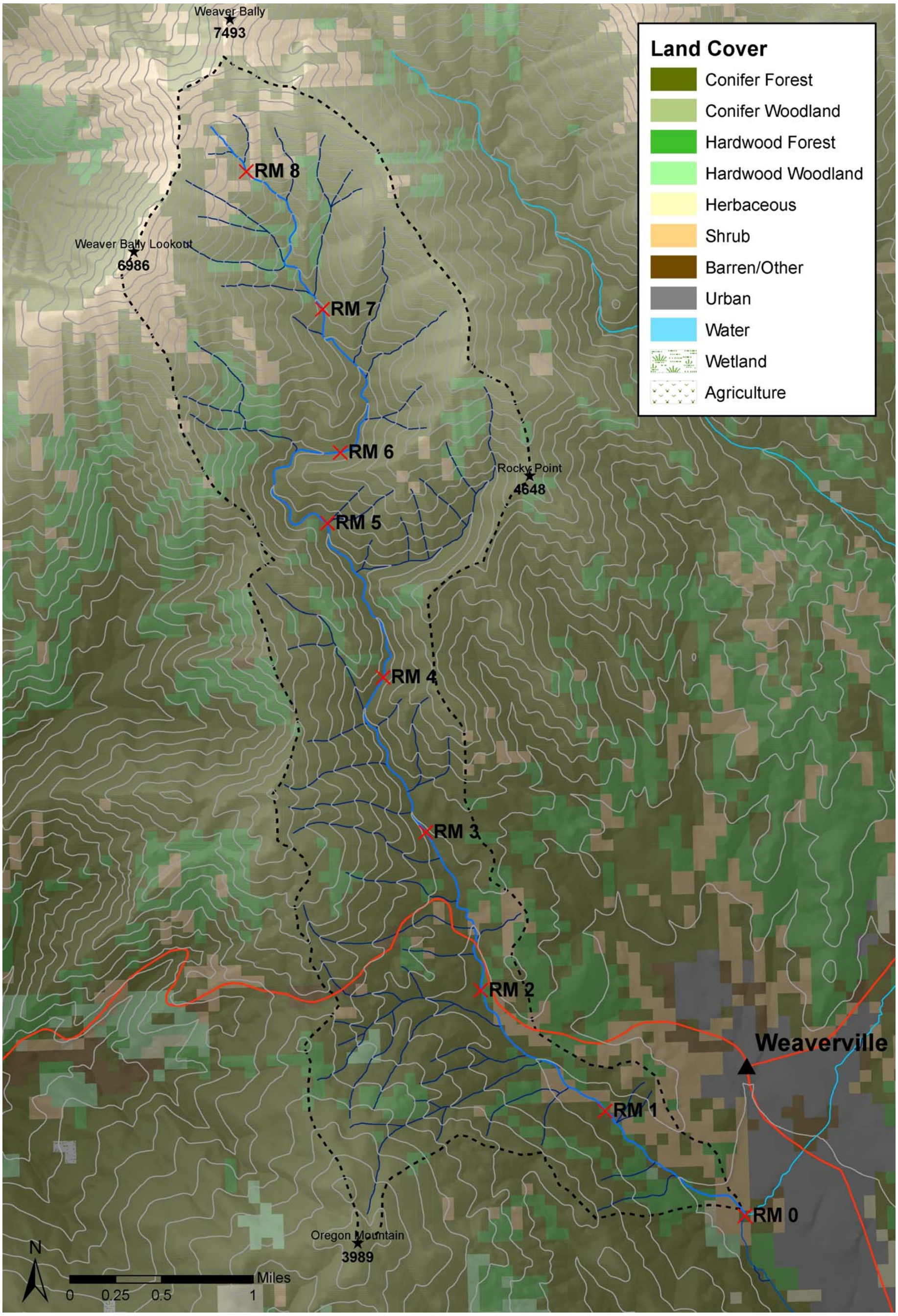
SOURCE: USGS 7.5 Minute Quadrangles (updated 1982); vertical datum=NGVD29.

NOTE: Profile broken into similar reach slopes based on observed best fit.

West Weaver Creek Assessment and Action Planning

Figure 2.4

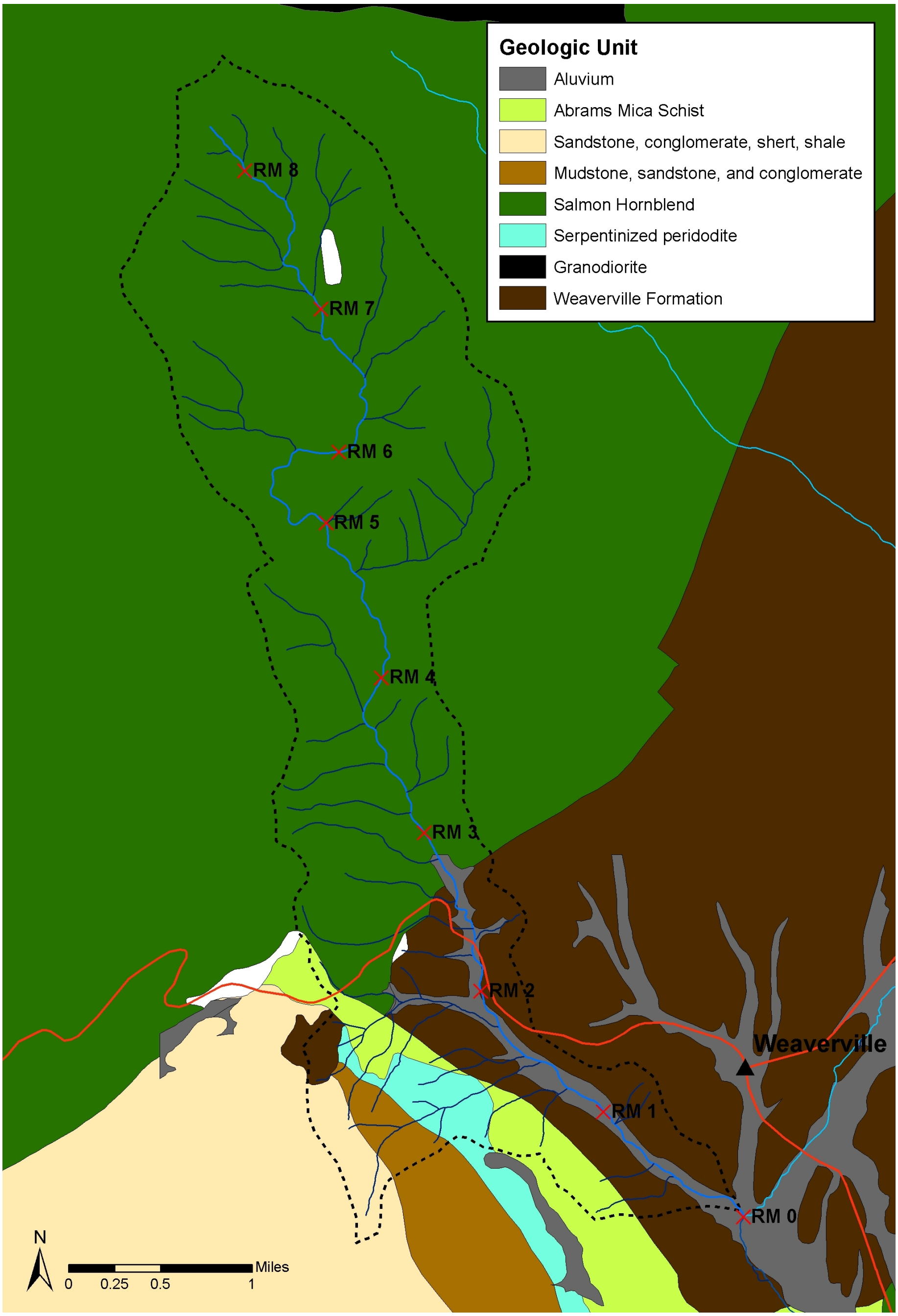
West Weaver Creek Valley Profile
Headwaters to the Confluence



SOURCE: Topography – USGS 7.5 Minute Quadrangles (updated 1982); contour interval = 200 feet.
Land cover – CDF-FRAP (updated 10/2002): based on multi-source data, does not account for changes to land cover due to 2006 Junction Fire.

West Weaver Creek Assessment and Action Planning

Figure 2.5
West Weaver Creek Topography and Land Cover

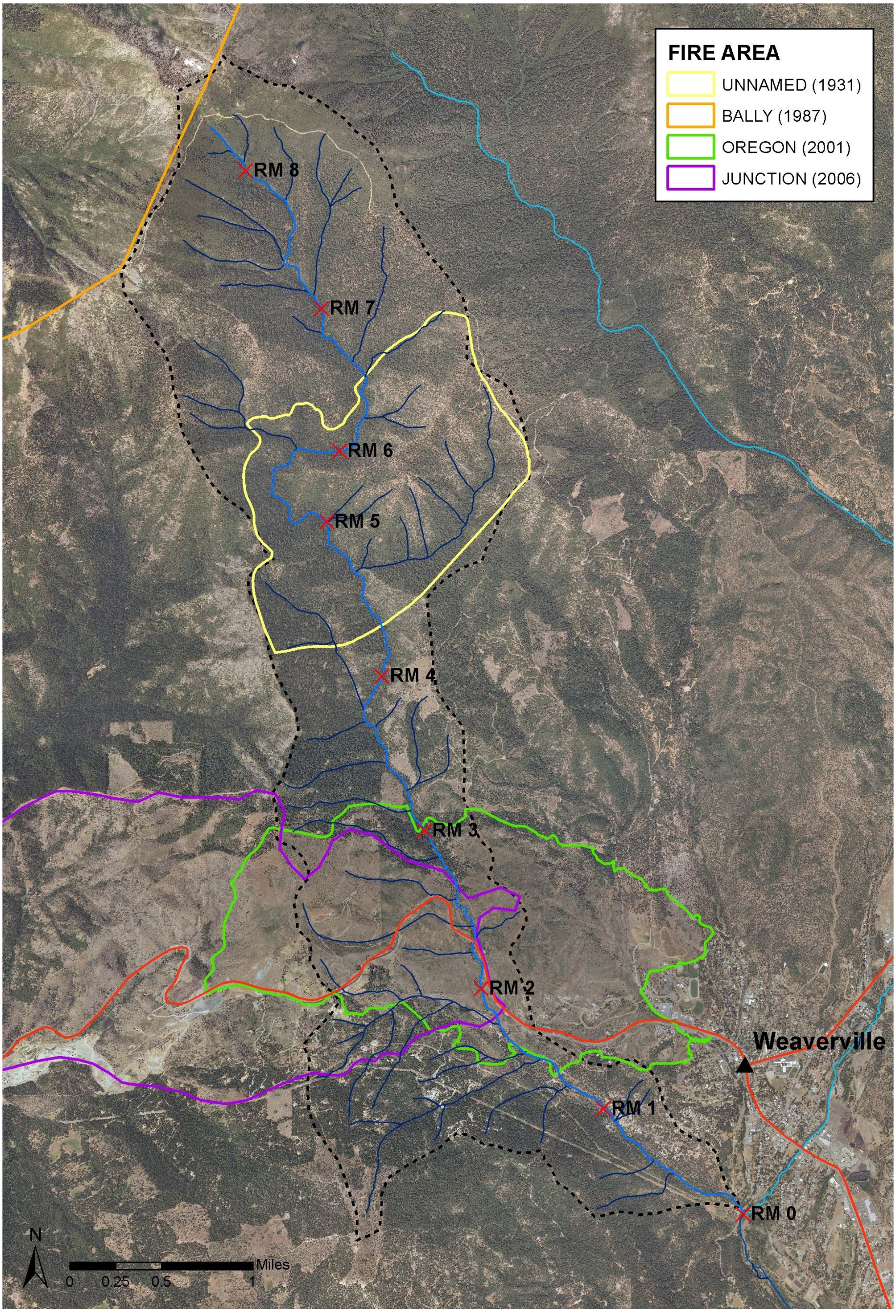


SOURCE:USGS (2010).

West Weaver Creek Assessment and Action Planning

Figure 2.6

West Weaver Creek Geology

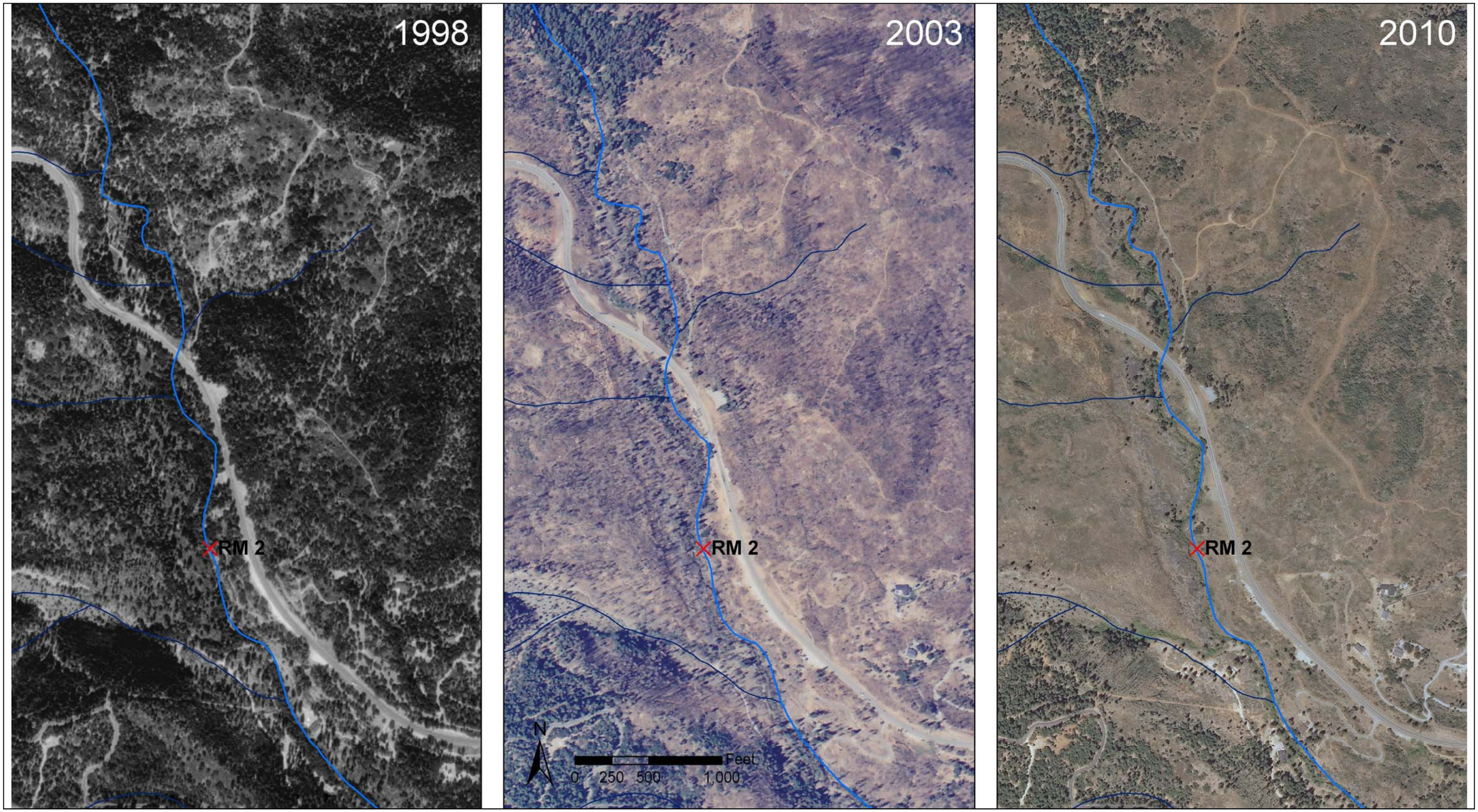


SOURCE: CDF

West Weaver Assessment and Action Planning

Figure 3.1

West Weaver Creek Recent Fire History

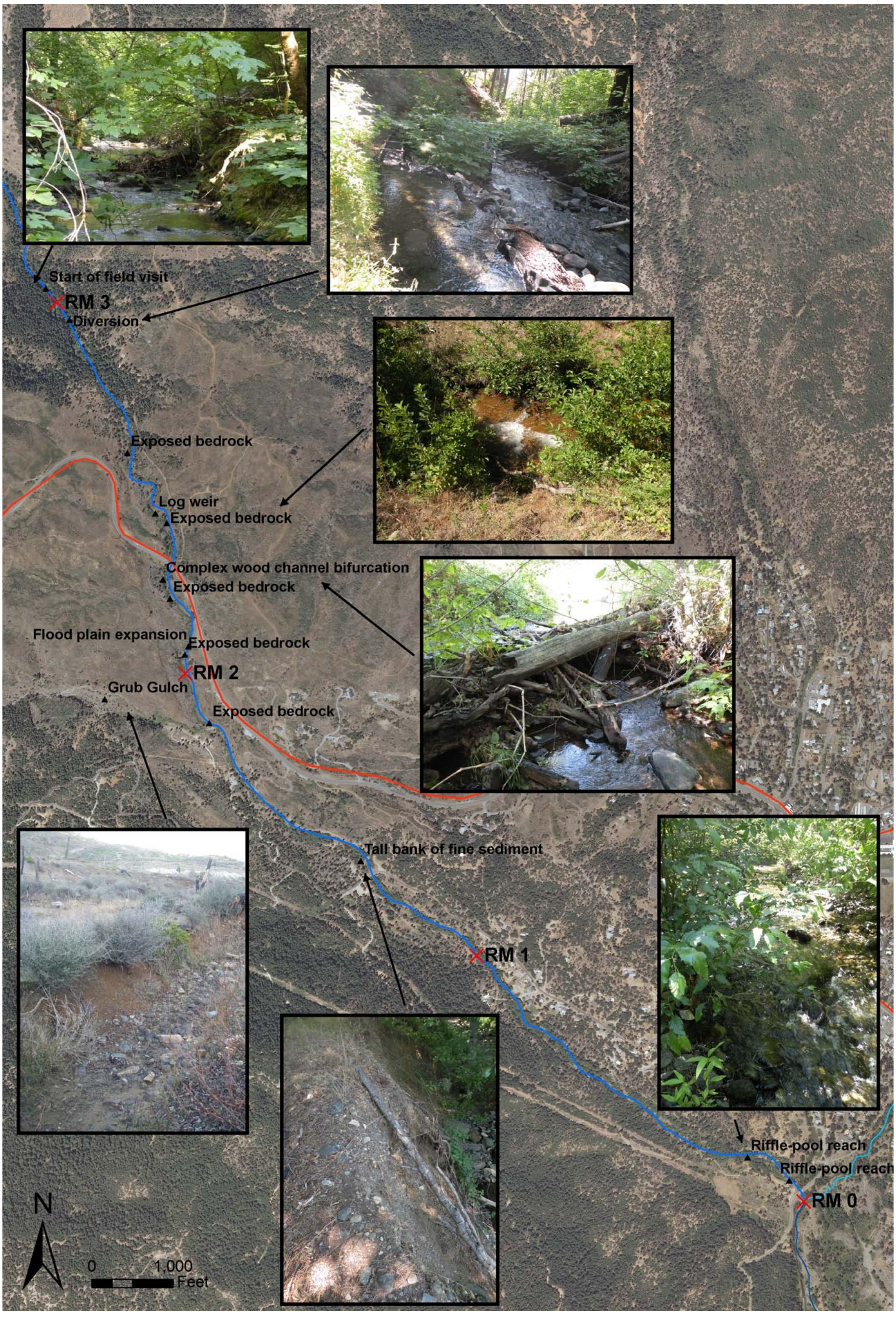


SOURCE: USGS EROS (1998), USDA NAIP (2003 and 2010)

West Weaver Creek Assessment and Action Planning

Figure 3.2

Affects of the Oregon (2001) and Junction (2006) Fires
Aerial Photo Time Series



SOURCE: Photos and notes by ESA PWA. Aerial image from USDA NAIP (2010).

West Weaver Creek Assessment and Action Planning

Figure 5.1

Initial Field Reconnaissance Notes and Photos

August 2011

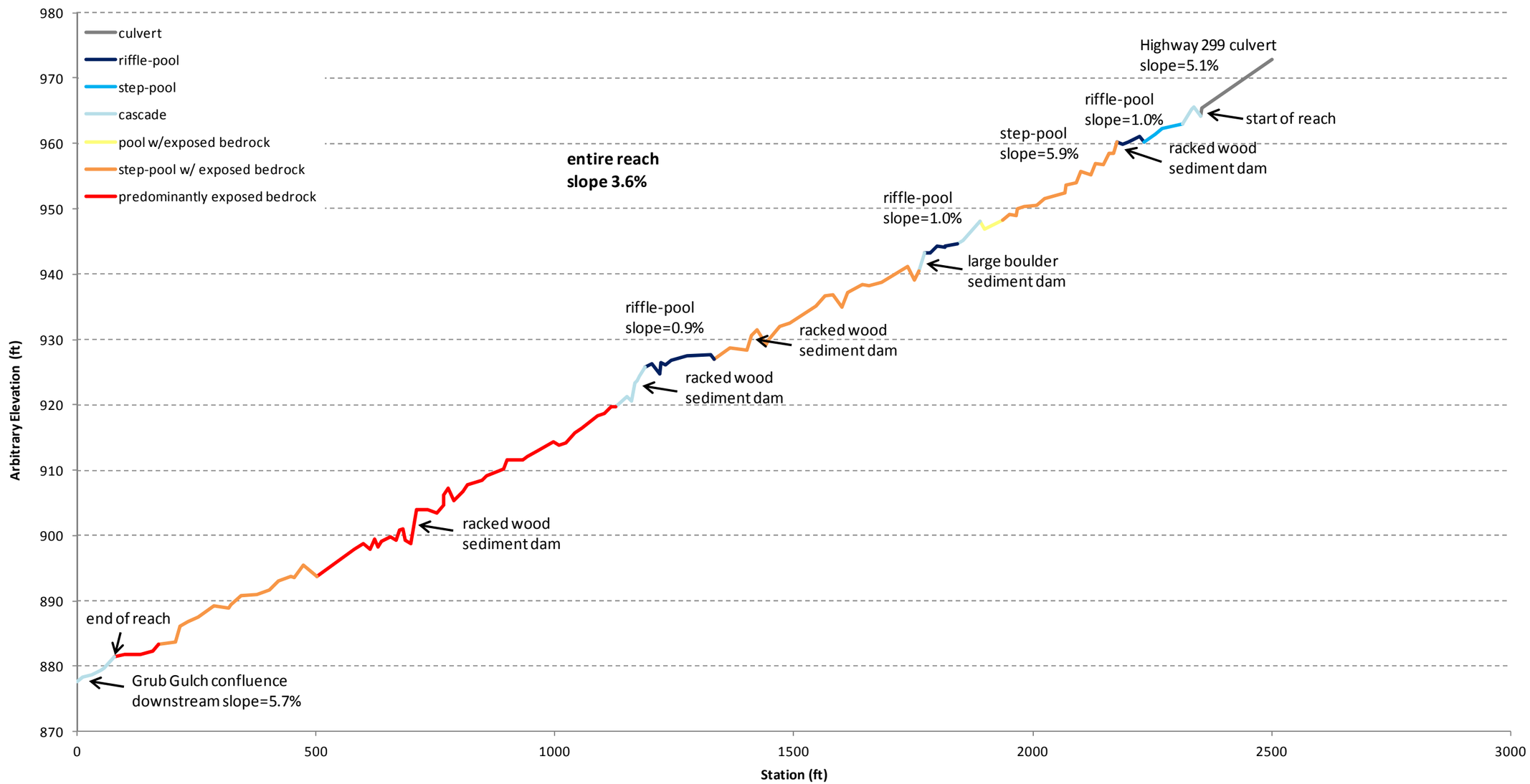
December 2011

SOURCE: ESA PWA. Photos taken looking upstream. Note water surface well below 1 foot tall baffles during the different seasons.

West Weaver Creek Assessment and Action Planning

Figure 5.2

Highway 299 Box Culvert and Fish Passage Baffles

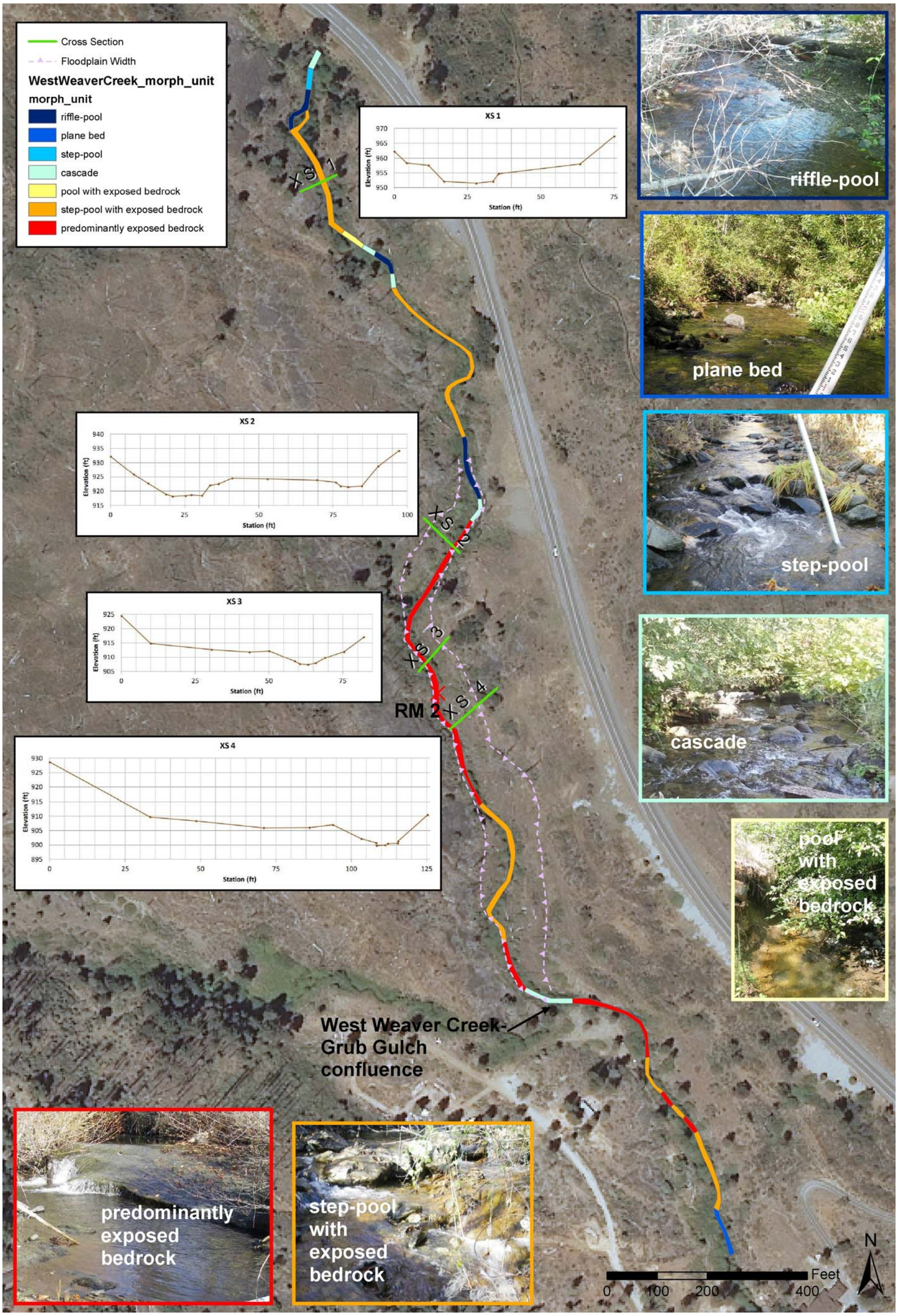


SOURCE: Longitudinal profile of creek thalweg surveyed 11/30/11 by ESA PWA in arbitrary coordinates.

West Weaver Creek Assessment and Action Planning

Figure 5.3

Surveyed Longitudinal Stream Profile of Focus Reach

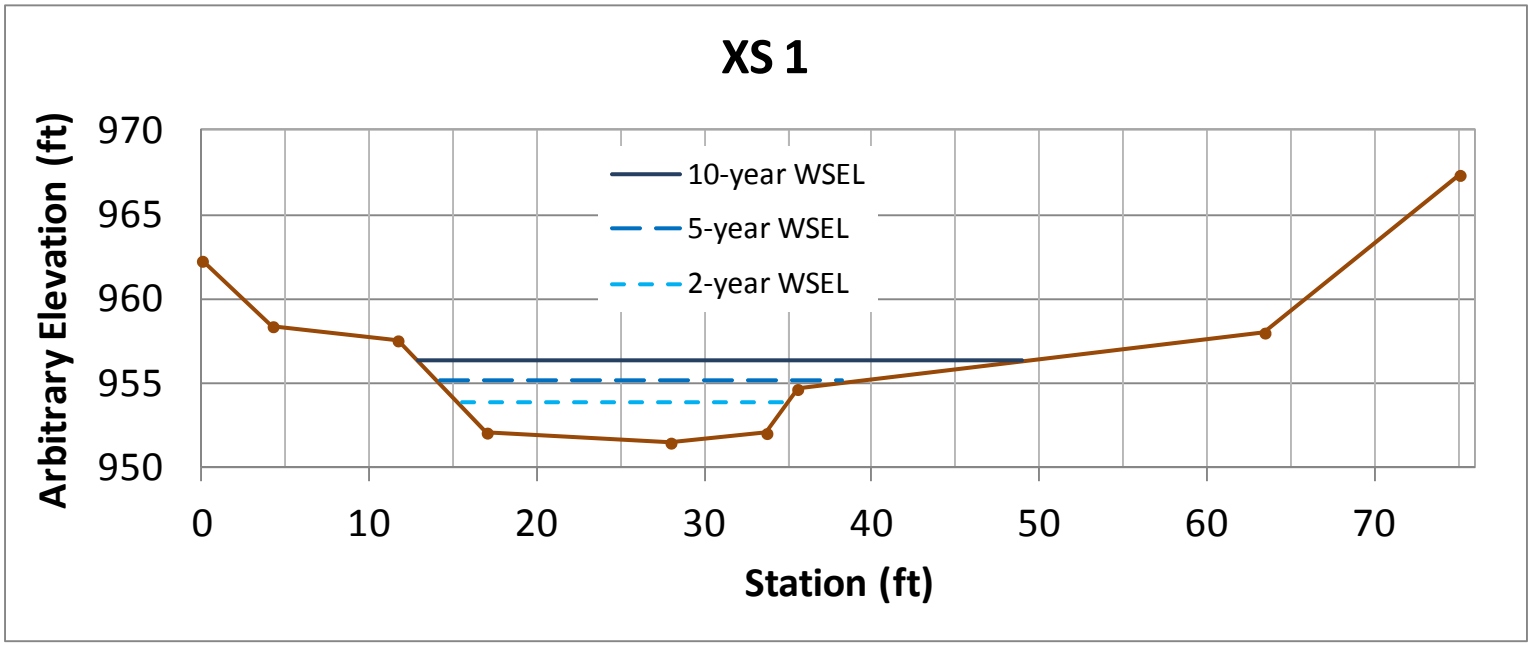


SOURCE: Detailed field assessment conducted 10/10/2011 and 11/30/11 by ESA PWA. Surveyed cross sections looking downstream.

West Weaver Creek Assessment and Action Planning

Figure 5.4

Detailed Field Reconnaissance of Focus Reach

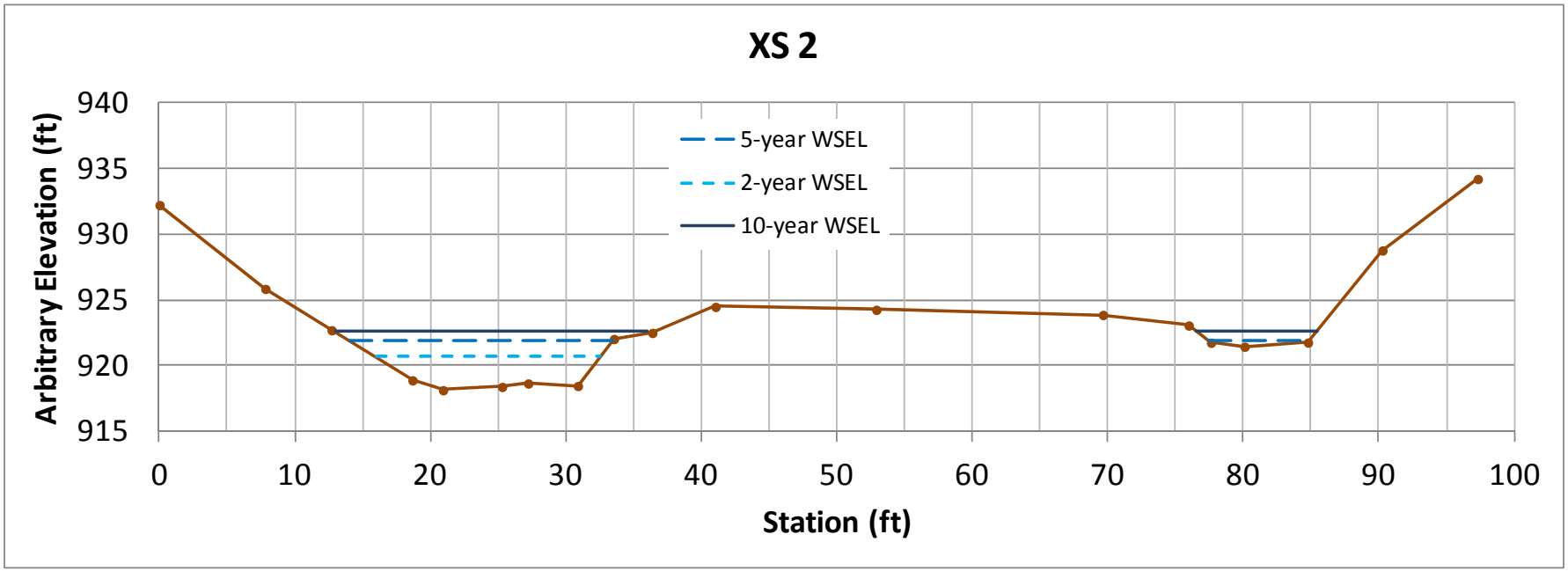


SOURCE: Cross section surveyed looking downstream 11/30/11 by ESA PWA in arbitrary coordinates.
NOTE: Cross section shows the 5-year nearly contained within the channel.

West Weaver Creek Assessment and Action Planning

Figure 5.5a

West Weaver Creek Hydraulic Analysis
Focus Reach: Cross Section 1

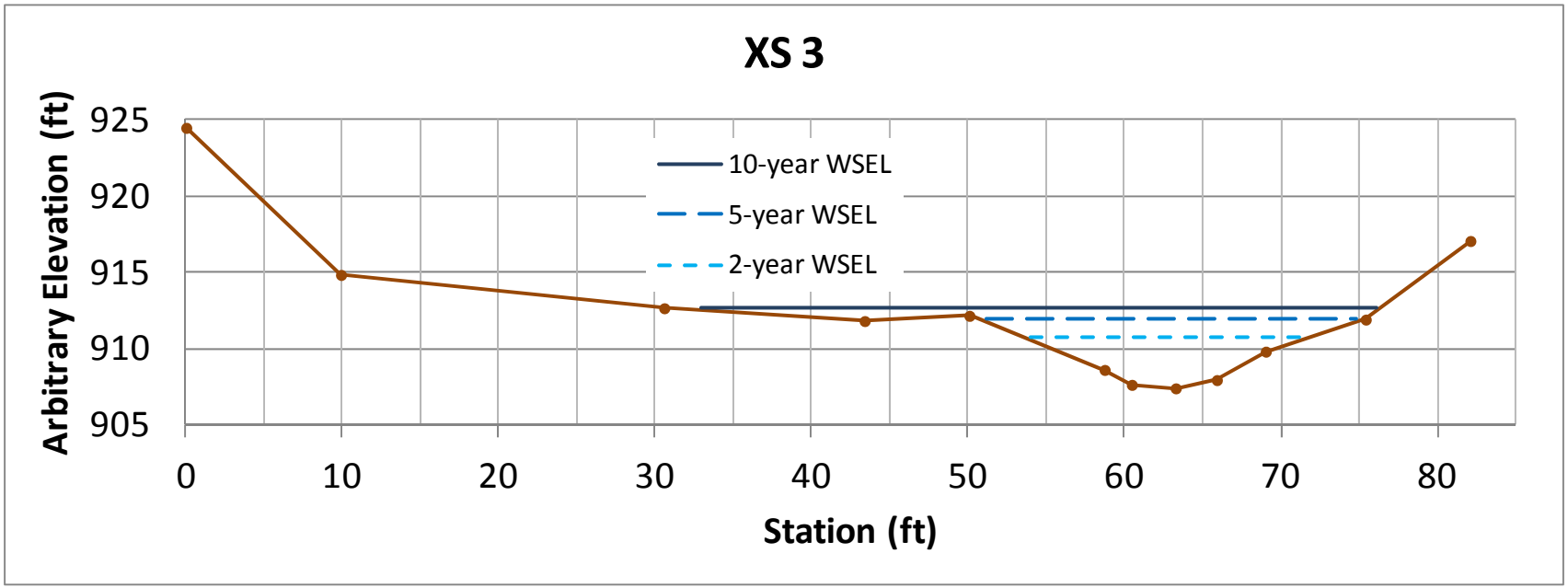


SOURCE: Cross section surveyed looking downstream 11/30/11 by ESA PWA in arbitrary coordinates.
NOTE: Cross section shows the 10-year nearly contained within the channel.

West Weaver Creek Assessment and Action Planning

Figure 5.5b

West Weaver Creek Hydraulic Analysis
Focus Reach: Cross Section 2

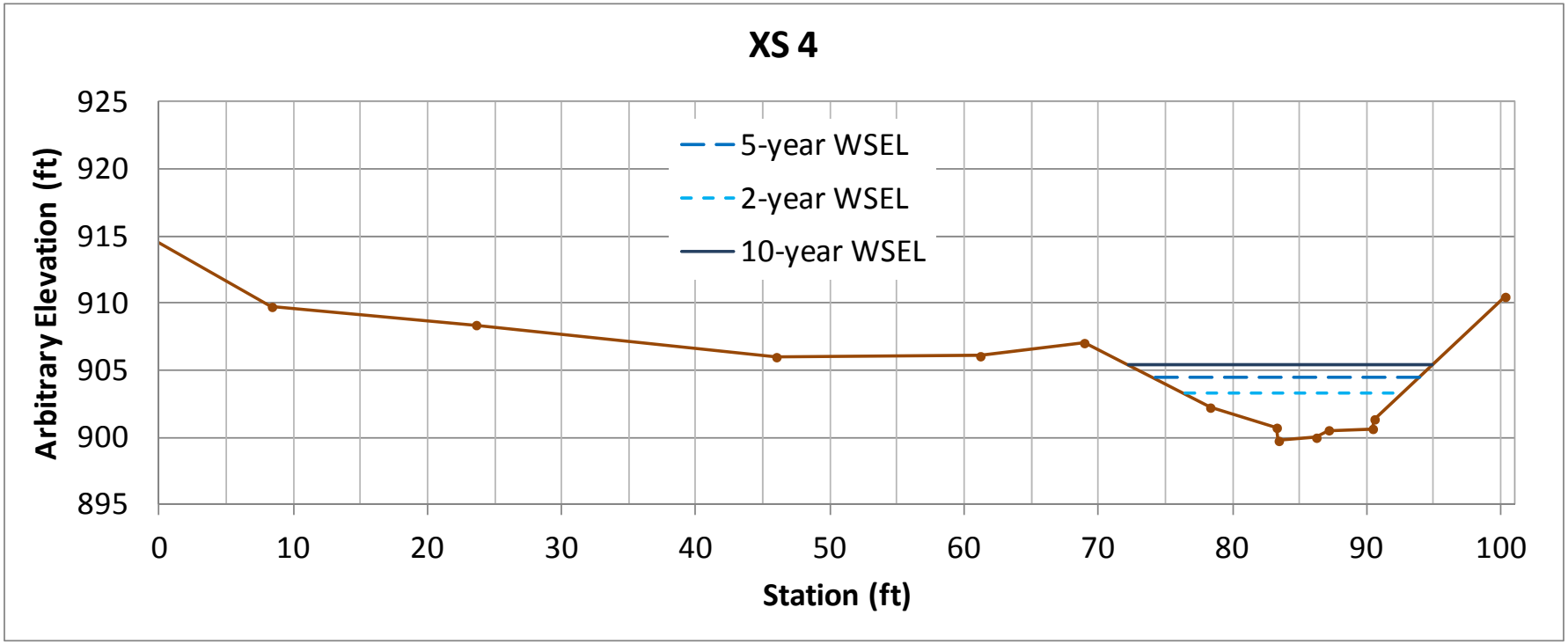


SOURCE: Cross section surveyed looking downstream 11/30/11 by ESA PWA in arbitrary coordinates.
NOTE: Cross section shows the 5-year fully contained within the channel.

West Weaver Creek Assessment and Action Planning

Figure 5.5c

West Weaver Creek Hydraulic Analysis
Focus Reach: Cross Section 3

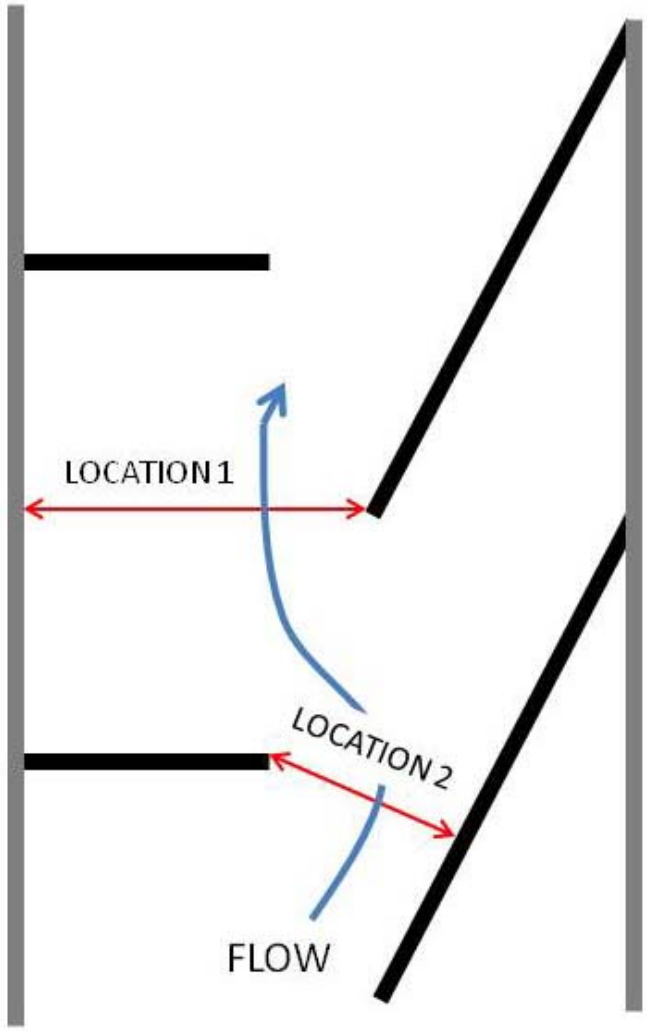


SOURCE: Cross section surveyed looking downstream 11/30/11 by ESA PWA in arbitrary coordinates.
NOTE: Cross section shows the 10-year fully contained within the channel.

West Weaver Creek Assessment and Action Planning

Figure 5.5d

West Weaver Creek Hydraulic Analysis
Focus Reach: Cross Section 4

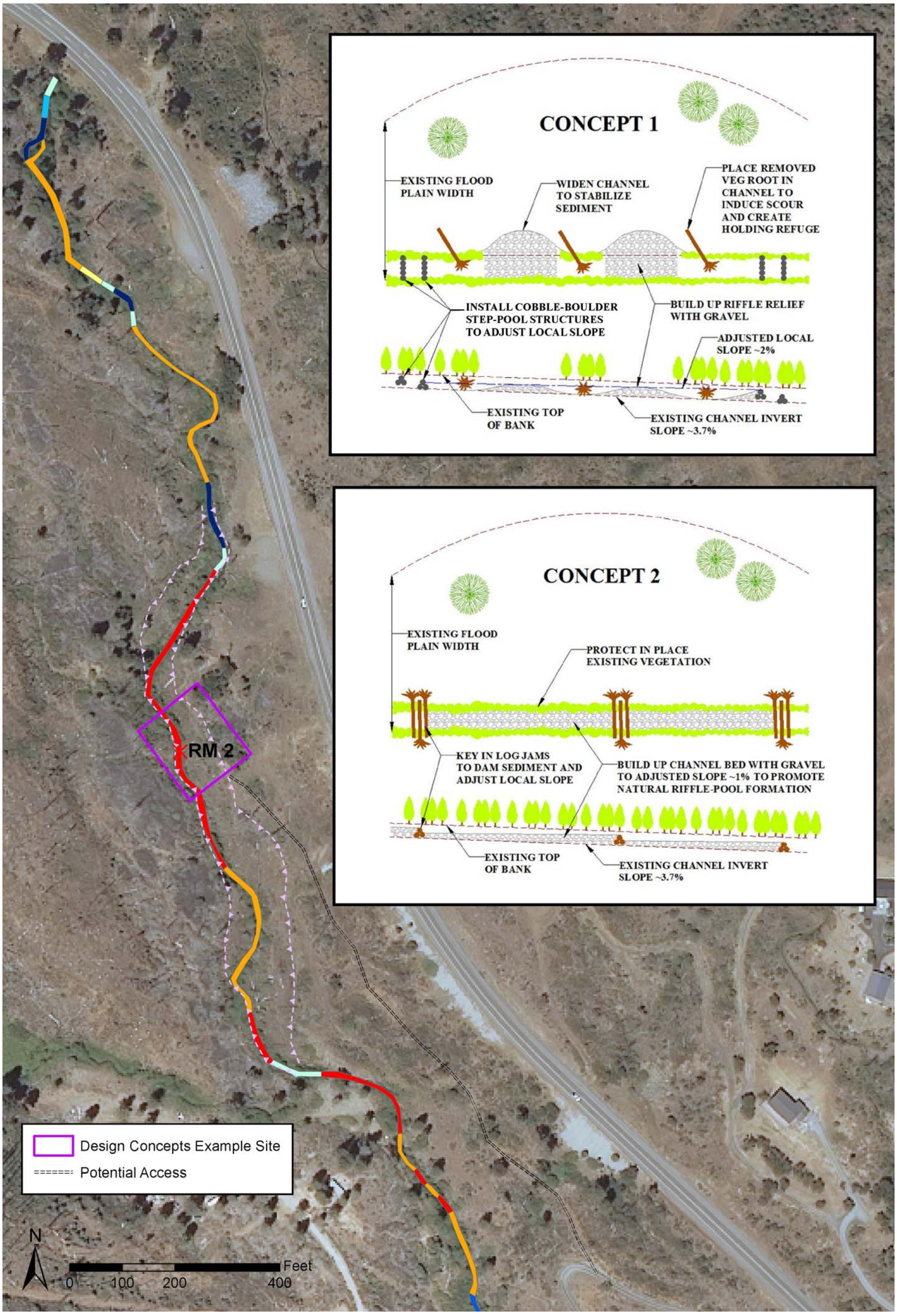


NOTE: Fish passage baffles shown in black, culvert sides in gray, flow path in blue, and locations of hydraulic analysis in red.

West Weaver Creek Assessment and Action Planning

Figure 5.6

Highway 299 Box Culvert Baffles
Hydraulic Analysis Locations



NOTES: Concept 1 and Concept 2 are two possible alternatives for the location delineated by the purple box.
A combination of the two the concepts is also an option.

West Weaver Creek Assessment and Action Planning

Figure 7.1

Conceptual Design Alternatives for the Focus Reach

Weaverville Watershed Analysis

Shasta-Trinity National Forest
Trinity River Management Unit
March 2004

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INTRODUCTION

The Purpose of Watershed Analysis

Watershed analysis (WA) is a procedure used to characterize the human, aquatic, riparian, and terrestrial features, conditions, processes and interactions (collectively referred to as "ecosystem elements") within a watershed. Watershed analysis is an important component of the Aquatic Conservation Strategy (ACS) along with Riparian Reserves, Key Watersheds, and watershed restoration. It provides a systematic way to understand and organize ecosystem information. In doing so, watershed analysis enhances our ability to estimate direct, indirect and cumulative effects of our management activities on ACS objectives and guide the general type, location and sequence of appropriate management activities within the watershed.

In planning for ecosystem management and establishing Riparian Reserves to protect and restore riparian and aquatic habitat, the overall watershed condition and the array of processes operating there need to be considered. Watershed condition includes more than just the state of the channel and riparian area. It also includes the condition of the uplands, distribution and type of seral classes of vegetation, land use history, effects of previous natural and land-use related disturbances and distribution and abundance of species and populations throughout the watershed.

The watershed analysis is not a decision document; its purpose is to provide an information baseline to evaluate the existing conditions in terms of the desired conditions. The WA provides existing condition information to enable identification and prioritization of appropriate project opportunities that would enhance, maintain, or improve the landscape conditions in order to achieve or move toward the desired conditions of the land allocations given by the Shasta-Trinity Land and Resource Management Plan.

Watershed analyses are conducted by a team of journey-level specialists who are guided by the process outlined in *"Ecosystem Analysis at the Watershed Scale – Federal Guide for Watershed Analysis"*. This process is issue driven.

Focus of This Watershed Analysis

The focus of this analysis is vegetation condition as it relates to fuel loading, water quality, aquatic habitat, wildlife habitat, and soil productivity. The WA will provide information on the current condition in these watersheds as well as the desired condition based on the Land and Resource Management Plan (LRMP). This watershed analysis will focus lands within this watershed that are administered by the Shasta Trinity National Forest.

Format of the Document

This document is organized into five chapters.

Chapter 1 – Characterization of the Watershed: This chapter provides a brief overview of the dominant physical, biological and human processes or features of the watershed that affect ecosystem functions or conditions. It includes the most important land allocations, Forest Plan objectives and regulatory constraints that influence resource management in the watersheds. The watershed context is used to identify the primary ecosystem elements that will be analyzed in detail.

Chapter 2 – Issues and Key Question: This chapter provides the key elements of the ecosystem that are most relevant to the management questions or objectives, human values, or resource conditions within the watersheds. These issues and key questions are developed by the team and District Ranger.

Chapter 3 – Current Conditions: This chapter addresses the dominant physical, biological and human processes or features of the watershed that affect ecosystem functions or conditions relevant to the issues and key questions identified in Chapter 2. The current range, distribution and condition of these ecosystem elements are documented.

Chapter 5 – Desired Conditions: This chapter presents desired conditions of specific ecosystem elements based on the LRMP and professional judgment.

Chapter 5 – Management Opportunities to Meet Desired Conditions: This chapter summarizes the opportunities to move from existing conditions to the desired conditions identified in the Forest Plan or this Watershed Analysis.

CHAPTER 1
CHARACTERIZATION OF THE WATERSHEDS

This chapter provides a brief overview of the Weaverville watershed in terms of the dominant physical, biological and human processes that affect ecosystem function or condition. These processes will be covered throughout this analysis.

Physical Setting

Location

The watershed analysis area encompasses 53,646 acres: 29,463 acres are within the National Forest Boundary. The Weaver and Rush Creek watersheds are located in northwestern Trinity County, California, on the Trinity River Management Unit of the Shasta-Trinity National Forest. The community of Weaverville is within this watershed.

Climate

The climate of the Weaverville watershed is Mediterranean; hot and dry in the summer with temperatures occasionally above 100°F, and cold and wet in the winter with temperatures often below freezing. Winter storms are usually brought in from the Pacific on south to southwesterly winds. Snow frequently accumulates above 4,000 feet elevation during the winter months. Elevations between 3,000 feet to 4,000 feet are frequently subjected to rain on snow events. Mean annual precipitation varies between 70 inches in the upper portions of the watershed to nearly 40 inches at the lower end. About 90 percent of the precipitation falls between October and April, with snow usually remaining at higher elevations through May or June.

Terrestrial System

Fire and Fuels

Wildfires are a critical component in the development and maintenance of western ecosystems, especially within the forests dominated by Douglas fir in the northern Klamath Mountains. Forests are shaped by distinct ecological processes that are driven largely by climate and topography. Historically, frequent low-intensity wildfires played a major role in determining the dispersion and succession of tree stands in the interior west.

The most extensive and serious problem related to the health of national forests in the interior west is the over-accumulation of vegetation, which has caused an increasing number of large, intense, uncontrollable, and catastrophically destructive wildfires. Significant portions of this watershed are within the Wildland Urban Interface (WUI) and fuels conditions within the WUI are a primary focus of this analysis.

Vegetation

The Weaverville watershed, like most of the area in the central part of the Forest, is dominated by conifer forests and mixed conifer/hardwood forests. The primary disturbance agents in this watershed have been mining, logging, urbanization, fire, and recreation.

Plant Species of Concern

Habitats for species of concern include mid- to late-seral forests, rock outcrops, perennial riparian areas, and tree canopy openings. There are no documented populations of Sensitive or Survey and Manage plant species within the analysis area, primarily because of the lack of historical surveys.

Wildlife Species

Wildlife species known to occur within the Weaverville watershed include federally listed and Forest Service sensitive species based on current records. The area is an important wintering are for the Weaverville deer herd.

Aquatic System

Water Quality

The important water quality parameters that most influence the beneficial uses for the Weaverville watershed are sediment and turbidity. Several streams within the Weaverville watershed are used as domestic water supply for residents of Weaverville and Rush Creek areas.

The Trinity River is listed as sediment limited by Environmental Protection Agency (EPA) under the Clean Water Act section 303(d) and the Weaverville watershed is included within the Maximum Daily Load (TMDL) listing.

Fish Species

The fishes include anadromous fall Chinook salmon, winter steelhead trout, coho salmon, and resident rainbow trout and brook trout. The Southern Oregon Northern California Coastal (SONCC) Coho salmon have been listed as threatened under the Endangered Species Act (ESA). All stream areas accessible to anadromous fish have been listed as critical habitat. Due to the long-term overall decline of Chinook and steelhead runs, the Pacific Southwest Region of the Forest Service has put them on a regional sensitive species list to help ensure that Forest Service activities do not result in a trend towards listing them under the ESA.

Land Allocations and Management Direction

Planning direction for the Shasta Trinity National Forest is covered in the 1995 Shasta-Trinity National Forest Land and Resource Management Plan (LRMP). The LRMP

incorporated the direction in the Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl, or ROD, as it is commonly known.

Management Direction

The Shasta-Trinity National Forest is divided into 22 management areas. The LRMP defines desired future conditions and management prescriptions within each management area. The Weaverville watersheds fall within Management Area 4, Trinity Alps Wilderness, and Management Area 7, the Weaverville/Lewiston Management Area.

Land Allocations

Table 1-1 summarizes the land allocations for this watershed, Map 1 displays where these land allocations occur spatially.

Weaverville Watershed

Management Area	Acres
Wilderness	9,449
LSR	1,793
Matrix	742
Adaptive Management Area (AMA)	10,282
Other (Private/BLM)	31,380
Total	53,646

Wilderness

A portion of the Trinity Alps Wilderness is within the Weaverville Watershed area. Wilderness areas are managed according to the Wilderness Act of 1964, the California Wilderness Act of 1984, and regulations pursuant to those acts and the Forest Service Manual. The Wilderness area is managed to preserve the integrity of the wilderness resources.

Late-Successional Reserve (LSR)

A portion of the Weaverville watershed area is located within Late-Successional Reverse (LSR). Late-Successional Reserves are to be managed to protect and enhance late-successional and old growth forest ecosystems, which serve as habitat for late-successional and old-growth dependent species.

Adaptive Management Area (AMA)

A portion of the Weaverville watershed is within the Hayfork Adaptive Management Area. The emphasis of this AMA is development, testing, and application of forest management practices, including partial cutting, prescribed burning, and low impact approaches to forest harvest, which provide for a broad range of forest values, including

commercial timber production and provision of late-successional and high quality riparian habitat.

Aquatic Conservation Strategy Components

Riparian Reserves (RR)

Riparian Reserves are designated under the ACS for all permanently flowing streams, lakes, and wetlands as well as intermittent and ephemeral channels. Riparian Reserves are present along stream channels throughout the analysis area, and occur across all land allocations. Riparian Reserves are to be managed to provide benefits to riparian associated species, improve travel and dispersal for many terrestrial animals and plants, and provide for habitat connectivity within the watershed. The Riparian Reserves also serve as corridors to connect Late Successional Reserves.

Human Uses

Communities

The communities of Weaverville, Rush Creek and dispersed neighbors are within the influence of the analysis area. The main industries are service, tourism associated with recreation, forest products, local branches of state, county, and federal agencies.

Transportation System

The transportation system in the analysis area is made up of roads and trails that provide access for motorized and non-motorized vehicles, livestock, and foot traffic. The road system in this watershed consists of state highways, county roads, arterial routes, collector routes, and a series of local spur roads.

Recreation Resources

Outdoor recreation in the area consists of a variety of opportunities. Opportunities in or adjacent to the Weaverville Watershed include hiking, OHV, mountain biking, hunting, swimming, and wildlife observation. Other opportunities in the area include camping, backpacking, kayaking, rafting, picnicking, fishing, and scenic driving.

CHAPTER 2
ISSUES AND KEY QUESTIONS

The purpose of this chapter is to focus the analysis on the key elements of the ecosystem that are most relevant to the management questions, human values, and resource conditions within the Weaverville watershed.

Six issues critical to the future management of this watershed were identified. They are:

- Issue #1: Human Uses, Values, and Expectations
- Issue #2: Access and Travel Management
- Issue #3: Erosional Processes
- Issue #4: Aquatic Systems
- Issue #5: Terrestrial Wildlife Habitat and Species
- Issue #6: Fire, Fuels, and Air Quality
- Issue #7: Plant Communities

The following is a broader description of each issue accompanied by key questions pertaining to the issue.

Issue #1: Human Uses, Values, and Expectations

Recreation

Key Question 1.1 What are the major recreation resources and uses of the watershed? What is the condition of these resources?

Outcome 1.1 Identify recreation areas. Identify potential recreation opportunities. Determine management practices that would restore or improve recreation opportunities.

Wood Products

Key Question 1.2 Are there areas with timber harvesting opportunities that would contribute to ecosystem management objectives?

Outcome 1.2 Identify areas for applying timber management practices that would result in a benefit to ecosystem management.

Key Question 1.3 Are there existing fuel wood opportunities within the watersheds? Are there areas that fuel wood opportunities may be developed?

Outcome 1.3 Identify areas that may be opened to fuel wood gathering or areas that fuel wood projects may be developed.

Issue #2: Access and Travel Management

Key Question 2.1 What are current trail conditions? What actions can be taken to provide access to the forest and protect the natural resources? Should some trails be closed and abandoned from the trail transportation system?
Outcome 2.1 Identify the level of trail maintenance necessary to protect the natural resources, and provide recreational opportunities. Determine management practices that would protect the natural resources, and provide trail access for recreation. Identify trails that could be abandoned and removed from the system.

Key Question 2.2 What role does the transportation system play in access to the area? Are there areas that would benefit from increased or decreased access?
Outcome 2.2 Identify roads of concern to local and extended users. Assess current condition of roads. Identify the road system necessary to serve management needs.

Issue #3: Erosional Processes

Geology, Hydrology, and Soil Resources

Key Question 3.1 What mass wasting processes are inherent within the watershed? What management actions, if any, would protect soil and water resources.
Outcome 3.1 Identify predominant mass wasting features, the delineation of priority treatment areas and appropriate techniques to protect riparian and soil resources.

Key Question 3.2 What soil erosion processes are occurring in the analysis area? What is the soils' sensitivity to erosion?
Outcome 3.2 Identify predominant soil erosion areas, the delineation of priority treatment areas and appropriate techniques to protect riparian and soil resources.

Key Question 3.3 What is the current level of Cumulative Watershed Effects? Are there any subwatersheds that area at or near threshold of concern?
Outcome 3.3 Identify areas where management actions may be modified to protect watershed function or where restoration actions are needed.

Issue #4: Aquatic Systems and Species

Key Question 4.1 What is the relative abundance and distribution of anadromous fishes in the watershed? What is the condition of aquatic habitats?
Outcome 4.1 Identify trends of anadromous fish populations and their distribution. Identify priority treatment areas and appropriate techniques to protect and/or improve fish habitat.

Issue #5: Terrestrial Wildlife Habitat and Species

Key Question 5.1 What is the amount and condition of Late Successional Old Growth (LSOG) habitat within these watersheds?
Outcome 5.1 Identify the amount and quality of LSOG habitat within these watersheds. Identify priority treatment areas (if any) and appropriate techniques to protect and/or improve LSOG habitat.

Key Question 5.2 What is the amount and condition of winter range deer habitat within the Watershed and within the Browns Integrated Project Area?
Outcome 5.2 Identify the amount and quality of deer habitat within these watersheds. Identify priority treatment areas (if any) and appropriate techniques to protect and/or improve deer habitat.

Issue #6: Fire, Fuels, and Air Quality

Key Question 6.1 What is the degree of threat from wildfires to local communities? How can the Fire Safe Council recommendations be implemented to reduce the treat of wildfires to local communities?
Outcome 6.1 Determination of the level of threat to local communities and identification of projects to reduce the threat. Identify fuels management projects that would reduce the threat of wildfires to local communities.

Issue #7: Plant Communities

Key Question 7.1 How have human-caused activities altered plant communities and lead to changes in plant species of concern?
Outcome 7.1 Identify plant populations and plant communities with restoration needs.

Key Question 7.2 What are the abundance and the distribution patterns of invasive weeds?
Outcome 7.2 Determine invasive weed treatment priorities.

CHAPTER 3
CURRENT CONDITIONS

This chapter describes the current conditions of the various physical, biological, and human ecosystem elements in the Weaverville watersheds relevant the issues and key questions identified in Chapter 2. The information provided here will provide a more detailed analysis of the watersheds than did the characterization in Chapter 1.

1. Human Uses, Values, and Expectations

1.1 CURRENT RECREATION RESOURCES AND USES

The primary recreation resource of the watershed is the open space setting with the forest, mountains and streams. The road and trail systems are other major recreation resources, along with the East Weaver Campground.

Travel is a major recreation use, including motorized touring on forest roads and off-highway vehicle travel on forest roads, unclassified roads, system trails, and unclassified trails. Non-motorized travel with hiking, biking and horseback riding on system and unclassified trails is also very popular. Historical interpretation, exploring nature, bird watching and wildlife viewing are favored pastimes of many forest visitors. Fishing, hunting, target shooting, and paintball games are popular activities. In addition, both dispersed camping and developed site camping and relaxation are favorite recreation ventures.

The Weaverville Basin has been heavily impacted from mining, logging, and road construction, and is undoubtedly in worse condition than it was 150 years ago. However the forest ecosystem is resilient, and as the sun shines and the birds sing, it remains an outstanding opportunity for recreation. Recreation is not without its impacts and there are specific sites in the watershed that require mitigation and repair from recreation use. OHV use tramples vegetation and causes erosion, and represents unmanaged recreation – one of the four items to address on the Chief's Agenda.

1.2 CURRENT TIMBER HARVESTING OPPORTUNITIES

The Weaverville watershed is dominated by mixed conifer timber stands, primarily consisting of Douglas fir. Current timber harvesting opportunities that would contribute to ecosystem management objectives are available on Forest Service land outside of the wilderness, as displayed on the following table.

Table 3-1. Current timber-producing National Forest land within the Weaverville Watershed.

Conifer dominated stands	Late Successional Reserve (LSR)	Wildlife Management Emphasis	Roaded Recreation Emphasis	Total Acreage Available	Wilderness Area
Young conifer plantation or seedling	76 ac.	0 ac.	909 ac.	985 ac.	0 ac.
Pole-size conifer	373 ac.	0 ac.	1,573 ac.	1,946 ac.	961 ac.
Early or mid-mature conifer	769 ac.	231 ac.	4,959 ac.	5,959 ac.	4313 ac.
Mature or old growth conifer	348 ac.	0 ac.	630 ac.	978 ac.	977 ac.
Total	1,566 ac.	231 ac.	8,071 ac.	9,868 ac.	6,251ac.

Table 3-1 displays the acreages National Forest conifer stands existing within the Weaverville Watershed. The 6,251 acres of timbered wilderness lands are not available for harvesting; the 1,566 acres of LSR may be harvested to a limited degree where harvesting is expected to enhance desired old growth conditions and/or protection. The 8,302 acres of wildlife management and roaded recreation emphasis areas are available for timber harvesting to a greater degree providing consistency with LRMP ecosystem management objectives.

The 985 acres of young conifer plantations and seedlings are the result of previous timber harvest activities, which included regeneration harvests followed by planting Douglas-fir and ponderosa seedlings in the clearcut units. These plantations are densely stocked with conifers, averaging over 250 trees/acre. In addition, brush species and grasses have occupied the spaces between the plantation trees resulting in reduced conifer growth due to competition for water and other soil nutrients.

The 1,946 acres of pole-sized conifer stands include both older plantations and natural stands. Generally, these pole-sized stands are very dense, with 1,754 acres (90%) identified as having crown closures of over 70%. Timber production on these stands is reduced due to inter-tree competition.

The early or mid-mature conifer component is the dominant vegetative type represented within the Weaverville watershed, comprising about 60% of the timbered acreage. Similar to the pole-sized stands in that the densities are generally high, about 53% of these stands (3,167 acres) have crown closures of over 70%. Likewise, timber production is reduced due to inter-tree competition; but unlike the pole-sized stands, these early or

mid-mature stands are currently available for timber harvesting opportunities due to the larger (over 12” dbh) size of the individual trees.

Mature or old growth conifers occupy about 10% (978 acres) of the available National Forest timberland within the Weaverville watershed. These older stands are currently suitable for timber harvest opportunities, but may not be available for timber harvesting due to ecosystem management objectives of other resources.

1.3 CURRENT FUELWOOD OPPORTUNITIES

The Weaverville watershed is adjacent to the community of Weaverville and has traditionally been heavily used by woodcutters as a prime fuel wood collecting area. Since the area is dominated by mixed conifer timber stands, woodcutters use the existing road system to access dead and down trees whenever the roads are open for travel. In addition, numerous “user-created” roads have been pioneered to access fuel wood since demand for fuel wood apparently exceeds the supply available on the existing road system.

Most of the 9,868 acres of the available conifer forest land outside of the wilderness is roaded; however, only the strips of land bordering the roads offer reasonable fuel wood gathering opportunities. There is no opportunity for fuel wood collecting in the wilderness.

2. Access and Travel Management

2.1 CURRENT TRAIL CONDITIONS

The current trail conditions in the watershed vary from good to poor. The trails in the Weaver Basin Trail system are generally in good condition, but in need of improvement in some aspects. The trails in the Weaver Basin Trail system are maintained in partnership with the Resource Conservation District and the Weaver Basin Trail Committee. User-created trails are more often in poor condition, receive little, if any maintenance, and cause resource damage.

Motorized use on non-motorized designated trails is a conflict both to user expectations and user safety. OHV use on user-created trails is widespread and represents unmanaged recreation.

The Weaver Basin Trail system commonly traverses ‘soft’ clay soils and during late fall, winter, and early spring the tread is wet and unstable, and undesirable for travel. The trail crossings at some drainages have culverts that are functionally inadequate, and some have non-standard bridge structures.

Access to the Weaver Basin Trail system can be improved with an additional entry point between downtown Weaverville and East Weaver Creek. A limited OHV trail system can be developed on Musser Hill, using roads recommended for decommissioning, existing

user-created trails, and a short segment of new trail construction. Most user-created OHV trails (unclassified trails) in the watershed can be decommissioned. A program of education, signing, and enforcement can be implemented to change existing use and behavior.

2.2 CURRENT ROAD SYSTEM

See the Browns Roads Analysis for a discussion of road systems, conditions and management opportunities within the Weaverville watershed (Appendix A).

3. Erosional Processes

3.1 CURRENT MASS WASTING

Due to the incompetent nature of the rocks within this area, mass wasting has played a dominant role in shaping the geomorphology. Mass wasting features include deep-seated dormant rotational landslides and shallow stream headwall basins. In general deep-seated dormant landslide terrain dominates northeast-facing slopes while headwall basins dominate the southwest-facing slopes. This characteristic is no doubt due to higher moisture conditions within northeast facing landscapes. Although mass wasting features occur throughout the analysis area, their occurrence is less frequent in the Musser Hill area.

The major analysis area creek systems of Weaver, East Weaver, Browns, and Rush form the major transporters of rock debris and sediments produced through these mentioned geomorphic processes. Debris flow deposits presently occupy all of these creeks. In several instances the processes that contribute to mass wasting are presently active, in most however they are dormant (Map 2).

By far the greatest occurrences of mass wasting features within the analysis area are dormant rotational/translational slides (1056/1076). Movement of a coherent mass characterizes this type of slide over a discrete, broadly concave failure surface. Most slides have occurred in association with at least one of the following: serpentinized shear zones, faults, lithologic contacts, wet zones such as inner gorges and areas encompassed by the Weaverville geologic formation. The latter is almost always associated with landsliding activity. The highest danger for precipitating further sliding exists where surface or groundwater is associated with at least one of the former factors.

Internested rotational landslides (1250) occur in proximity to perennial and ephemeral drainages. These areas are somewhat stable if ground slopes remain under thirty-five percent. At greater slope gradients these slides are considered unstable. Such slides commonly creep gradually, but where undercut by a road or drainage will slide out rapidly.

Valley inner gorges (1260) are defined as those slopes adjacent to channel margins having gradients in excess of sixty-five percent. The valley inner gorge is formed through

mass wasting triggered by channel downcutting, oversteepening and undercutting. Valley inner gorges occur throughout the analysis area.

Associated with inner gorges are rock debris flows (1101) that can be found throughout the analysis area especially along Sidney, Munger, Five Cent, and Garden Gulches and Weaver, Browns, Rush Creeks and their tributaries. These along with inner gorges are active mass wasting process zones.

The slope stability hazards of the mass wasting features have been first stratified through photo-interpretation techniques and reconnaissance field study according to their potential to be activated by possible management activities. This is a subjective; relative rating meant only to *compare* different mass wasting features within the area and is not meant as a site-specific tool.

Extreme hazards are defined for all active slides, regardless of their type. Some extreme areas were found or delineated during the initial stratification (1251) along China Gulch and Highway 3 areas.

High hazards are defined for all valley inner gorges (1260). The area where the stream channel evolves to an inner gorge profile also has a relatively high stability hazard. This area marks the point of headward migration of the tributary inner gorge and is usually formed through debris sliding, debris avalanching, and debris torrents. The upslope migration of the tributary inner gorge is an on-going geologic process. The migrational process is active in many of the tributary streams. Considering the abundance of dormant slide features these zones should be considered highly sensitive to management practices. In addition, most debris slide/avalanche prone slopes (1111) are also assigned a hazard level of high. Some rotational landslide prone slopes west of Rush Creek are also in this category.

Moderate to high hazards are defined for some translational/rotational areas (1059/1079) and debris flow areas (1101/1103/1104). Within these areas it is judged that there can be a relatively high probability of initiating some 1,000-to 10,000 cubic-yard landslides through intensive management *without proper mitigation*.

Low to moderate hazards is defined for crown scarp areas of translational and rotational type landslides (1056/1076). Perennial streams are common in these areas and ephemeral channels also carry significant seasonal flows. Most mass wasting processes are presently dormant and should remain so until the inner gorge zone migrates into these areas. Within these areas there is potentially a risk of initiating 100 to 1,000 cubic-yard headward-working rotational landslides through management without proper mitigation.

It should be noted that this zonation method is generalized. The possibility thus exists of differing hazard levels occurring within these general zones.

3.2 CURRENT SOIL EROSION

Soils within the watershed area have predominately formed in metavolcanic and metasedimentary residuum on the upper mountain sideslopes and ridges. Soils formed in these areas are generally shallow (less than 20 inches) to moderately deep (20 to 40 inches) loams to gravelly and very gravelly clay loams (Chaix, Chawanakee, Deadwood, Holland, Marpa, and Neuns soils). Soils formed in nonmarine sediments are moderately deep to very deep (greater than 60 inches), (Forbes, Soulajule, and Xerofluvents) (Table 3-2).

Table 3-2. Major Soils Information.

Soil Series	Map Units	Depth	Parent Material	Surface Texture	Clay %	Rock Frags	Burn Damage	Erosion Hazard
Chaix	18, 21, 25	MD	G	cosl	8-12	10-15	severe	H/14
Chawankee	25, 27	S	G	gsl	8-18	10-20	high	H/13
Deadwood	34, 35	S	MS	vgsl	10-20	50-85	moderate	M/7
Forbes	66, 67, 68	VD	NS	l	20-50	5-10	moderate	MH/12
Holland	21, 214	MD-D	MV	l	20-34	10-35	moderate	MH/12
Marpa	175, 218	MD	MS	gl	18-30	25-55	moderate	M/10
Neuns	34-5, 214 -18	MD	MV	vgl	10-25	40-60	moderate	M/8
Soulajule	304, 305	MD	NS	gl	20-45	10-40	moderate	MH/11
Xerofluvents	351	VD	NS	vcsl	4-10	50-90	low	L/2

Depth Classes:	Parent Material:	Soil Texture:	Erosion Hazard Rating:
S = shallow (10-20”) MD = mod deep (20-40”) D = deep (40-60”) VD = very deep (>60”)	G = granitic MS = metasediments MV = metavolcanics NS = nonmarine sediments	l = loam gl = gravelly loam vgl = very gravelly loam sl = sandy loam	L = low (<4) M = moderate (4 to 12) H = high (13 to 29)

Soil Cover/Erosion

Many land use activities have the potential to cause erosion rates to exceed natural soil erosion or soil formation rates. In order to assess the potential risk of a given soil to erode, an erosion hazard rating (EHR) was developed (R-5 FSH 2505.22). Many interrelated factors are evaluated in an EHR system to determine whether land use activities would cause accelerated erosion. The EHR system is designed to assess the relative risk of accelerated sheet and rill erosion. This rating system is based on soil texture, depth, clay percent, infiltration of soil, amount of rock fragments, surface cover (vegetative and surface rocks), slopes, and climate. Risk ratings vary from low to very

high with low ratings meaning low probability of surface erosion occurring. Moderate ratings mean that accelerated erosion is likely to occur in most years and water quality impacts may occur for the upper part of the moderate numerical range. High to very high EHR ratings mean that accelerated erosion is likely to occur in most years and that erosion control measures should be evaluated. These ratings assume varying amounts of vegetation cover depending on degree of vegetative management.

Analysis shows that most of the soils in this watershed area are moderately deep (20 to 40 inches) to shallow (< 20 inches) with areas of nonmarine sediments having deep and very deep (>40 inches) soils. Soil erosion levels are moderate to high depending on slope and cover (with soil cover greater than 50% on all slopes).

Low to moderate erosion hazard ratings insure soil erosion will not exceed the rate of soil formation. High to very high erosion hazard ratings indicate that soil erosion will exceed the rate of soil formation and site productivity will degrade if no erosion control measures are enacted. Maintaining soil cover to reduce erosion is the goal of the regional Soil Quality Standards (SOS, 1995), (see Appendix B for EHR determinations).

Soil Compaction/Porosity

About 800 acres of nonmarine sediment soil (Forbes, Holland, Soulejule series) are in a compacted state around Musserhill area just north of Weaverville (Map 3 hatched blue area). Soil Quality Standards (SQS) state that in an uneven-aged managed stand no more than 20% of the area shall be in a nonproductive state (landings, roads, main skid-trails) on matrix lands. Porosity (an expression of compaction) shall not decrease by 10% over background levels. In this 800 acres porosity exceeded threshold levels on 25 to 50% of the area (based on sampled line transects with a cone soil penetrometer and bulk density samples).

Soil Cover/Large Woody Debris

Cover transects indicate that the dominate cover is the 1 to 3 inch and the 3 to 20 inch class of woody material. Duff thickness ranged from ½ in on south-facing slopes to 3 inches on north-facing slopes. Average tons/ac for mixed conifer ranged from 10 to 16, for tree/brush stands from 8 to 12 and brush stands from 4 to 7. Large woody debris (LWD) ranged from 10 to 20 trees/ac for mixed conifer stands, for tree/brush stands it ranged from 4 to 8 trees/ac, and for brush areas 1 to 3 logs/ac old decayed class 4 and 5. SQS state that in areas of granitic soils cover should be maintained at 90% since these areas are highly erosive. For other soils, (metavolcanics, metasediments, nonmarine sediments) cover can range from 40 to 70% depending on erosion hazard rating for the particular soil. Overall, for this watershed, granitic soils need more soil cover on south and west facing slopes and nongranitic soils need more LWD on the south and west facing slopes.

Project Risk Assessment

By evaluating soil parent material type, depth, erosion hazard rating, and minimum slope a risk assessment map can be produced (Map 3). This map shows the areas of concern are the adjacent units west along the border of the Trinity Alps Wilderness and small granitic pluton that exists on the eastern border above Rush Creek. These areas are steep, shallow to moderately deep granitic and metasediment soils that have high erosion hazard ratings. These areas have sandy soil textures, low clay amounts and high burn damage risk. Other areas that have moderately high erosion hazard are the nonmarine sediment hills in and around Musser Hill. These areas are susceptible to sheet and rill erosion due to fine textures with lots of silt material. These soils are susceptible to compaction that changes the hydrologic function of the soil causing a decrease in infiltration and increased surface runoff (Map 3 and Appendix B).

If a catastrophic fire were to occur in the Weaverville Watershed severe erosion would occur on the granitic soils and the fine textured nonmarine sediments (see Appendix B, Soil Erosion Hazard ratings). Catastrophic fire would remove soil cover and cause organic matter destruction in the topsoil of the granitics. These factors would cause rill and gully erosion in the granitics and sheet and rill erosion in the nonmarine sediments. Erosion rates would be excessive (Appendix B), thus necessitating the need a for fuel reduction program in these areas to protect the resources.

3.3 CURRENT CUMULATIVE WATERSHED EFFECTS

Streams draining the analysis area are nested within the Upper-Middle Trinity River basin and directly contribute water and sediment to Rush, Little Browns, East Weaver, and West Weaver Creeks (Plate 1).

Beneficial Uses and Water Quality Objectives Within and Downstream of the Analysis Area: The designated beneficial uses for the Trinity River within the analysis area are established in the Water Quality Control Plan for the North Coast Region and are listed below (NCRWQCB, 1994):

- municipal and domestic supply (MUN);
- agricultural supply (AGR);
- groundwater recharge (GWR);
- freshwater replenishment (FRSH);
- hydropower Generation (POW);
- water contact recreation 1 and 2 (REC-1 and REC-2);
- commercial and sport fishing (COMM);
- cold freshwater habitat (COLD);
- wildlife habitat (WILD);
- migration of aquatic organisms (MIGR); and
- spawning, reproduction, and/or early development (SPWN).

The following is a list of the applicable water quality objectives that apply to the tributaries draining the Weaverville analysis area:

- general objective (anti-degradation);
- suspended material;
- settleable material;
- oil and grease;
- sediment;
- turbidity;
- pH;
- temperature;
- toxicity; and
- chemical constituents.

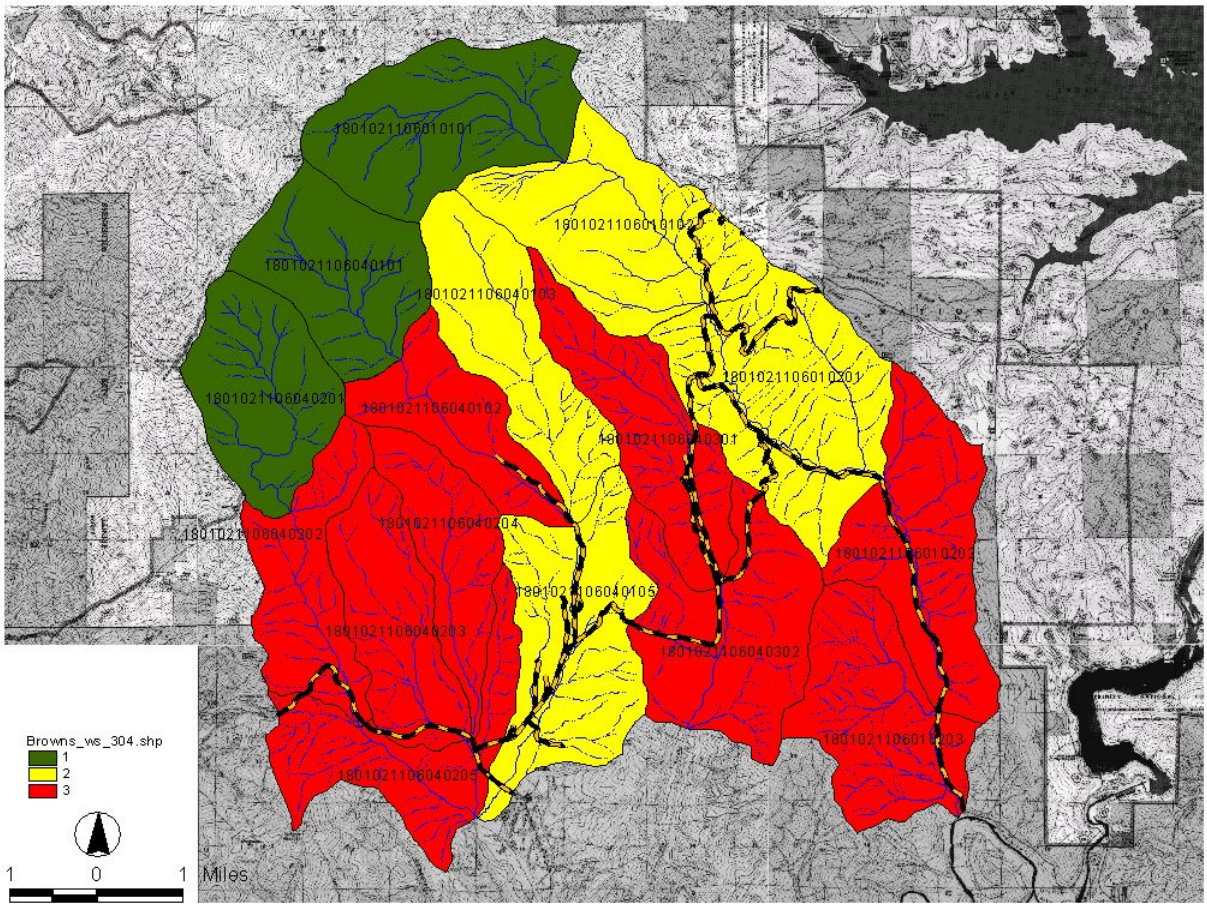


Plate 1. Map illustrating Weaverville Watershed Analysis subwatersheds and condition class.

These pollutants cannot be above a level that adversely effects human, plant, animal, or aquatic life (NCRWQCB, 1994). As a Water Quality Management Agency (WCMA) the Forest Service must demonstrate that proposed management activities will not further degrade local and regional water quality (USDA Forest Service, 2000). The main water quality concern for the analysis area is suspended and coarse sediment.

Trinity River Sediment TMDL: In 1992, the Trinity River watershed was listed as water quality impaired due to sediment under California's Clean Water Act Section 303(d) (NCRWQCB, 1994). A water quality management plan or Total Maximum Daily Load (TMDL) was developed by the EPA (2001) to reduce the amount of sediment in the Trinity River. The TMDL sets sediment load allocations that specify the amount of sediment reduction needed to meet the water quality objectives.

EPA (2001) infers that the limiting factor to beneficial uses is excess sediment transported and/or deposited in the Trinity River. The California State water quality objectives for sediment are listed in Table 3-3. Fine and coarse sediment are considered negative to the environment. Indicators to include: spawning gravel quality and permeability, pool depth and other geomorphic indicators.

The TMDL sediment source analysis attempts to show that the majority of suspended sediment and turbidity are sourced from timber harvest and roads. The Weaver-Rush watersheds were analyzed as a subset of the TMDL analysis area. According to the TMDL, fine and coarse sediment sourced from the Weaver-Rush 6th field watersheds needs to be reduced 42 percent to meet water quality objectives (EPA, 2001). In addition, the Watershed Condition is rated as "at risk."

Table 3-3. Sediment water quality objectives applicable to the Weaverville Watershed Analysis.

Parameter	Water Quality Objective
Suspended Material	Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.
Settleable Material	Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affect beneficial uses.
Sediment	The suspended sediment load and suspended sediment discharge rate of surface water shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.
Turbidity	Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution with which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof.

The Shasta-Trinity Cumulative Watershed Effects (CWE) analysis process is used to characterize and quantify the current condition of water quality and quantity of the Weaverville Watershed Analysis. This CWE analysis compares the Forest Plan Threshold of Concern (TOC) to the existing Equivalent Roaded Area (ERA). Subwatersheds that are at risk are identified and investigated to determine which actions need to be taken to restore and or mitigate the level of ground disturbance. Specific recommendations from this analysis, if implemented, are likely to improve the long-term channel stability and help meet sediment TMDL goals.

CWE Analysis, Scope and Definitions: The Shasta Trinity National Forest CWE analysis process evaluates the potential impacts of land management on balance between rainfall-runoff, erosion, and stream channel response. CWE are defined in the Forest Plan

(USDA Forest Service, 1994) as the additive or compound effects of land management activities to water quantity and quality and beneficial uses, occurring away from the site of primary development, which are transmitted to the fluvial system.

CWE appear to result from the combination of changes in surface and mass failure erosion rates, instream sedimentation rates, and peak streamflows within watersheds in response to management activities (Haskins, 1983). The Federal Register defines a cumulative effect as the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonable foreseeable future actions regardless of what agency or person undertakes such other action (40 CFR 1508.7).

CWE Analysis Level and Confidence: For the Weaverville Watershed Analysis, a Level 1 CWE analysis was completed that relied on readily available information, no sediment budget, and limited field data collection. This level of CWE analysis uses the Haskins (1986) ERA model as a tool to identify at risk or "red flag" watersheds. The confidence in analysis is low to medium due to the lack of accurate legacy land use history, accurate and current timber harvest and road data on private lands, current road condition data, and current channel stability data.

CWE Analysis Core Data Sources: This CWE analysis relies on the Equivalent Roaded Area model developed by Haskins (1983). The existing ERA is calculated using readily available data from the Forest Service, State, and local agencies. The following summarizes the core data layers used to complete the CWE analysis.

Timber Harvest ERA: The timber harvest ERA is calculated using the land area and rate of timber harvest on public and private lands. The harvest history factors the type of harvest (e.g., thinning from below), the yarding method (e.g., tractor), the site preparation method (e.g., tractor pile and burn), and future actions (e.g., planting and prescribed burning). The public land harvest history relies on data from the Forest Service Stand Record System (SRS) database stored and maintained in GIS. The SRS data were updated to reflect public land harvest as of fiscal year 2004. Several of the units were inventoried to verify the ERA model recovery rates.

The private land harvest history was developed using harvest history data summarized as part of the Trinity River sediment TMDL (EPA, 2001), DWR (1980), and aerial photos from 1998. Several errors and gaps in the TMDL timber harvest GIS data were corrected and identified after comparing the GIS data and the aerial photos. GIS data was corrected using aerial photos and limited ground truthing to develop the harvest history. Several errors and gaps in the TMDL timber harvest data still exist as of the date of this report.

Road ERA: The road ERA is calculated using the area of land disturbed by the road prism. The road ERA calculation uses data from the Forest Service road database stored and maintained in GIS. The road layer was updated as part of the Weaverville Watershed Analysis and Browns Integrated Project Roads Analysis Process. The existing road ERA was calculated using the updated road layer that includes existing and new classified and unclassified Forest Service roads and trails, user created ATV trails, private roads and trails, county roads, and state and federal highways.

Several errors and gaps in the road layer were corrected and identified after comparing the road database to field inventory data and the 1998 aerial photos. For example, about 40 miles of private road were mapped from the 1998 aerial photos. There are still roads missing from the database as of the date of this report. In addition, very little data were readily available on road conditions.

To calculate the road ERA, the road length is multiplied by road width. The road length is summarized using GIS data. Road width varies depending on the road and surface type, and maintenance level. Road width accounts for the average prism width, pullouts, and landings.

Fire ERA: Watershed disturbances caused by wildland and prescribed fires and their impact on the hydrologic balance, sediment yield, and beneficial uses is analyzed as part of the CWE analysis. The fire ERA is calculated using the known wildland and prescribed fire history for the analysis area. Only landscape scale fires are of importance because the frequent lightning fire typically is not large enough to excess runoff or erosion.

Each fire is characterized according to how severe it burned and when it burned. A burn severity map is drawn to calculate the disturbed watershed area. Fire disturbance factors and recovery rates for different vegetation types and burn characteristics are used to estimate the likely-hood of negative cumulative effects. Typically, runoff and erosion caused by vegetation and duff layer removal are assumed to be recovered, or within the natural range of variation, at five to 10 years. For example, chaparral or brush fires typically have a high rate of fuel consumption are large and can cause severe burns, however, these disturbances recover rapidly. Within coniferous vegetation types, the rate of disturbance recovery depends more on the type of burn, for example, a low severity under-story burn is fully recovered within two to five years, whereas, a high severity crown fire may not recover for 30 or more years.

Fire history data, stored in GIS, was used to calculate the fire ERA. The Oregon Fire was the most recent large fire and burned in the western portion of the Weaverville Watershed Analysis area.

ERA Field Data: Field extensive data are used to help verify present and potential watershed conditions. These data are used to help verify or inventory the following items:

1) Inventory of channel stability;
2) Inventory of landslide prone terrane;
3) Inventory of needed restoration and mitigation measures;
4) Location, type, and condition of riparian reserves; and
5) road restoration and upgrade opportunities.

ERA Disturbance Factors and Recovery Rates: ERA disturbance factors for the analysis area were developed using the coefficients described by Haskins (1986), surrounding

forests, and scientific literature. Listed in Appendix C are the CWE disturbance factors and their recovery rates.

All mechanical ground disturbances from project activities are assumed to be fully recovered after 20 to 30 years. Ground disturbances caused by wildland and/or prescribed fire are assumed to be recovered in five to 10 years. Roads, landings, and skid trails do not recover with time unless specific mitigation or restoration occurs (Haskins 1986). Once a road is decommissioned or a landing is rehabilitated they are assumed to have a positive effect on ERA.

CWE Analysis Threshold of Concern and Watershed Condition Class: The Forest Plan LMP established TOC for 5th field watersheds and defines Watershed Condition Class (WCC) (USDA Forest Service, 1994). The WCC are defined as follows:

- Watershed Condition Class I: ERA less than 40 percent TOC;
- Watershed Condition Class II: ERA between 40 and 80 percent TOC; and
- Watershed Condition Class III: ERA greater than 80 percent TOC.

The following summarizes the FSM 2521.1 - Watershed Condition Classes. The ERA evaluates watershed condition and assigns one of the following three classes:

1. Class I Condition. Watersheds exhibit high geomorphic, hydrologic, and biotic integrity relative to their natural potential condition. The drainage network is generally stable. Physical, chemical, and biologic conditions suggest that soil, aquatic, and riparian systems are predominantly functional in terms of supporting beneficial uses.

2. Class II Condition. Watersheds exhibit moderate geomorphic, hydrologic, and biotic integrity relative to their natural potential condition. Portions of the watershed may exhibit an unstable drainage network. Physical, chemical, and biologic conditions suggest that soil, aquatic, and riparian systems are at risk in being able to support beneficial uses.

3. Class III Condition. Watersheds exhibit low geomorphic, hydrologic, and biotic integrity relative to their natural potential condition. A majority of the drainage network may be unstable. Physical, chemical, and biologic conditions suggest that soil, riparian, and aquatic systems do not support beneficial uses.

CWE Analysis Results: The existing ERA is listed for each 8th field subwatershed within the analysis area and used to calculate the present WCC (Table 3-4) (Plate 1). The TOC for the analysis area is 16 percent. There are five 7th field watersheds draining the analysis area to include:

- Rush Creek (i.e., broken into two 7th);
- Little Browns Creek;
- East Weaver Creek; and
- West Weaver Creek.

Rush Creek has a WCC of three, and the ERA increases downstream. The headwaters of Rush Creek drain wilderness and are in WCC one, whereas, the lower portion of the creek has been heavily managed and exceeds the TOC by a factor of two. The road network and rate of timber harvest are the main causes of the high ERA. There are several mass wasting features chronically contributing large volumes of sediment to Rush Creek.

Table 3-4. Weaverville Watershed Analysis current condition ERA spreadsheet.

HUC8	HUC6_NAME	Drainage Area (acres)	Forest Plan TOC (%)	Existing ERA (acres)	Existing ERA (%)	WCC
1801021106010101	Rush Creek	2860	16	5	0	1
1801021106010102	Rush Creek	2997	16	255	9	2
1801021106010201	Rush Creek	3470	16	410	12	2
1801021106010202	Rush Creek	2676	16	657	25	3
1801021106010203	Rush Creek	2384	16	813	34	3
Rush Creek (7ths)		14388	16	2140	15	3
1801021106040101	E Weaver Creek	2148	16	10	0	1
1801021106040102	E Weaver Creek	1567	16	210	13	3
1801021106040103	E Weaver Creek	2291	16	209	9	2
1801021106040105	E Weaver Creek	2886	16	356	12	2
E Weaver Creek (7th)		8892	16	784	9	2
1801021106040201	W Weaver Creek	2143	16	62	3	1
1801021106040202	W Weaver Creek	1836	16	282	15	3
1801021106040203	W Weaver Creek	1895	16	878	46	3
1801021106040204	W Weaver Creek	1530	16	237	15	3
1801021106040205	W Weaver Creek	2035	16	669	33	3
W Weaver Creek (7th)		9440	16	2127	23	3
1801021106040301	L Browns Creek	2151	16	304	14	3
1801021106040302	L Browns Creek	2838	16	426	15	3
L Browns Creek (7th)		4989	16	731	15	3

Little Browns Creek has a WCC of three. Smaller than the other three 6th field watersheds, the ERA of this watershed is equal to the TOC (i.e., 16%). The road network, rate of timber harvest, and urban development are the main causes of the high ERA. Highway 3 has impacted stream channel stability significantly in the lower subwatershed (1801021106040301) were the Highway 3 occupies ¾ of the original channel width.

East Weaver Creek has a WCC of two, however, one of the subwatersheds (1801021106040102) is in WCC three (Table 3-4). The headwaters of East Weaver Creek drain wilderness and have a WCC of one. The ERA increases downstream with urban development as the main cause of high ERA. Roading, urban development, and surface water use are significantly altering water quality and quantity in lower Weaver Creek.

West Weaver Creek has a WCC of three. The headwaters of West Weaver Creek drain wilderness and have a WCC of one. The ERA increases downstream with urban development and recent large severe wildland fire (i.e., Oregon) as the main cause of high ERA. Roading, urban development, and surface water use are significantly altering water quality and quantity in lower Weaver Creek. In addition, Highway 299 has impacted stream channel stability significantly because of highway runoff, channel diversion, and road-cut instability.

4. Aquatic Systems and Species

4.1 CURRENT ANADROMOUS FISH POPULATIONS AND DISTRIBUTION

The Weaverville planning watershed is made up of several subwatersheds where only the upper portions are located on National Forest System lands. The condition of anadromous fish abundance and habitat conditions will be addressed at the 7th field subwatershed level. The four watersheds are Rush Creek, Little Browns Creek, East Weaver Creek, and West Weaver Creek.

In general, streams of the Weaverville watershed begin in the Trinity Alps Wilderness area and are in very good condition in the upper areas of the watershed. Significant amounts of water are withdrawn from East and West Weaver Creeks by the Weaverville Community Service District and from Rush Creek at the Rush Creek Estates area. After streams leave the National Forest, the quality of riparian areas and instream habitat declines quickly. High water temperature and low flow are limiting factors to fish, especially during the mid-summer and fall.

Anadromous fishes found in the Weaverville Watershed include Fall-run Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), Winter-run Steelhead (*O. mykiss*) and Pacific Lamprey (*Lampetra tridentata*). The coho salmon is part of the Southern Oregon Northern California Coast Evolutionary Significant Unit and listed as threatened by the National Oceanic and Atmospheric Administration under the Endangered Species Act. Adult fishes are found in the Weaverville watershed during their spawning migrations. Chinook are found infrequently due to low stream flows that prevent migration during the fall. Coho salmon run later in the year can usually ascend streams in the watershed by late November or early December. Steelhead and lamprey ascend streams in the watershed during early spring and are limited by natural waterfalls, dams, and culverts. Juvenile fish of all species may be found at any time in the watershed, with juvenile steelhead being most abundant.

Fish habitat surveys have been performed periodically since the early 1980's for most streams (1963 for Rush Creek) in the analysis area. Many surveys note poor habitat conditions and from 1986 to 1992 most streams had habitat improvement structures installed. In confined channels such as West Weaver Creek and Little Browns Creek, some well-constructed structures still persist and provide complex habitats. In streams with less confinement and high bedload transport, the structures were less successful.

Water quality is generally very high in streams of the Weaverville watershed. Surveyed streams have had dissolved oxygen levels from 11 to 12 ppm, pH from 7 to 7.5, and temperatures around 60° F.

Rush Creek

Anadromous fishes have access to approximately 9.5 miles of stream habitat before steep bedrock falls block passage. Chinook are only found during years of early fall rain that

creates suitable migration conditions. Low fall flows generally prevent anadromous fishes from using Rush Creek until late November. Spawning surveys for salmon and steelhead have been conducted on sections of Rush Creek intermittently since 1964. Counts have varied widely according to year and survey effort, but have ranged from zero to one Chinook, zero to 32 coho, and five to 439 steelhead.

The very first fish habitat surveys in Rush Creek noted excessive bedload and recommended that measures be taken to improve habitat. During the 1980's a Coordinated Resource Management Planning group was formed of state and federal agencies to address habitat needs in Rush Creek. The group recommended placing instream structures and 32 structures were build in 1988 and 1989. Surveys in 2002 and 2004 showed that only 40% of the structures remain and less than 20% are still functioning. A 2002 Stream Condition Inventory (SCI) found that most of the large woody debris was less than 1 foot in diameter, pools averaged only 1.6 feet deep and 68% of the stream banks were unstable.

Little Browns Creek

Little Browns Creek has approximately 0.9 miles of habitat accessible to anadromous fishes on National Forest System lands. Culverts on County Road 232 present a complete barrier to migrating fishes. Juvenile steelhead and coho salmon have been observed in the analysis area however spawning has not been documented.

Highway 3, County Roads 230, 232 and 807, and FS road U34N77A closely parallel Little Browns Creek within the analysis area. Little Browns Creek has been channelized and its habitat greatly simplified. Large woody debris is lacking, pools are shallow, and the stream banks are vulnerable to erosion (2003 stream condition inventory). Six habitat improvement structures were installed in 1992, several of the structures still exist and provide valuable habitat.

East Weaver Creek

East Weaver Creek has approximately 0.5 miles of habitat accessible to anadromous fishes on NFS lands. The diversion dam for the Weaverville Community Service District blocks migration .25 miles above the East Weaver Campground. Juvenile coho salmon and steelhead have been observed near East Weaver Campground but adult spawning has not been observed.

Stream condition inventory surveys performed in 2002 found that most large woody debris was of small diameter (< 1 foot), pools are shallow (ave. 1.1 feet) and 83% of stream banks are unstable.

West Weaver Creek

West Weaver Creek has approximately two miles of habitat accessible to anadromous fishes on NFS lands. Coho salmon are found up to Highway 299 where a culvert presents a migration barrier; steelhead can ascend the culvert but a waterfall near Bear gulch stops their migration. Up to four adult coho salmon and 12 steelhead have been observed spawning on NFS lands in West Weaver Creek.

Stream condition inventory surveys performed in 2003 found that most large woody debris was of small diameter (< 1 foot), pools are shallow (ave. 1.4 feet) and 51% of stream banks are unstable.

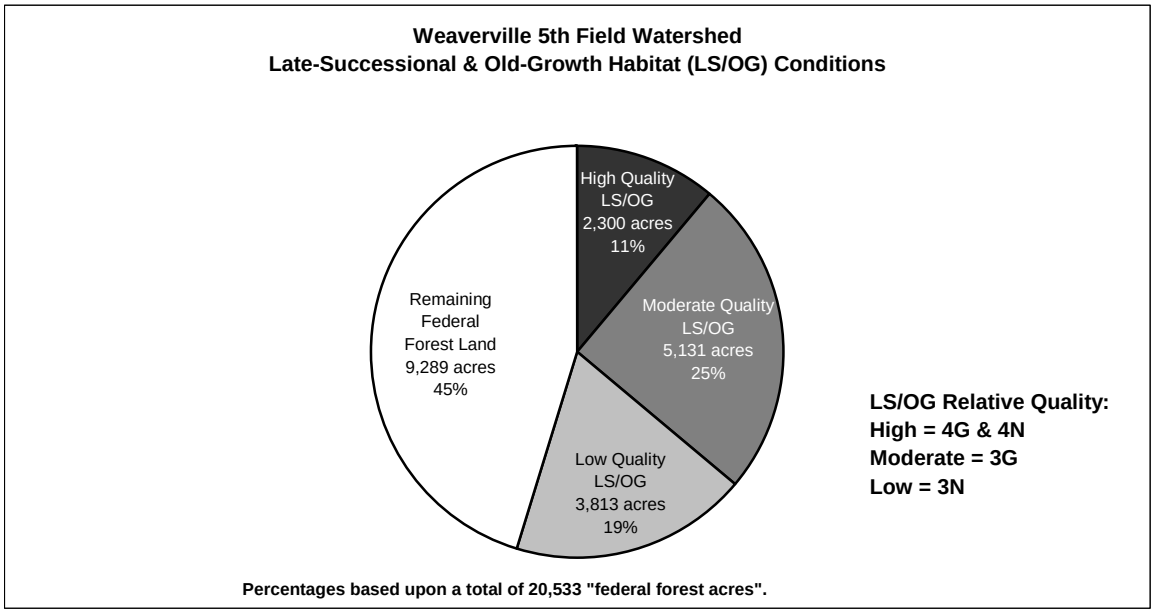
Sidney Gulch
Anadromous fishes have been observed in Sidney Gulch up FS road 33N42. A section of concrete channel passing through the Weaverville Ranger District compound stops migration in all but optimal flows. Up to 12 coho and two steelhead have been observed spawning on NFS lands in Sidney Gulch.

Stream habitat has not been formally inventoried on Sidney gulch. However, observations during spawning surveys suggest that Sidney Gulch suffers from similar habitat deficiencies as other local streams with low levels of large wood, shallow pools and an unstable channel.

5. Terrestrial Wildlife Habitat and Species

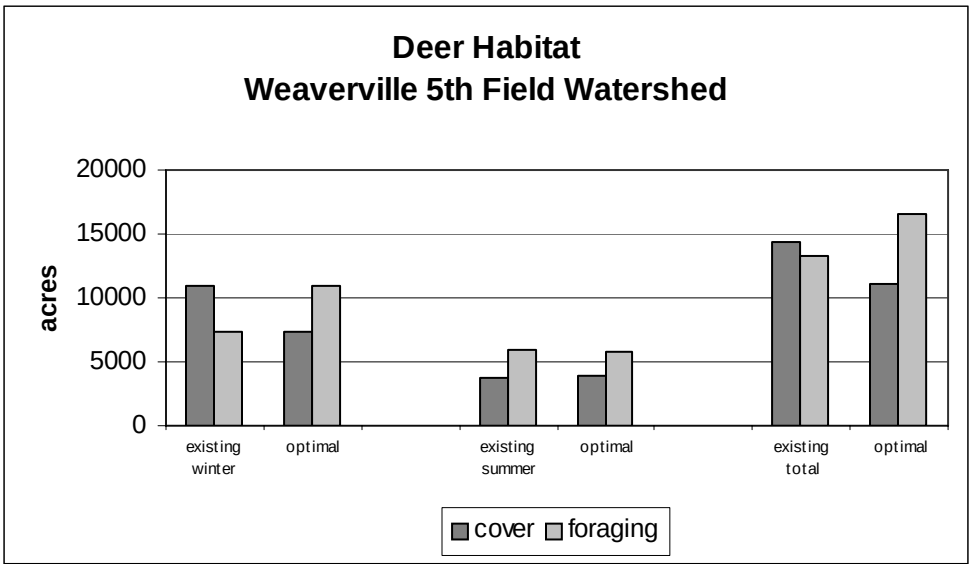
5.1 CURRENT LSOG AMOUNT AND CONDITION

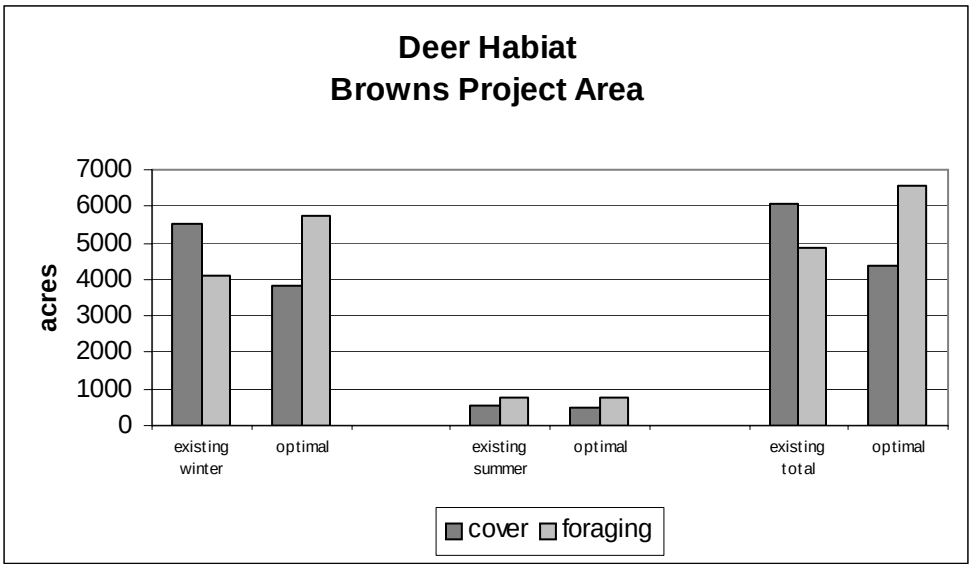
The 54,000-acre Weaverville Watershed includes 20,533 acres of federal forest land (i.e., federal land capable of producing LSOG). Old-growth comprises 2,300 acres or roughly 11 percent of this land. This old-growth exists in scattered patches ranging from roughly 2 to 400 acres in the upper two-thirds of the watershed with approximately 650 acres lying with the Browns Integrated Project Area. Mature (i.e., late-successional) forest dominates the watershed (12,937 acres or 63 percent of the federal forest land). The Watershed Analysis file includes a more comprehensive analysis of LSOG conditions along with maps, definitions and assumptions used (Appendix D).



5.2 CURRENT DEER HABITAT AMOUNT AND CONDITION

Winter range deer habitat within the Weaverville 5th Field Watershed is currently not providing optimum habitat conditions for deer assuming a rough ideal deer habitat ratio of 40% cover and 60% foraging (Thomas el al. 1979). The cover to forage ration in the watershed is currently 52% cover (14,381 acres) to 48% forage (13,225 acres). The Browns Integrated Project Area lies largely within winter range where the current ratio is currently 56% cover (6,053 acres) to 44% forage (4,840 acres). Most of the existing chaparral (i.e., brush-dominated) foraging habitat is decadent and thus too thick to allow deer access and too woody to provide nutritious browse (Gartner 1991). Much of the hardwood (i.e., acorn-producing) foraging habitat is overly dense and at risk to loss from wildfire. The Watershed Analysis file includes a more comprehensive analysis of deer habitat conditions along with maps, definitions and assumptions used (Appendix E).





6. Fire, Fuels, and Air Quality

6.1 CURRENT WILDFIRE THREAT TO LOCAL COMMUNITIES

Fire History

In pre-settlement forests of the Klamath region, biomass ultimately burned by frequent, low to moderate-severity fire. High-severity fires more than a few acres in size were unusual. Dead biomass on the forest floor was kept at low levels, and small understory trees were killed and subsequently consumed by fire. Small areas of high-severity fire killed patches of large trees, however the majority of large trees survived and were consumed at some point after their natural death (Weatherspoon and Skinner 1996).

Native Americans that inhabited the Klamath Mountains were dependent on local resources for commodities and shelter; therefore, periodic understory burning was a desired strategy. Mixed-conifer-Douglas-fir/hardwood forests were frequently burned along ridgetops to maintain travel corridors and openings for food and commodity production (Agee 1993). They used fire to promote the growth of acorns, berries, and plants, such as beargrass and hazel that provided fiber used in basket construction (Key 2000). In addition, natives burned to reduce the hazard of large, severe fires (Skinner and Chang 1996). Local Indians known to have inhabited the Klamath Mountains belonged to the Wintu, Yurok, and Hoopa tribes.

Native American activities before 1850; activities of miners, trappers and settlers in the mid-nineteenth century, and fire suppression in the twentieth century have all influenced fire history (Agee 1993). Biomass consumption dropped proportionately with annual burned acres as fire suppression was initiated in the early century. Fire suppression, in

forests that previously experienced frequent fires, has allowed fuels to build up both vertically and horizontally, increasing the chance of stand-replacement events.

Sixty-seven fire events within the proposed Brown's project area boundary occurred between the years 1931 and 1996 (Table 3-5) (Map 4). The longest fire interval between two fires was 12 years; however, the majority of them occurred between 0-2 years. Since all fires located on map 4 occurred during the 20th century, we assume that suppression tactics were employed. In addition, located on the map are fires that occurred outside of the proposed Brown's project boundary for the period of 1917 to 2000.

Table 3-5. Average number of years between fire events within the proposed Brown's project area from 1931 to 1996.

Fire Decade	Total Fires	Average Number of Years Between a Fire
1930-1939	16	2.0
1940-1949	8	1.5
1950-1959	14	1.7
1960-1969	0	12
1970-1979	19	1.3
1980-1989	5	2.0
1990-1999	5	3.0

Lightning is a common and important source of ignition in the Klamath Mountains. Wet and dry thunderstorms generally occur throughout the summer and early fall months. The computer program, Fire Family Plus was used to determine fire causes from 1993-2003. Approximately 70% of the fires on the Weaverville district occurred from lightning and 30% were caused from human, equipment, or miscellaneous (Figure 3-1).

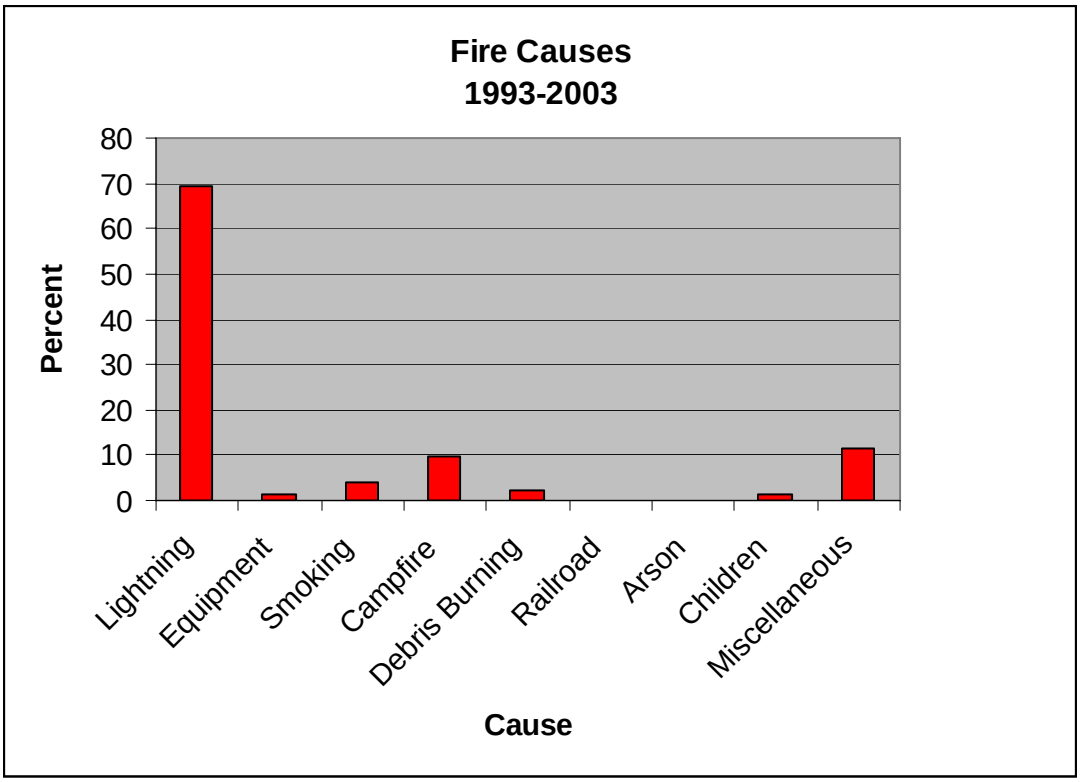


Figure 3-1. Fire causes on the Weaverville Ranger District for the period 1993-2003

Fuels History

Historically, fuel treatments on National Forest land had been accomplished for purposes of site preparation for reforestation, and the treatment of timber sale generated fuels. Today, however, fuel treatment objectives often incorporate ecosystem health and restoration (Omi and Martinson 2002).

A much greater percentage of biomass historically was stored in the boles of large trees, and herbaceous vegetation in relatively open stands, whereas now much more goes into small trees in dense stands (Weatherspoon and Skinner 1996). Larger, fire resistant trees have been harvested and replaced by smaller, fire susceptible trees. Dead biomass in the form of logging slash and natural fuels has increased due to the lack of fire, and inadequate or nonexistent fuel treatments (Weatherspoon and Skinner 1996).

In California's Mediterranean climate, decomposition rates are generally low and limited by low temperatures in the winter and inadequate moisture in the summer. Neither historically, nor presently has decomposition been the primary remover of biomass in a mixed-conifer forest (Weatherspoon and Skinner 1996). Frequent, low-severity fire plays an important role in regulating fuel accumulations in forested stands of the Klamath Mountains. This type of fire influences vertical and horizontal fuel continuities, as well as creates and maintains canopy gaps that mitigate crown fire propagation (Sinner and Chang 1996).

A long-term fuels history is not known in the Brown's area since fuel accumulations were not sampled during the pre-settlement period. Fuel assessments were conducted in the later 20th century and are found in four Forest Service planning documents (Table 3-7). In addition, old photographs from the late 1800's, and early 1900's of Trinity County were assessed to see if fuel loadings could be determined. Either no photographs were found of the proposed Brown's project area, or fuel loadings were indistinguishable.

Table 3-7. Average fuel loadings and their geographical location found within the proposed Brown's project area taken from four different Forest Service Environmental Assessments (EA).

Name of EA	Date	Geographical Area	Avg. Tons Per Acre
East Weaver	1985	Musser Hill ridge-road and East Weaver	35
Brown's	1985	Little Browns, Finley Gulch, China Gulch, Musser Hill	35
Lewiston	1988	Trinity Dam Blvd	21
West Weaver	1992	Glennison Gap	15

Stand Composition

The Klamath Mountains of northern California are known to be unique with high floristic diversity (Mohr et al. 2000). This region encompasses several mountain ranges such as the Marble, Siskiyou, Scott and Salmon Mountains; and consists of alpine, subalpine, and montane forests. The proposed Brown's project area is located in a montane forest, and its vegetation is characterized by mixed conifer-Douglas-fir, in which Agee (1993) further describes as the Psuedotsuga/hardwood zone.

Dominant conifer species within this area consist of *Pseudotsuga menziesii var. menziesii* (Douglas-fir), *Pinus ponderosa var. ponderosa* (ponderosa pine), *Pinus lambertiana* (sugar pine), *Calocedrus decurrens* (incense-cedar) and *Pinus sabiniana* (gray pine). Dominant hardwood tree species consist of *Quercus garryana* (Oregon white oak), *Quercus kelloggii* (California black oak), *Arbutus menziesii* (Pacific madrone), and *Quercus chrysolepsis* (canyon live oak). Dominant brush species consist of *Arctostaphylus patula* (greenleaf manzanita), *Arctostaphylus viscida* (whiteleaf manzanita), and *Ceanothus cuneatus* (buck brush).

Stand composition in the proposed Brown's project area was determined from data collected using a variable plot sampling method. Plots in China Gulch were sampled in 1999, and plots at Musser Hill and Little Browns creek were sampled in 2003. The total sample area is composed of 525 acres, 12 units and 136 plots. Three of the units consist of brush and were sampled only for dead and down fuel loadings, which is discussed in the fuels portion of this report. Basal area (BA) per acre, trees per acre, canopy closure, and fire condition class were determined by unit and are shown in Table 3-8.

In addition, a weighted average was calculated for basal area per acre, trees per acre, trees per acre between 2-12 inches, canopy closure and fire condition class rating (Table 3-9).

Species composition by percent basal area was also determined so that probability of mortality from a fire could be calculated (Table 3-10.)

Table 3-8. Basal area per acre, trees per acre, canopy closure, and fire condition class rating for the proposed Brown's project area per unit.

Unit	Basal Area Per Acre (ft^2)	Trees Per Acre	Canopy Closure (%)	Fire Condition Class Rating
1A	Brush			
1B	51	158	44	3
1C	94	431	80	3
1D	105	280	50	3
2A	151	307	73	3
3A	Brush			
3B	221	519	74	2
3C	240	678	82	3
3D	192	533	84	3
3E	Brush			
China Gulch 1	245	322	NA	NA
China Gulch 4	248	386	NA	NA

Table 3-9. Weighted average BA per acre, trees per acre, trees per acre (2-12 inches), canopy closure, and fire condition class rating for the proposed Brown's project area.

Weighted Average BA/Acre (ft^2)	Weighted Average Trees/Acre	Weighted Average Trees/Acre (2-12 in.)	Weighted Average Canopy Closure (%)	Weighted Average Fire Condition Class Rating
185	369	233	73	3

Table 3-10. Species composition by percent basal area for the proposed Brown's project area (China Gulch included).

Tree Species	Total Trees Counted in Sample	Percent Basal Area
Douglas-fir	491	66
Ponderosa pine	95	13
Incense cedar	57	1
Sugar pine	9	8
Gray pine	7	1
California black oak	73	10
Oregon whit oak	11	1
Canyon live oak	6	1
Pacific madrone	0	0
TOTAL	749	100

Condition Class

Three Condition Classes have been developed to classify the current state of vegetation with respect to each of the five Historic Fire Regime Groups (Cohesive Strategy 2000). Table E lists the descriptions of each condition class, the fire regime associated with it, and an example of management options.

The Brown's area currently falls within condition class 3. This was determined by referring to the Cohesive Strategy (2000) for a locality map of vegetation types that are currently classified in this condition. In addition, stand data plots sampled within the Brown's area show 6 out of 7 units fell within Condition Class 3, and 1 out of 7 units fell within Condition Class 2 (China Gulch and brush fields excluded) (Table 3-11).

Condition class 3 ecosystems contain stands littered with substantial amounts of dead material and are choked with hundreds of small trees that reach into the canopy of the larger, older-age forest above (Cohesive Strategy 2000). These ecosystems are at relatively high risk for damage from wildfires.

Fire Regime

Fires in the Klamath Mountains are more frequent and less severe than in the Pacific Northwest, however, less frequent than in Sierra Nevada forests (Mohr et al. 2000). Several fire researchers found the pre-settlement median fire return intervals for mixed-conifer-Douglas-fir forests in the Klamath Mountains. Their results show 16 years, 10-19 years, and 11-18 years (Skinner and Chang 1996). For ponderosa pine, studies show that prior to 1900 most stands experienced low-severity surface fires at intervals ranging from 1 to 30 years (FEIS 2003).

Fire regimes for the Brown's area are described in the Cohesive Strategy (2000), and fall within Groups I and II (Table 3-12). Both groups describe many of the lower elevational zones across the United States, which have been affected by the presence of human intervention, and are the furthest away from historical levels (Cohesive Strategy 2000). These areas are at greatest risk to loss of highly valued resources, commodity interests, and human health and safety (Cohesive Strategy 2000). Timber stands within the proposed Brown's project area are classified as a I and brush stands are classified as a II.

Table 3-11. Current condition class attributes as described in the Cohesive Strategy (2000).

Condition Class[1] descriptions		
Condition Class	**Fire Regime**	**Example Management Options**
Condition Class 1	Fire regimes are within an historical range and the risk of losing key ecosystem components is low. Vegetation attributes have been moderately altered from their historical range.	Where appropriate, these areas can be maintained within the historical fire regime by treatments such as fire use.
Condition Class 2	Fire regimes have been moderately altered from their historical range; the risk of losing key ecosystem components is moderate. Fire frequencies have departed from historical frequencies by one of more return intervals (either increased or decreased). This results in moderate changes to one or more of the following: fire size, intensity and severity, and landscape patterns. Vegetation attributes have been moderately altered from their historical range.	Where appropriate, these areas may need moderate levels of restoration treatments, such as fire use and hand or mechanical treatments, to be restored to the historical fire regime.
Condition Class 3	Fire regimes have been significantly altered from their historical range. The risk of losing key ecosystem components is high. Fire frequencies have departed from historical frequencies by multiple return intervals. This results in dramatic changes to one or more of the following: fire size, intensity, severity, and landscape patterns. Vegetation attributes have been significantly altered from their historical range.	Where appropriate, these areas may need high levels of restoration treatments, such as hand or mechanical treatments, before fire can be used to restore the historical fire regime.

[1] Current conditions are a function of the degree of departure from historical fire regimes resulting in alterations of key ecosystem components such as species composition, structural stage, stand age, and canopy closure. One or more of the following activities may have caused this departure: fire suppression, timber harvesting, grazing, introduction and establishment of exotic plant species, insects or disease (introduced or native), or other past management activities.

Table 3-12. The Five Historic Natural Fire Regime Groups (Cohesive Strategy 2000).

Fire Regime Group	Frequency (Fire Return Interval)	Severity
I	0-35 years	Low severity
II	0-35 years	Stand replacement severity
III	35-100+ years	Mixed severity
IV	35-100+ years	Stand replacement severity
V	>200 years	Stand replacement severity

Hazard/Risk/Values

Hazard describes the potential for resource damage should a fire occur. This was determined from local historical weather data coupled with local fuel models, and then calculating fire behavior for a particular area. These values are assigned a rating of low, moderate and high and were taken from the Shasta-Trinity Fire Management Plan (SHF-FMP)(2004).

Risk describes the probability of a fire occurrence, and was determined by plotting the location of historical fire starts on a map, and then locating their concentrations. These values are assigned a rating of low, moderate and high and were taken from the SHF-FMP (2004).

Value describes resources that would suffer a significant or irretrievable loss if they were damaged or lost by wildfire. It may be monetary and/or non-monetary worth such as wildlife habitat, homes, timber, and aesthetic values. This was determined by the SHF Forest Leadership team, and was assigned a rating of low, moderate and high (SHF-FMP)(2004).

A combined analysis was then used to develop the Hazard/Risk/Value map by combining ratings and assigning a low, moderate and high value based on these combinations, which were also taken from the SHF-FMP (2004). These ratings were then applied within the proposed Brown's project area boundary to more specifically assess the hazard/risk/values (Map 5).

Wildland Urban Interface (WUI)

Approximately 50% of the proposed Brown's project area falls within the Wildland Urban Interface. The nearest town is Weaverville, which is listed in the Federal Register for communities at high risk from wildfire (2001), therefore making this area a high priority for fuels treatments (10-year Plan 2001).

Existing Fuels

Fuel Models: There are three Fire Behavior Fuel Models represented within the Brown's area which are 5, 8, and 10. Fuel Model 5 is described as brush, and models 8 and 10 are described as timber litter.

Fuel Loading: A random systematic sampling method was used to assess fuel loadings in the proposed Brown's project area. The total sample area is composed of 458 acres, 10 units, and 126 plots (10 plots from China Gulch were excluded due to a conflicting sampling method). Data was then entered into the Fuels Management Analyst Plus (FMA +) computer software program to calculate an average fuel loading for each unit. The units were then combined and a weighted average was calculated over the entire area for both timber and brush units.

Fuel loadings range from approximately 1.70 to 33.20 tons per acre for timber stands and 1.60 to 4.35 tons per acre for brush stands (Table 3-13). Minimum fuel loadings within the proposed Brown's project area are generally located in stands with south-west aspects and contain vegetation such as oak, gray pine and brush species. Maximum fuel loadings are generally located in stands with north-east aspects and contain vegetation such as Douglas-fir, cedar, sugar and ponderosa pines.

Table 3-13. Minimum, maximum, and weighted average fuel distributions by size class and fuel class for brush and timber units in the proposed Brown's project area (China Gulch excluded).

Size Class (inches)	Fuel Class	Minimum (tons/acre)		Maximum (tons/acre)		Weighted Average (tons/acre)	
		Timber	Brush	Timber	Brush	Timber	Brush
0-.24	1 hr	0.3	0.20	1.0	0.30	0.51	0.28
.25-.9	10 hr	1.0	1.00	3.2	1.00	2.29	1.00
1-2.9	100 hr	0.4	0.40	7.9	0.60	1.86	0.44
3+	1000 hr	0.0	0.0	27.1	6.30	10.1	2.63
TOTAL		**1.70**	**1.60**	**33.20**	**8.20**	**14.76**	**4.35**

Fuel Bed and Duff Depths: A weighted average was calculated for fuelbed and duff depths in brush and timber units using the same sampling method and calculations as described for fuel loadings (Table 3-14).

Table 3-14. Minimum, maximum, and weighted average fuel bed and duff depths in brush and timber units in the proposed Brown's project area (China Gulch excluded).

	Minimum (inches)		Maximum (inches)		Weighted Average (inches)	
	Timber	Brush	Timber	Brush	Timber	Brush
Duff Depth	0.79	0.48	7.2	2.40	3.99	0.67
Fuel Bed Depth	1.63	0.60	2.06	3.00	1.93	0.91

Fuel Arrangement: Also known as fuel orientation, is described by how fuels are arranged either on the surface floor or aerially. Vertically oriented fuels may rapidly increase in depth with an increase in fuel load. This arrangement of fuel is found in brush fields and patches of conifer reproduction throughout the proposed Brown's project area. Vertically arranged fuels may create a hazard because they function as ladders for fire to enter tree crowns.

Horizontally oriented fuels are common in timber litter and logging slash, and slowly increase in depth as the load increases. Twigs, branches and trees that fall onto the forest floor create a criss-cross mosaic of fuels that stack up over time. This type of fuel arrangement may increase residence times and create high fire severity effects. The proposed Brown's project area is composed of many timbered stands of which horizontal fuels exist.

Fuel Continuity: The continuity of fine fuels is especially important to the spread of surface fire. If fuels are patchy such as in open stands or brush fields, fire will have difficulty traveling from one fuel island to another. It often requires a strong wind with spotting for a fire to travel from patch to patch (NWCG S-290). In the proposed Brown's project area, brush fields are a prime example of patchy fuels, however, many of these stands are decadent, therefore, fire may spread throughout the crowns under 90th percentile weather conditions.

On the other hand, continuous fuels will determine where a fire will spread, how fast it will spread, and whether the fire travels through ground fuels, aerial fuels, or both. In the proposed Brown's project area, timber stands are a prime example of this type of continuity since needles, leaves, and branches are continually falling creating a blanket of fuels on the forest floor.

Fire Behavior

Fire behavior for timber units was determined by FMA+ and is based on dead and down fuel loadings, tree stand data, and 90th percentile weather. Two fuel models were used from the FMA+ Master Fuel Model Set based on sampled fuel loadings, which are separated into low (letter A) and moderate (letter M). Breaking out fuel models into these two categories gives a more accurate description of the amount of fuels present at any given site.

Surface fire: All fire behavior outputs for the proposed Brown's project area were that of a surface fire. Fuel model 8 resulted in the lowest rates of spread, flame lengths, and fire intensities (Table I). Direct attack by fire suppression personnel would be feasible without mechanical equipment. The probability of a large, high-severity fire occurring in this fuel model with 90th percentile weather would be low.

Fuel model 10 resulted in the highest rates of spread, flame lengths, and fire intensities (Table 3-15). Many areas throughout the proposed Brown's project area fall within this fuel model. Fire suppression tactics would be indirect attack, and mechanical equipment and air support would be required. The probability of a large, moderate to high-severity fire with 90th percentile weather conditions would be high, and provides the chance for the initiation and propagation of crown fire.

Crown fire: Approximately 58% of the plots sampled within the proposed Brown's project area exceeded the critical canopy bulk density of 0.0023 lbs/ft^3, which is a minimum needed to provide vertical propagation of fire in the canopy (FMA+ 2004). For

trees to torch, however, surface fire intensity must be high enough to ignite them, which fuel models 8 and 10 may not always provide. However, these fire behavior outputs do not take into account jackpot fuels, brush and other ladder fuels that may be present. Therefore, the chance for a passive and active crown fire does exist, and may occur with a change of fuel loadings, weather conditions, ladder fuels, slope, or a combination of them.

Fire behavior outputs for fuel model 5 were determined using the computer software program Behave + (Table 3-16). Resulting flame lengths for this fuel model would require suppression personnel to employ indirect attack methods as well as mechanical and aerial support.

Table 3-15. Fire behavior in timber units for the proposed Brown's project area using FMA+ (2004) for fuel models 8 and 10.

Fuel Model	Rate of Spread (chains/hour)			Flame Length (feet)			Fire Intensity (btu/ft/sec)		
	8A	**8M**	**10A**	**8A**	**8M**	**10A**	**8A**	**8M**	**10A**
Timber	1.2	2.2	6.4	0.8	1.4	4.2	3	10	129

Table 3-16. Fire behavior in brush units for the proposed Brown's project area using Behave + (2004) for fuel model 5.

Fuel Model	Rate of Spread (chains/hour)	Flame Length (feet)	Fire Intensity (btu/ft/sec)
Brush	24.0	6.5	334

Fire Severity

Fire severity is the degree to which a site has been altered or disrupted by fire; loosely, a product of fire intensity and residence time (NWCG 1996). Since the proposed Brown's project area falls within Groups I and II of the Five Historic Natural Fire Regime Groups; resulting fire severities for timber stands should be low and for brush stands stand replacement (Table 3-12). However, given that the current condition class rating for this area is a 3 (Table 3-11), we can assume that changes in fire severity would occur, and be more severe than that of historical periods.

Probability of mortality was calculated for 4 tree species between 2-12 inches dbh using FMA+. Douglas-fir, ponderosa pine, incense cedar and oak species were used for the calculation since most of the basal area sampled came from these species (Table 3-10). The mortality rate is intended for trees per acre for a specific diameter and species, not for a single tree. All units were combined and an average mortality was calculated (Table 3-17).

More than half of the trees per acre within the proposed Brown's project area are between 2-12 inches diameter (Table 3-9). By removing small diameter trees from the stand, percent mortality would decrease. Trees greater than 12 inches diameter have lower mortality rates due to thicker bark and higher branches, thus larger trees may not need to be removed. However, this does not always hold true in older stands that are crowded with touching tree crowns, which was previously discussed in the fire behavior section

Table 3-17. Probability of mortality for 4 tree species by diameter for timber units sampled in the proposed Brown's project area.

Species	Diameter					
	2	**4**	**6**	**8**	**10**	**12**
Ponderosa Pine	NA	59 %	44 %	31 %	22 %	57 %
Douglas-fir	76 %	65 %	47 %	34 %	24 %	19 %
Incense cedar	84 %	79 %	74 %	69 %	63 %	58 %
Oak species	NA	95 %	89 %	63 %	41 %	11 %

7. Plant Communities

7.1 CURRENT POPULATIONS OF PLANT SPECIES OF CONCERN

Known Populations of Species of Concern

There are no known Federally Threatened or Endangered plant species on the Shasta-Trinity National Forest. There are 38 known Forest Service Sensitive or Survey and Manage plant populations within the Weaverville 5th field watershed (Table 3-18). No Survey and Manage bryophytes or fungi are known from the watershed, or are there any Forest Plan Endemic species.

Table 3-18. Sensitive and Survey & Manage species found within the Weaverville 5th Field Watershed

Species	No. Populations	General Location	Protection Status	Habitat
Brownie lady's-slipper *Cypripedium fasciculatum*	4	Musser Hill Rush Creek	FS Sensitive Survey & Manage	Shady riparian areas; very mesic conifer forest
mountain lady's-slipper *Cypripedium montanum*	18	Glennison Gap Lit. Browns Creek Rush Creek Browns Mtn.	FS Sensitive Survey & Manage	Shady riparian areas; very mesic conifer forest
olive-thorn lichen *Dendriscocaulon intricatulum*	2	Musser Hill Weaverville	Survey & Manage lichen	Black oak woodland
English Peak greenbriar *Smilax jamesii*	14	East weaver drainage Rush Creek Little Browns Creek	FS Sensitive	Shady riparian areas

Potential Suitable Habitat within the Analysis Area

The Weaverville watershed lies within four subsections of the Klamath Mountains Ecological Section of California, but is mainly represented by two of those subsections, Oregon Mountain (M261Ac) and Eastern Klamath Mountains (M261Ai). Metamorphic soils dominate, although some ultramafic (serpentine) soils are present. 442 acres of ultramafic (serpentine) soils are present within the Browns Integrated Project analysis area.

Mixed conifer, Douglas fir, ponderosa pine, and combinations of these forest types represent the dominant plant communities within the watershed. Interspersed within these forest types are oak woodlands, mixed chaparral at lower elevations and canyon live oak stands on stony steep slopes. Large granitic and other rock outcrops are present at higher elevations in the northern third. Riparian habitat is found throughout, primarily in the form of streams and associated springs and seeps, but some seasonal and perennial wetlands are present. Overall the watershed is very hot and dry in the summer.

Field survey for rare plants has occurred most intensively in the Browns Integrated Project area. No formal surveys have occurred in the Trinity Alps Wilderness, but rare plant populations have been found incidental to recreational visits. Limited access and steep terrain limit survey work in the wilderness. Rare plant discoveries on private land are not documented with the Forest Service and the extent of rare plant populations is unknown there.
Suitable habitat for Sensitive and Survey & Manage plant species is thought to exist based on plant association maps, soil and geology maps, and observations made in the analysis area. Within the portion of the watershed that is not administratively withdrawn, suitable habitat for Sensitive plants is restricted to the forested plant communities or

large, rock outcrops. Plant species of concern that have potential for suitable habitat are listed in Tables 3-19. All species except Oregon willow herb have been found within the watershed.

Table 3-19. Sensitive and Survey and Manage Species with potential for Suitable Habitat within the Weaverville Watershed

Species	Habitat
Brownie lady-slipper *(Cypripedium fasciculatum)* Mountain lady-slipper *(Cypripedium montanum)* English Peak greenbriar *(Smilax jamesii)* Canyon Creek stonecrop *(Sedum paradisum)*	Douglas-fir or mixed conifer montane forest, riparian-influenced or not
Red Mountain catchfly *(Silene campanulata* ssp. *campanulata)*	Ponderosa pine forest on serpentine soils
Oregon willow herb (*Epilobium oreganum*)	Serpentine wetlands
Olive-thorn lichen (*Dendriscocaulon intricatulum*)	Black oak trees

7.2 CURRENT POPULATIONS OF INVASIVE WEEDS

Invasive Weeds

Invasive weed species have been introduced and dispersed along existing roadways. Annual, non-native grasses have largely replaced native grasses and are prolific throughout the watershed, but especially in open chaparral, oak woodlands, and in close proximity to all roads. The watershed includes two major highways (Hwy. 3 and Hwy. 299), both provide access to all National Forest roads and act as vectors for introduction and spread of weeds from outside areas.

Six weed species have been documented within the watershed (Table 3-20), but more are known to exist that have not been documented. As is typical of weed spread and establishment, more weeds are found along transportation vectors and within developed urban areas. Two species, spotted knapweed and lens-podded hoary cress, are significant because of their ability to invade extensively and because populations in Trinity County are very restricted. Lens-podded hoary cress is a State List B species and spotted knapweed is a State List A species, making both very high priority for control and management. Both are located on private land within the town of Weaverville and have not been seen on National Forest to date.

Table 3-20. Documented Invasive Weeds within the Weaverville Watershed

Scientific Name	Common Name	Areas Found
Cytisus scoparius	scotch broom	McKinzey Gulch Rush Creek Little Browns Creek
Centaurea solstitialis	yellow starthistle	throughout
Cardaria chalapensis	lens-podded hoary cress	town of Weaverville
Centaurea maculosa	spotted knapweed	town of Weaverville
Cirsium arvense	Canada thistle	Rush Creek
Cirsium vulgare	bull thistle	East Weaver Creek

CHAPTER 4
DESIRED CONDITIONS

This chapter describes the desired conditions of resources within the Weaverville watersheds. The ecological conditions and management objectives pertain to the issues and key questions identified in Chapter 2. The information provided here will be used in Chapter 5 for identification of possible management actions.

1. Human Uses, Values, and Expectations

1.1 RECREATION RESOURCES AND USES

The desired condition is to meet the Forest objective to provide a variety of high quality recreation experience opportunities. The desired condition for the major recreation resources in the watershed is that the forest, mountains, and streams would be part of a healthy, sustainable ecosystem. The desired condition is for the East Weaver Campground, and system roads and trails to be improved and maintained to standard. The desired condition is for the development of a limited OHV trail system in the Musser Hill area.

1.2 TIMBER HARVESTING OPPORTUNITIES

The desired condition of the mixed conifer timber stands within the Weaverville watershed is specific to the management prescription identified in the LRMP. The desired condition within the LSR areas is different from the desired condition within the Matrix lands, which include wildlife management emphasis and roaded recreation emphasis. Timber harvest opportunities could be used to provide the desired conifer forest conditions on Forest Service land outside of the wilderness, as displayed in Table 4-1.

Late-Successional Reserves are to be managed to protect and enhance conditions of late-successional and old-growth ecosystems, which serve as habitat for late-successional and old-growth related species including the northern spotted owl. Therefore, the 1,566 acres of conifer stands within the Weaverville watershed would be best served as representing the mature or old growth conifer stand condition. Roads to access any timber harvest opportunities such as thinning, silvicultural treatments, or salvage harvesting consistent with LSR Standards and Guidelines would be maintained to allow for access.

Table 4-1. DFC of timber-producing National Forest land within the Weaverville Watershed.

Conifer dominated stands	Late Successional Reserve (LSR)	Wildlife Management Emphasis	Roaded Recreation Emphasis	Total Acreage Available
Young conifer plantation or seedling	0 ac.	19 ac.	670 ac.	689 ac.
Pole-size conifer	0 ac.	39 ac.	1,348 ac.	1,387 ac.
Early or mid-mature conifer	0 ac.	96 ac.	3,366 ac.	3,462 ac.
Mature or old growth conifer	1,566 ac.	77 ac.	2,687 ac.	4,330 ac.
Total	1,566 ac.	231 ac.	8,071 ac.	9,868 ac.

Within the Wildlife Management and Roaded Recreation emphasis areas, LRMP prescriptions emphasize a variety of management activities while maintaining healthy and vigorous ecosystems. In addition, a sustained yield of wood products is emphasized. Therefore, on a 120 year rotation and a 10-year re-entry for timber harvesting, the desired condition of the conifer stands within the Weaverville watershed would represent an equal amount of each stand type to perpetuate the sustained level of forest products. The acreages reflected on Table 4-1 reflect an even distribution of timber age classes and the number of years each age class remains within the listed type of conifer stand (i.e. stands up to 10 years of age would be within the young conifer or seedling stage; whereas stands 10 to 30 years of age would be in the pole-sized conifer stage).

In addition, within the Matrix areas, a well-developed transportation system would benefit timber harvesting opportunities. Therefore, the desired condition to meet timber harvesting needs would include roads to access as much of the area as possible to the extent acceptable to other ecosystem management objectives.

1.3 FUELWOOD OPPORTUNITIES

The desired condition for fuel wood opportunities is an area managed for fuel wood supply and access. Periodic timber sales with cull and non-merchantable wood products available to the public for fuel wood would benefit fuel wood collection opportunities. In addition, a well-developed transportation system with road surfaces armored to allow for wet weather access would provide needed access to both timber sale generated wood and annual “dead and down” fuel wood collection opportunities.

2. Access and Travel Management

2.1 TRAIL CONDITION

The desired condition is to implement trail management objectives to provide for user safety and resource protection. The desired condition would provide standard bridge structures at trail crossings in some drainages, and hardening or rocking the tread surface on some segments of trail for resource protection. The desired condition would add access to the Weaver Basin Trail from the airport with a new trail alignment. The desired condition would construct a small segment of trail to combine with some decommissioned roads to develop a limited OHV trail system, in conjunction with education, signing, and law enforcement.

3. Erosional Processes

3.1 and 3.2 MASS WASTING FEATURES AND SOIL EROSION AREAS

The desired future condition of the Weaverville Watershed Analysis area is to improve watershed condition and meet water quality objectives. To accomplish the desired condition several actions need to be taken and are summarized in chapter 5.

3.3 CURRENT CUMULATIVE WATERSHED EFFECTS

The five 7th field watersheds draining the Weaverville Watershed Analysis area are currently in a degraded condition (Table 3-4) and are not meeting water quality objectives for sediment according to EPA (2001). A WCC ranking of three indicates the watersheds exhibit low geomorphic, hydrologic, and biotic integrity relative to their natural potential condition. A majority of the drainage network may be unstable. Physical, chemical, and biologic conditions suggest that soil, riparian, and aquatic systems do not support beneficial uses.

The desired future condition of the Weaverville Watershed Analysis area is to improve watershed condition and meet water quality objectives. To accomplish the desired condition several actions need to be taken and are summarized in chapter 5.

4. Aquatic Systems and Species

4.1 ANADRAMOUS FISH DISTRIBUTION AND HABITAT

Desired conditions would be to have anadromous fish migration unimpeded by culverts, dams or other manmade structures. Streams would provide a complex mix of aquatic habitats including deep pools with adequate cover, riffles with good spawning gravel and

adequate flows to allow year round survival. Riparian Reserves would be in good condition to provide large woody debris input, stream shade, and effective filter strips.

5. Terrestrial Wildlife Habitat and Species

5.1 LSOG AMOUNT AND CONDITION

To benefit species associated with late-successional and old-growth ecosystems, at least 15 percent of federal forest land consists of stands exhibiting old-growth characteristics in blocks of at least 100 acres.

5.2 DEER HABITAT AMOUNT AND CONDITION

To benefit wintering deer, shrub dominated habitat exists as a mosaic of young vigorous shrubs and older thicker pockets and stringers while oak dominated habitat exists in a fire resistant condition consistent with desired landscape fuel conditions.

6. Fire, Fuels, and Air Quality

6.1 WILDFIRE THREAT

Forest health is restored and maintained using controlled fire and silvicultural approaches.

Wildland-urban interfaces are managed to provide for community and firefighter safety.

Municipal watersheds are protected from uncharacteristic wildfire effects and remain within the range of ecological conditions characteristic of the fire regime under which they developed.

In Roaded Recreation areas, an average of 10 tons per acre of unburned dead/down material is maintained on slopes less than 40 percent. Preference is to have a portion of this tonnage in large material (i.e., 4 to 6 logs over 10 feet long at the largest diameter available). Where feasible, maintain the same amount on slopes over 40 percent.

Threatened and endangered species habitats are protected from uncharacteristic wildfire effects and remain within the range of ecological conditions characteristic of the fire regime under which they developed.

Existing low risk Condition Class 1 areas are maintained.

7. Plant Communities

7.1 POPULATIONS OF PLANT SPECIES OF CONCERN

Developed road and trail mileage are reduced to limit uncontrolled human caused fires and spread of fire-prone invasive weeds.

Natural fire regimes are restored to protect sensitive plant habitat. Severe fires that could have significant impacts on habitat for mountain and Brownie lady slipper orchids, English Peak greenbriar, and Canyon Creek stonecrop are limited. All of these species easily survived fires prior to human settlement when fires were more often low-intensity and occurred on a regular, frequent basis.

7.2 INVASIVE WEED SPECIES

Yellow starthistle and scotch broom populations are controlled or reduced in number.

Severe wildfire and activities that create disturbed ground are limited to prevent the spread and establishment of invasive weeds in the watershed.

CHAPTER 5
OPPORTUNITIES TO MEET DESIRED FUTURE CONDITIONS

This chapter identifies possible management actions that would move the current condition identified in Chapter 3 closer to the desired condition identified in Chapter 4. Actions identified here are for a specific resource element and need to be taken in context with other resource needs. The presence of an opportunity in this chapter does not constitute a decision that must be implemented; they are specific areas that resource specialists wish to bring to the line officers attention. Not all opportunities are feasible and some may be mutually exclusive. The line officer is responsible for deciding which action may be taken forward and analyzed as "proposed actions" in a NEPA analysis.

Issue #1: Human Uses, Values, and Expectations

Recreation

Management Opportunities 1.1

There are several opportunities to meet objectives for desired future conditions for recreation in the watershed:

- Improve East Weaver Campground with new SST, and redesign campsite units to accommodate recreational vehicles (RV's).
- Develop a day use picnic area at the bridge site on the Rainbow-Hansen trail.
- Provide historical interpretative signing on the La Grange Ditch and at Sykes Hole sites.
- Accommodate organized paintball game area.
- Improve trail system with OHV trail area.

Wood Products

Management Opportunities 1.2 and 1.3

- Use commercial timber sales to meet both wood product needs and vegetation needs of other resources (e.g. fuels objectives or wildlife habitat objectives).
- Improve the road transportation system to provide maximum access within resource constraints. Surface the road surfaces with gravel or shale to allow for wet weather public access.

Issue #2: Access and Travel Management

Management Opportunities 2.1

There are several opportunities to meet objectives for desired future conditions for trails in the watershed:

- Improve trailheads on Weaver Bally and East Weaver roads.
- Construct a new segment of the Greasy Loop trail #09W85 to avoid private property and excessively steep trail grades.
- Rehabilitate and restore OHV impact areas and user-created trails.
- Harden / rock segments of the Weaver Basin #09W87 and Rainbow-Hansen #09W85 trails in clay soils.
- Construct standard bridge structures on Weaver Basin Trail #09W87.
- Develop limited OHV trail system in the Musser Hill area, converting roads 34NO5Y; 34N52Y.1; 34N52YA; 34N95C; 34N96B; U343N05YA; U34N34B; U34N95A; U34N95B; and 34N95J to trails, and utilizing unclassified trail UT34N95CA. In addition, a short segment of trail (approximately ¼ mile) may be constructed.
- Implement a signing project to sign designated motorized and non-motorized trails, regulatory and trail directional signs.
- Provide additional access to the Weaver Basin Trail system by constructing new trail from the Airport to the Weaver Basin Trail #09W87.
- Add the segment of the Moon Lee Ditch from the waterwheel to the South line of Section 2, as a Foot-only trail, to the Weaver Basin Trail system.

Issue #3: Erosional Processes

Management Opportunities 3.1

- Avoidance of land disturbing activities is probably the most practicable scheme for large dormant landslide areas.
- Any on-site erosion and sediment control measures that increase infiltration and subsequently soil moisture should not be used on slopes that have a high probability of landslide failure.
- Channel cleanout should be performed on *strategic* areas. Because channels, culverts or basins designed to contain a given volume of debris will become blocked by an irregular mass of trees or other debris unless removed, resulting in an overtopping or destruction of the structure and diversion of the flow.
- For larger intermittent and perennial channels, more significant measures may need to be employed. In alluvial channels, there may be a need to try to establish some local base levels and sediment catchments in order to control lateral cutting and bed load transport of sediment, especially within gutted channels. Measures such as log and rock check dams, bank stabilization, head cut structures, planting

of riparian vegetation and placement of large organic material can all be used to aid channel stabilization. These measures could most appropriately be employed along tributary streams to Rush Creek underlain by granitics.

- For bedrock-controlled channels, artificial structures may not be as important or practical as in alluvial type channels (since these are usually avalanche chutes for debris flows). However, structures may be necessary in gutted channels where sediment is now available for transport. Structures may be feasible in certain reaches of these channels, which will aid in sediment stabilization, help restore or maintain pool habitat and provide needed cover. Planting riparian vegetation may also contribute to sediment stabilization and will also help provide shading for critical reaches.
- When planning structures at particular locations it must be remembered that channelized debris flows have enormous amounts of energy. It is nearly impossible to try to stop them in the channel. Virtually all debris flows begin to stop flowing naturally when two conditions are met: (flow becomes non-channelized on at least on side (2) the stream channel gradient is less that 10-15 degrees. The destructive scouring phase of the flow will not usually extend more than 200 meters past this point. Deposition can occur well beyond this point however, depending on the volume and water content of the flow. Another method of predicting runout is to look at fan deposits from old debris flows. Debris flows out of the same valley tend to have similar volumes and runout distances. Future debris flows usually will not extend far beyond the old fans.
- For roads that are contributing sediment to creeks, consider a regular maintenance program. This is especially true within the Weaverville formation, especially along the China Gulch road. Other possible measures include: armoring the road and drainage ditch, out sloping, enlarging culverts, installing rolling dips and waterbars, or relocation and reconstruction. Road closure should also be considered where roads are needed only for a short term.

Since the geomorphology and bedrock geology of the Analysis area has been fully mapped this specific information can be used in detailed land management applications:

- Stratification of the landscape into different erosional regimes (landslide-prone or highly erodible terrain) for a wide variety of purposes, in particular the delineation of riparian reserves.
- Identification of watershed restoration opportunities and problems.
- Predicting the distribution of special habitats.
- Establishing priorities for road decommissioning or long-term road maintenance needs.
- Provide recommendations for timber harvest practices**.**

Management Opportunities 3.2

The following activities may be implemented to restore and protect soils in the Weaverville Watershed.

- Decrease compaction in the Musser Hill area to acceptable SQS levels.

- Increase soil cover on granitics by lop and scatter fuels especially on south and west facing slopes.
- Increase LWD on nongranitic soils on south and west facing slopes.
- Masticate brush fields instead of burning to retain soil cover and return nutrients.

Appropriate treatment techniques to protect soil resources during projects are:

Adherence to the Region 5, Soil Quality Standards for land management (SQS, 1995) i.e.

- Soil Stability – Soil Cover and Erosion Standards
- Soil Hydrology – Soil Compaction and Porosity Standards
- Nutrient Cycling – Soil Fertility and Nutrient Banks Standards

Adherence to the Region 5, Water Quality Best Management Practices (BMP, 2000) i.e.

- Timber Management Practices – Index 12.11
- Vegetation Manipulation Practices – Index 12.51
- Fire and Fuel Management Activities – Index 12.61

Management Opportunities 3.3

The following recommendations were developed using findings from this CWE analysis, the Trinity River TMDL (EPA, 2001), and the priorities of the Trinity Management Council.

The following actions may be implemented to improve the condition of watersheds within the Weaverville Watershed analysis area:

- Perform a comprehensive sediment budget and sediment source analysis for the following watersheds in order of priority: Rush Creek, Little Browns Creek, West Weaver Creek, and East Weaver Creek.
- Inventory, implement, and track watershed improvement needs on Forest Service lands.
- Cooperate and participate with the Trinity River Management Council, Trinity River Restoration Program, and the Trinity County Resource Conservation District.
- Work with private timber companies to improve harvest practices and road management.
- Reduce probability of large high burn severity wildland fire by reducing fuel load on a landscape scale.
- Evaluate and limit effects of suction dredge operations in stream reaches that overlap spawning sites.
- Evaluate and limit effects of storm water runoff from Weaverville and other urban areas.
- Evaluate and implement water conservation practices in Weaverville and other urban areas.
- Evaluate and stabilize existing mass wasting features where possible.

- Prevent new mass wasting features by using geoscience and geotechnical experts to help locate and design new roads, timber harvest units, prescribed fires, and urban development.
- Upgrade culverts to pass the 100-year flood event and allow fish passage.
- Reduce road diversion potential by upgrading, maintaining, or decommissioning roads.
- Limit new road construction.
- Design new roads to current standards and best management practices.

Issue #4: Aquatic Systems and Species

Management Opportunities 4.1

The following actions may be implemented to improve the condition of aquatic habitat within the Weaverville Watershed analysis area:

- Manage Riparian Reserve vegetation to promote tree growth and maintain riparian function.
- Use instream habitat structures to create complex habitat were Riparian Reserve function is impaired and stream channels are stable.
- Modify man-made migration barriers to allow anadromous fishes full access to the watersheds.
- Decommission roads within Riparian Reserves; priority should be give to roads near stream reaches occupied by anadromous fishes.
- Reduce cumulative watershed impacts to restore a more natural flow regime.

Issue #5: Terrestrial Wildlife Habitat and Species

Management Opportunities 5.1

The following activities may be used to meet the intent of the 15 percent retention standard and guideline and to maintain our options for meeting this S&G into the future within the Weaverville Watershed:

- The GIS databases used for this analysis are an appropriate “coarse grain’ tools for landscape level (i.e., 5th field watershed) analyses. At the project level, individual stands proposed for treatment should be examined to determine what ecological role they are filling related to old-growth habitat.
- Defer timber harvesting in all 4G and 4N stands (2,300 acres). These stands are likely the highest quality old-growth habitat and currently comprise only 11 percent of the watershed. Timber harvesting may become appropriate within

these stands that lie within MATRIX when we can demonstrate that other 3G stands are meeting the ecological roles of old-growth habitat.

- Prescriptions designed to reduce fuel ladders within 4G and 4N stands may be appropriate in strategically located areas where community fire protection is a concern. Prescriptions should be designed to maintain LSOG conditions to the extent practicable. *For example, areas of Musser Hill in the Browns Integrated Project Area*.

Management Opportunities 5.2

The following activities may be used to maintain and improve deer habitat within the Weaverville Watershed:

- The GIS databases used for this analysis are an appropriate "coarse grain' tools for landscape level (i.e., 5th field watershed) analyses. At the project level, individual areas proposed for treatment should be examined to determine current conditions and appropriate treatments related to deer habitat.
- Defer timber harvesting in all 4G and 4N (i.e., old-growth) stands (2,300 acres). With the large deep-crowned conifers, these stands are likely the highest quality deer cover habitat and currently comprise only 11 percent of the watershed. Timber harvesting may become appropriate within these stands that lie within MATRIX when we can demonstrate that other younger stands are meeting the ecological roles of old-growth habitat.
- Utilize prescribed burning or mechanical methods (e.g., mastication) within existing decadent foraging habitat to stimulate new nutritious growth and improve access for deer (see Gartner 1991).
- Thin around existing viable black oak within conifer stands to maintain and improve acorn production.
- Give priority to treatments within deer winter range.

Issue #6: Fire, Fuels, and Air Quality

Management Opportunities 6.1

Reduce Hazardous Fuel

- Reduce the total number of acres at risk to severe wildland fire.
- Ensure communities most at risk in the wildland-urban interface receive priority for hazardous fuels treatment.
- Expand and improve integration of the hazardous fuels management program to reduce severe wildland fires to protect communities and the environment.
- Incorporate public health and environmental quality considerations in fire management activities undertaken for the hazardous fuels management program.

- Develop smoke management plans in conjunction with prescribed fire planning and implementation.
- Develop strategies to address fire-prone ecosystem problems that augment fire risk or threaten sustainability of these areas.
- Assure maintenance of areas improved by fuels treatment by managing activities permitted on the restored lands to maintain their resiliency.
- Conduct and utilize research to support the reduction of hazardous fuels in wildland urban interface communities and environments.
- Ensure local environmental conditions are factored into hazardous fuels treatment planning.

Promote Community Assistance

- Reduce the losses to communities and individuals from wildland fire.
- Promote markets for traditionally underutilized wood as a value-added outlet for by-products of hazardous fuel reduction and ecosystem restoration efforts.
- Increase incentives for private landowners to address defensible space and fuels management needs on private property through local land use policies.
- Promote local government initiatives to implement fire-sensitive land use planning.
- Promote public knowledge and understanding of wildland fire, including risks and the role of fire in natural ecosystem processes.

The Shasta-Trinity Forest Standards and Guidelines as described in the Land and Resource Management Plan (SHF-LRMP) for this specific land allocation that pertains to fire and fuels states:

- Remove only biomass material that is in excess of that required to meet the standards for soil quality, wildlife diversity, and natural fire regimes (pg. 4-15, LRMP # 3).
- Assess brush fields for multi-resource management opportunities such as the natural fire regime (pg. 4-16, LRMP # 5).
- Plan and implement fuel treatments emphasizing those treatments that will replicate fires natural role in the ecosystems (pg. 4-18, LRMP # 8d).
- Natural fuels will be treated in the following order of priority: (1) public safety; (2) high investment situations (structural improvements, powerlines, plantations, etc.); (3) known high fire occurrence areas; and (4) coordinated resource benefits, i.e., ecosystem maintenance for natural fire regimes (pg. 4-18, LRMP # 8e).
- Consider fuelbreak construction investments when they compliment Forest health/biomass reduction needs, very high and extensive resource values are at risk, and to protect Forest communities (pg. 4-18, LRMP # 8f).

To implement the above fuels management goals and directions, **fuel management zones** have been designated for the proposed Brown's project area. See map 5 for the specific locations that following management prescriptions may be applied.

Management prescriptions by fuel management zones in closed timber (< 40 % Slope) for the proposed Brown's project.

Fuel Management Zone 0-150 feet	**Fuel Management Zone 150-300 feet**	**Fuel Management Zone 300-450 feet**	**Fuel Management Zone 450-600 feet**
Desired "light" Fuel Model 8. Cut all conifers <12"on 20' spacing. Pile activity slash and natural fuels >10 hr. and <20" and burn. Cut suspended logs to ground level. Thin hardwoods to 10' spacing. Fuelwood utilization. Minimum canopy closure of 40%	Desired Fuel Model 8. Cut all conifers <10" on 20' spacing. Cut dead hardwoods and snags to 24" Cut suspended logs to ground level. Pile activity slash and natural fuels >10hr. and <20" and burn. Cut and burn all brush species. Minimum canopy closure of 40%.	Desired Fuel Model 8. Cut all conifers <8" on 20' spacing. Pile activity slash and natural fuels >3" and <20" and burn. Thin brush species. Cut suspended logs to ground level. Retain snags >24" Minimum canopy closure of 40%.	Desired Fuel Model 8. Cut all conifers <4" on 20' spacing. Cut snags to 10" Lop and scatter slash (buck to 8' and limb to 18"). Spot burn fuel concentrations.

Management prescriptions by fuel management zones for closed timber and brush areas (>40% Slope) for the proposed Brown's project.

Fuel Management Zones	**0-600 feet-Timber**	**0-600 feet-brush**
	Desired Fuel Model 8. Masticate 30' to as far as possible. Cut all conifers <6" on 20' spacing. Lop and scatter slash (buck to 8' and limb to 18") and pile where feasible. Minimum canopy closure of 40%.	Masticate as far as possible. Spot burn concentrations.

Management prescriptions for roadside fuel management zones on Rush Creek road for the proposed Brown's project.

Fuel Management Zones	**0-150 feet Riparian Reserve**	0-150 feet (< 25% slopes) **Non-riparian Reserve**	**0-150 feet (>25%) Decomposed Granite Slopes**
	Desired "light" Fuel Model 8. Cut all conifers <6" on 16' spacing. Pile activity slash and natural fuels >10 hr. and <20" and burn. Retain brush species.	Desired "light" Fuel Model 8. Cut all conifers <10" on 16'spacing. Thin brush species, pile and burn. Cut and remove dead and dieing hazard trees that compromise fire fighter and public safety. Pile activity slash and natural fuels >10 hr and <20" and burn. Fuelwood utilization.	Desired "light" Fuel Model 8. Cut all conifers <6" on 16' spacing. Lop and scatter to meet soils requirements; pile and burn on benches if available. Retain material >4"

Management prescriptions for roadside fuel management zones on Highway 3 for the Brown's project.

Fuel Management Zones	**0-150 feet Timber**	**0-150 feet** Brush
	Desired "light" Fuel Model 8. Cut all conifers <12" on 20' spacing. Pile activity slash and natural fuels >10 hr. and <20" and burn. Cut dead hardwoods. Cut and remove dead and dieing hazard trees that compromise fire fighter and public safety. Thin hardwoods to 10' spacing. Cut and burn all dry site brush species. Fuelwood utilization.	Desired "light" Fuel Model 5. Cut, pile, and burn brush to meet Fuel Model 5 specifications (leave scattered brush species required for soil stabilization). Cut all dead oaks and snags. Cut oak clumps to 1 to 2 main stems. Cut and remove dead and dieing hazard trees that compromise fire fighter and public safety. Prune conifers to 7' or 50% of total height.

Issue #7: Plant Communities

Management Opportunities 7.1

- Reduce fuel loadings in conifer plant communities to reduce the risk of stand-replacement fire in habitat for mountain and Brownie lady slipper, English Peak greenbriar and Canyon Creek stonecrop habitat.

Management Opportunities 7.2

- Discourage creation of user-created trails to reduce creation of habitat suitable for invasive weeds and reduce ignitions of human-caused wildfires.
- Develop a designated trail plan that will lessen impacts to soil and will reduce spread of invasive weeds
- Use signs to provide information to off-road vehicle and other recreational users on weed introduction and spread.

REFERENCES

A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment. 10-Year Comprehensive Strategy. August 2001.

Agee, James K. 1993. Fire Ecology of Pacific Northwest Forests. Island Press, Suite 300, 1718 Connecticut Avenue, NW, Washington, DC, 20009.

Behave Plus Fire Modeling System. Version 2.0.2. USDA Forest Service, Rocky Mountain Research Station Systems For Environmental Management.

Cohesive Strategy, 2000. *Protecting People and Sustaining Resources in Fire-Adapted Ecosystems.* The Forest Service Management Response to the General Accounting Office Report GAO/RCED-99-65, October 13, 2000.

Department of Water Resources, 1980. Trinity River watershed erosion investigation. State of California, Department of Water Resources, Northern District.

EPA, 2001. Trinity River Sediment Total Maximum Daily Load. USEPA Region IX.

FEIS. 2003. www.fs.fed.us/database/feis/. Fire Effects Information System. USDA Forest Service.

Fire Management Analyst Plus (FMA+). *Dead and Down Woody Inventory*, version 1.2.38 and *Crownmass* version 1.1.107. Fire Program Solutions/Acacia Services, 1999, 2000, 2001.

Haskins, D.M., 1983. An overview of the use of cumulative watershed impact analysis, Shasta-Trinity National Forest, internal publication.

Haskins, D.M., 1986. A management model for evaluating cumulative watershed effects. In: Proceedings from the California Watershed Management Conference, West Sacramento, CA, November 18-20, 1986, pp. 125-130.

Key, Jennifer. 2000. *Effects of Clearcuts and Site Preparation on Fire Severity, Dillon Creek Fire 1994.* A Thesis Presented to The Faculty of Humboldt State University…Master of Science In Natural Resources: Forestry. May 2000.

National Wildfire Coordinating Group (NWCG). 1996. *Glossary of Wildland fire Terminology.*

Omi, Philip N. and Martinson, Erik J. 2002. *Effect of Fuels Treatment on Wildfire Severity- Final Report*. Submitted to the Joint Fire Science Program Governing Board. March 25, 2002.

Shasta-Trinity Land and Resource Management Plan (SHF- LRMP). USDA Forest Service, Pacific Southwest Region.

Skinner, C. N., and C. Chang. 1996. *Fire Regimes, Past and Present*. *In Sierra Nevada Ecosystem Project : Final Report to Congress*, vol. II, chap. 38 Davis University of California, Center for Water and Wildland Resources.

USDA. Forest Service. 1994 Record of Decision and Standards and Guidelines for management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. Portland Oregon.

USDA Forest Service, 1994. Final Environmental Impact Statement, Shasta-Trinity National Forests Land and Resource Management Plan. Pacific Southwest Region.

USDA Forest Service, 2000. Water Quality Management for Forest System Lands in California, Best Management Practices. Pacific Southwest Region.

USDA Forest Service. 2000. Water Quality Management for National Forest System Lands in California – Best Management Practices. Pacific Southwest Region, Vallejo, California – section 12.6.

USDA Forest Service. 1995. Soil Quality Standards. In: FSH 2509.18, R5 Supplement 2509.18-95-1, Ch. 2, Section 2.2.

Weatherspoon P. C. 1996 and Skinner C. N. *Sierra Nevada Ecosystem Project* report to Congress, vol. II *Assessment and scientific basis for management options*. Davis: University of California, Center for Water and Wildland Resources.

Appendix A: Browns Area RAP

Executive Summary

A. Project Proposals

The proposed activities within the Browns area include some additional roads to access unroaded areas and for the decommissioning/obliteration of existing non-system roads and trails. Many of those roads and trails have been "user-created" – but have utility as part of proposed modified fuel profile zones, access to managed timber stands, and/or serve to benefit an expanded recreational trail system. This document examines the long term needs and direction of management of the network of roads and trails in the project area.

B. Issues

The high road density of non-system roads, partly resultant from high levels of recreational activity adjacent to Weaverville, and ground disturbing impacts on privately owned land likely combine for a cumulative watershed effect approaching or exceeding the threshold of concern – Associated effects to stream channels and aquatic habitat are directly related to this water quality issue.

Most of the area under consideration is within a Wildland-Urban Interface (WUI); thereby introducing community fire protection needs as an important issue to affect project proposals.

The project area is within the Weaverville/Lewiston management area as identified in the Forest Plan. Specific management prescriptions are dominated by the Roaded Recreation prescription within Matrix Lands – emphasizing vegetation management activities to meet recreation, visual, and wildlife objectives while maintaining healthy and vigorous ecosystems. Relative to this prescription, the management issues for the project include access needs for timber management.

Since the project is adjacent to the town of Weaverville, community members frequently travel through and recreate in the project area. In addition, there is a well-developed trail system within the project area that is "growing" due to increased user-created trails. Therefore, project issues include the need for appropriate management of the roads and trails for public use and recreation.

C. Evaluations Completed

Specialists evaluated the risks and benefits in the subject areas of hydrologic process, water quality, fire and fuels management accessibility needs, timber management, and recreational/social aspects.

D. Management Recommendations

The management recommendations are to obliterate most non-system roads (refer to Table 1), decommission selected system roads, and to improve the condition and maintenance of the system roads to be retained.

Step 1 – Setting Up the Analysis

1-A. Objectives of the Analysis

The initial RAP meeting was held on Tuesday, January 27, 2004. Line Officer Joyce Andersen, Bill Branham, Sam Frink, Dale Stanley, Mike Archibald, Mike Mitchell, Jon Sandstrom, Steve Graves, and Tom Quinn attended this meeting. Joyce identified the "Objective of the Analysis" was to prepare an ISSUE-DRIVEN and FOCUSED road analysis considering the roads affected by the Browns Integrated Project proposal: The analysis would consider: 1) system roads and trails with proposed reconstruction or decommissioning; 2) non-system roads and trails (with "obvious" public use) which may be affected by project related reconstruction and/or decommissioning; and 3) all proposed new construction of roads and trails.

1-B. Interdisciplinary Team Members and Participants

Joyce identified the following core team members: Sam Frink (team leader and addressing Commodity Protection/Timber Management - TM), Dale Stanley (General Public Transportation - GT), Jon Sandstrom (Road-Related Recreation – RR), Steve Graves (Fire Protection – PT), & Loren Everest (Water Quality, Fishery Habitat, Riparian Zones – AQ).

1-C. Information Needs

Since much of the background analysis information considered necessary to make an informed decision on the road system had been captured in the 2003 OHV inventory and the ongoing field reviews for the planned Browns Integrated Project, the line officer directed the core team to identify specific information needs and questions to be answered.

The core team was directed to review the 71 questions in Chapter 5 and the Resource Risks and Benefits table in Chapter 6 to aid in identifying needs and questions subject to approval by the line officer.

Area maps with road locations and identifiers for non-system roads were needed. Coordination between Dale Stanley, Karol McGuire, Lindsay Large, and Mike Archibald was necessary to produce the appropriate map for the RAP.

Tables to document the road-by-road analysis were identified as a need that would be provided to the core team by transportation planner Dale Stanley.

1-D. Analysis Plan

Since this RAP is being prepared subsequent to the initiation of the planning process for the Browns Integrated Project, the RAP is being adopted into the final stages of the NEPA process. NEPA completed for the project area has already included public involvement through the scoping process, an inventory of the area and road system, and review of the project area by an interdisciplinary team. As such, the projected timeline for completing the six steps is proposed to reach completion prior to the Notice for Comment for the Browns Integrated Project EA.

Step 2 – Describing the Situation

2-A. Existing Road System and Access Needs

In general, the existing road system consists of 55 segments of system roads, 5 segments of planned system roads, and 78 segments of inventoried non-System roads (additional non-system roads are expected to be identified as field surveys continue). The system roads provide the access to trailhead features, permitted uses, interspersed Sierra Pacific land holdings, other private inholdings, recreational hunting and woodcutting opportunities, and National Forest management activities. This document should be viewed as a companion to the Weaverville Watershed Analysis (WA), which contains much more detailed project area descriptions and settings. The primary resource uses are recreation, due to proximity to the population center, with primary feature being the Weaver Basin Trail, with the remainder of the resource needs including plantation tending, fire access, and timber management activities.

In addition, the existing trail system consists of 16 segments of system trails and 48 segments of inventoried non-System trails (additional non-system trails are expected to be identified as field surveys continue).

2-B. Data Needs and Sources

Identification of non-system roads & trails and the information about access needed for permitted uses and private land owners was assembled using local knowledge, field verification, and a search of Special Use Permits. It was made into a GIS coverage to facilitate analysis efficiency.

2-C. Map of the existing project area and road system

The project area map is included in the project file including the WA and RAP.

Step 3 – Identifying Issues

3-A. Issue Summary

For this streamlined RAP, the line officer has determined that the categories of issues to be considered are:

1. Water Quality, Fishery Habitat, Riparian Zones
2. Community Fire Protection needs
3. Commodity Production/Timber Management
4. Traditional Recreational Uses and Weaver Basin Trail
5. General Public Transportation

To address the Issues specific to this project in the context of RAP, the line officer identified the following RAP Questions from the Project Level Handbook to be answered:

Questions AQ(2), AQ(4), AQ(6), and AQ(9) to be addressed by Loren Everest
Questions PT(1), PT(2), and PT(3) to be addressed by Steve Graves
Question TM(3) to be addressed by Sam Frink
Question GT(3) to be addressed by Dale Stanley
Questions RR(4) and RR(5) to be addressed by John Sandstrom

The questions are answered in tabular form on the attached Tables 1 through 3, and are incorporated in the narrative in the section "Ability of the Road System to Meet Objectives."

Step 4 – Assessing Benefits, Problems, and Risks

4-A. Current Road System Benefits, Problems, and Risks

The project area currently has a high density of roads & trails with many user-defined roads & trails that lack engineered drainage structures. The current roads and trails benefit access to the area for public recreation, woodcutting, and fire suppression. Periodic timber harvest opportunities are benefited from the existing road system.

Roads in the Weaverville Watershed have a profound influence on stream systems and aquatic habitats. Road densities are very high in many areas of the watershed leading to changes in timing, magnitude and duration of stream flow. These changes, coupled with surface erosion and disruption of physical channel dynamics, have greatly reduced the quality of aquatic habitat in most areas of the watershed.

4-B. Ability of the Road System to Meet Objectives

This section of the RAP addresses the issues to be considered as identified by the line officer.

<u>Water Quality, Fishery Habitat, Riparian Zones</u>

Questions AQ(2), AQ(4), AQ(6), and AQ(9) have been consolidated to address the question of "How does the road system affect surface erosion, aquatic habitat, and water quality and quantity?"

The primary factor evaluated for each road is the percent of road located in the Riparian Reserve. Roads located close to stream channels have the greatest chance of delivering surface erosion to streams, influencing stream channel migration, connecting hydrologicly, and disrupting the input of large woody debris.

Steelhead and Coho salmon are commonly found in streams of the Weaverville watershed. Chinook are found only in years of early heavy rainfall. No physical barriers to adult salmonid migration are found on forest system or non-system roads however altered flow timing reduces migration windows at the beginning of adult migration and end of juvenile out migration.

Decommissioning of roads near channels will directly benefit stream channels by reducing the input of sediment and allowing natural channel forming processes to resume. Decommissioning roads throughout the watershed regardless of location will benefit streams by restoring a more natural flow regime.

Community Fire Protection needs

PT(1) How does the road system affect fuels management?

Fuel Management Zones are planned for Forest Service Roads 34N95, 34N95C, 34N95E, 33N39, and U34N96D. These roads are strategically located along ridge tops and allow access for the construction and maintenance of the proposed fuel management zones. A 545-acre wildlife forage enhancement and mechanical fuels reduction project is planned for the Weaver Basin Trail area in sections 30 and 31. The only road access to this area is the unclassified road system located off County Road 236 in the southeast corner of section 31. The funding needed to implement and maintain these projects and future fuels project opportunities would increase dramatically if road access to the area was no longer available.

PT(2) How does the road system affect the capacity of the Forest Service and cooperators to suppress wildfires?

The Forest Service and cost share road system provides the only access to a majority of the analysis area. The county and state road systems typically follow drainages and afford little strategic value for suppression forces. The fuels surrounding Weaverville are in a highly flammable state as demonstrated by the 2001 Oregon Fire. The Forest Service roads allow federal, state, and county suppression forces access to reported wildfires. The road system is an intricate part of the proposed fuel management zones. The effectiveness of these fuel management zones decreases significantly with limited accessibility; ground based suppression forces need good access to be effective.

PT(3) How does the road system affect risk to firefighters and to public safety?

The roads being analyzed are within close proximity to the town of Weaverville. Weaverville is designated as a "Community at Risk" in the National Fire Plan. Individual residences and small communities are also located within the analysis boundary. The level of fire protection that agencies can provide for public safety is directly dependent upon the ability to access a wildfire in a timely manner. The road system reduces the amount of exposure to firefighters by allowing more fires to be contained at the initial attack stage and at a relatively small size. In most all circumstances, utilizing roads as planned escape routes enhances the safety of firefighters.

Commodity Production/Timber Management

TM(3) How does the road system affect access to timber stands needing silvicultural treatment?

Timber land access is needed roughly every 10 years for planned timber harvest activities throughout the RAP area. In addition, annual access is needed for timber stand tending analysis and timber salvage opportunities. With the exception of the areas accessed by roads proposed for new construction (34N47, 34N47A, 34N87, 34N87A, and 34N88), the RAP area is adequately accessed for planned silvicultural treatments (assuming non-system roads are available to be used).

Traditional Recreational Uses and Weaver Basin Trail

RR (4) Who participates in roaded recreation in the areas affected by road constructing, changes in road maintenance, or road decommissioning?

The participants of roaded recreation in the Browns Integrated Project area are primarily local users. There is a wide age range among the users, while the gender is predominately male. The participants are generally in small groups or solo, but sometimes take part as a family group.

The road-related recreation includes motorized recreation with motorcycle, quads, 4x4, and touring vehicles on system roads – as well as access by OHV's for off-road travel. Other activities related to roaded recreation are horse riding, hiking, biking, jogging, hunting, sightseeing, historical exploring, and occasional dispersed camping.

The road system also provides access to the Weaver Basin Trail system. There have been commercial mountain bike races utilizing portions of the road system and the Weaver Basin trail system. The participants of the mountain bike races are mostly seasoned racers from out of the area.

RR(5) What are these participants' attachment to the area, how strong are their feelings, and are alternative opportunities and locations available?
The participants' attachment to the area is deep-seated and concerned. The Browns Integrated Project is adjacent to Weaverville and the proximity puts the study area in the communities 'back-yard.' Many of the roads in the area have provided access for many

unauthorized recreation uses of National Forest lands: a gun range in Sidney Gulch; organized paintball games; and traditional party spots for teenagers. The roads have also provided access for illegal dumping of vegetation and trash, and unmanaged recreation with OHV use. Many people in the community are accustomed to doing whatever they want in the area, without regard health and safety or resource issues.

There are no other opportunities on public lands adjacent to town for unauthorized and/or unmanaged types of recreation (paintball play / OHV use). There are opportunities to improve the Weaver Basin Trail system, and to develop some limited OHV routes in the Browns Integrated Project area.

General Public Transportation

GT (3): How does the road system affect managing roads with shared ownership or with limited jurisdiction?

State Highways 299 west and 3 are both found within the perimeter of the assessment area. In addition, Trinity County roads 236, 228, 230, 232, 229, and 204 are also located within the boundary. All of these are under the jurisdiction of the respective State and County government agency. They are part of the transportation system in that they lead to the National Forest road network.

The only adjacent corporate landholder is Sierra Pacific Industries (SPI). Many of the roads with the assessment area are cooperatively owned. The government manages them. Maintenance and repair are jointly shared. Upgrades must be jointly agreed upon. Decommissioning and or obliteration of any co-op roads are seriously frowned upon as the official recorded easements i.e. rights-of-way have been exchanged.

Smaller in holdings are also found within the project boundary. The property owners use Forest Developed road system and unclassified roads to access their properties. Many have no easements or permits.

Also found within the area are unclassified roads. Even though many have existed for many, many years, they were never added to Forest road system network. By today's standard, most are considered to be the problem roads. In several examples utility companies use these routes to access poles and transmission/distribution lines. This RAP recommends closing/decommissioning a high percentage of all identified "U" roads.

Step 5 – Describing Opportunities and Setting Priorities

5-A. Problems and Risks Posed by the Current Road System

The primary risk posed by the current road system is to the cumulative watershed effects (CWEs) and the fisheries resource, as unmaintained non-system roads and trails can be significant contributors of sediment to the streams. In addition, unregulated travel on those roads can degrade the quality of experience to hikers on the trail system.

5-B. Opportunities for Road Management

The segment-by-segment description of the management opportunities is displayed on Table 3. In general, the recognized opportunities for road management are to improve the road surfaces of system roads and to eliminate roads and trails that are in excess of management and/or resource protection objectives.

5-C. Recommendations

It is recommended that the management opportunities on Table 3 be met by moving toward the "Recommended Road Status" as displayed on Table 1. The decommissioning will be delayed on segments needed for implementation of the Browns Integrated Project. The NEPA document will incorporate these recommendations into the decision.

Project Level Roads Analysis
Current and Recommended Road System Status

Current Road Status							Recommended Road Status				
Road Number	Road Length	Any Agree.	Road Status	Road Main. Level	Surface	Land Use Desig.		Road Length	Road Status	Road Main. Level	Remarks
33N01	0.40	WVC	Gate	2	AGG			0.40	Open	2	WVC Water System-OR RAP
33N38	6.10	SPI	Open	3	AGG			6.10	Open	3	Weaver Bally-Forest RAP
33N38F	0.80	N	Gate@	1	NAT			0.80	Decom	0	NE23
33N39	1.20	SPI	Gate	2	NAT			1.20	Open	2	Glennison Gap
33N39B	0.90	UNK	Gate@	1	NAT			0.90	Open	2	PVT agreement-Beans
33N39D	0.20	N	Gate@	2	NAT			0.20	Decom	0	NW27
33N40	0.14	N	Gate	2	AGG			0.14	Open	2	Bone Yard
33N40A	0.01	N	Gate@	2	AGG			0.01	Open	2	Bone Yard
33N42	1.75	SPI	Gate	2	AGG			1.75	Open	2	Sidney-OR RAP
33N42A	0.35	N	Gate@	2	NAT			0.35	Decom	2	Sidney-OR RAP
33N69	0.16	N	Open	1	NAT			0.16	Open	1	Grub Gulch - OR RAP
33N73	0.10	N	Open	2	AGG			0.10	Open	2	Glennison Ditch-SW2-OR RAP
33N76	0.10	Y	Open	2	AGG			0.10	Open	2	Beans-SW2
34N01Y	1.40	SPI	Gate	2	NAT			1.40	Open	2	Garden Gulch-NW25
34N01YC	0.40	SPI	Gate@	2	NAT			0.40	Open	2	Garden Gulch-NE25
34N05Y	1.62	N	Gate@	2	NAT			1.62	Open	2	Musser Home Site-NW33
34N22	1.30	SPI	Open	2	NAT			1.30	Open	2	Baxter-NE22
34N24	0.57	SPI	Gate	2	AGG			0.57	Open	2	Deer Creek- Non Cost Share-SE26
34N28	1.30	N	Gate	2	NAT			1.30	Open	2	Old County - PUD access-Yellowjacket-SE21
34N28A	0.80	N	Gate@	2	NAT			0.80	Open	2	PUD ACCESS
34N28B	0.30	N	Gate@	2	NAT			0.30	Open	2	Yellowjacket plantation
34N33	0.60	SPI	Gate	2	NAT			0.60	Open	2	S-China-NW27
34N33Y	0.74	SPI	Gate	2	A/N			0.74	Open	2	S27 - Non Cost Share
34N34	3.90	SPI	Gate	2	NAT			3.90	Open	2	East Branch - Microwave access-SW19
34N34A	0.02	N	Gate@	2	NAT			0.02	Open	2	Arbuckle Mine (PVT) & Microwave Access-SE13
34N41	1.00	SPI	Gate	2	NAT			1.00	Open	2	China Area-NW27
34N41A	0.40	SPI	Gate@	1	NAT			0.40	Open	2	China Area
34N41Y	0.10	N	Open	3	AC			0.10	Open	3	Rush Creek Vista
34N42	0.90	SPI	Open	2	AGG			0.90	Open	2	Baxter Ridge-NE22
34N42A	0.20	N	Closed	1	NAT			0.20	Decom	0	Baxter Ridge-NE22-Barrier
34N52Y.1	0.50	N	Open	2	NAT			0.50	Open	2	Long Gulch
34N52Y.2	0.93	N	Closed	I	NAT			0.93	Decom	0	Long Gulch - Closed by Barrier
34N52YA	0.80	N	Gate@	2	NAT			0.80	Open	2	Long Gulch
34N68	1.60	SPI	Gate	2	NAT			1.60	Open	2	Upper Sidney-S26
34N68A	0.50	SPI	Gate	2	NAT			0.50	Open	2	Upper Sidney
34N77	1.30	N	Open	2	AGG			1.30	Open	2	Browns Mtn. - Needs Agreements both PVT & SPI
34N82	1.19	N	Gate	2	NAT			1.19	Open	2	Monument S13
34N82A	0.40	N	Gate	2	NAT			0.40	Open	2	Monument NE24
34N83	1.00	SPI	Gate@	2	NAT			1.00	Open	2	S24
34N83A	0.30	N	Gate@	1	NAT			0.30	Decom	0	S24-Currently Bermed & Overgrown
34N83B	0.30	N	Gate@	2	NAT			0.30	Decom	0	S24-Currently Bermed & Overgrown
34N89	0.90	N	Gate	2	NAT			0.90	Decom	0	Low Gap-S23
34N89A	0.40	N	Gate@	2	NAT			0.40	Decom	0	Low Gap-S23
34N95	5.50	SPI	Gate	3	A/N			5.50	Open	3	Musser Hill-Forest RAP
34N95A	0.70	N	Closed	1	NAT			0.70	Decom	0	MusserHill-Barrrier
34N95B	0.30	N	Closed	1	NAT			0.30	Decom	0	Musser Hill-Barrier S32
34N95C	0.40	N	Closed	1	NAT			0.40	Decom	0	Musser Hill-Barrier S20

Project Level Roads Analysis
Current and Recommended Road System Status

Current Road Status							Recommended Road Status				
Road Number	Road Length	Any Agree.	Road Status	Road Main. Level	Surface	Land Use Desig.		Road Length	Road Status	Road Main. Level	Remarks
34N95E	0.60	N	Closed	1	NAT			0.60	Decom	0	Musser Hill- Barrier S28
34N95F	0.27	N	Closed	1	NAT			0.27	Decom	0	Musser Hill - Barrier S29
34N95G	0.20	SPI	Gate@	2	NAT			0.20	Open	2	Musser Hill - Barrier S18
34N96	1.69	N	Gate	2	NAT			1.69	Open	2	North Roundys
34N96A	0.80	N	Open	2	NAT			0.80	Open	2	S17
34N96B	0.55	N	Open	2	NAT			0.55	Decom	0	S20/21-last .10 miles behind barrier
34N96C	0.60	N	Open	2	NAT			0.60	Decom	0	S20/21
34N99	0.20	N	Open	3	AGG			0.20	Open	3	East Weaver CG
U09W95A	0.0917	N	Gate@	0	NAT			0.0917	Decom	0	NE2
U228A	0.9570	UNK	Open	2	NAT			0.9570	Open	2	East Branch-Home Access
U230A	0.2890	UNK	Open	0	NAT			0.2890	Decom	0	Old Homesite-Sorensen Well-NE33
U232A	0.4255	N	Open	0	NAT			0.4255	Decom	0	Off S. Roundy-NE33
U232B	0.1480	N	Open	0	NAT			0.1480	Decom	0	Head Gate-SW28
U236A	0.6310	UNK	UNK	0	NAT			0.6310	Open	2	Off Airport Road-SE31-Add to system
U236AA	0.1445	UNK	UNK	0	NAT			0.1445	Decom	0	5 Cent Gulch-SE31
U236AB	0.1742	UNK	UNK	0	NAT			0.1742	Decom	0	
U236AC	0.1665	UNK	UNK	0	NAT			0.1665	Decom	0	
U236AD	0.4263	UNK	UNK	0	NAT			0.4263	Decom	0	
U33N01A	0.2938	N	Gate@	2	NAT			0.2938	Decom	0	OR RAP - Shown as 09W84 - Moon Lee Ditch - S2 ,Convert Road to Trail
U33N01B	0.3248	N	Gate@	0	NAT			0.3248	Decom	0	OR RAP
U33N01BA	0.1730	N	Gate@	0	NAT			0.1730	Decom	0	OR RAP
U33N01C	0.0332	UNK	Gate@	0	NAT			0.0332	Decom	0	WVC Water Intake-OR RAP
U33N01K	0.4296	N	Open	0	NAT			0.4296	Decom	0	OR RAP
U33N38A	0.5290	UNK	Gate	0	NAT			0.5290	Open	0	Garden Gulch S36-PVT Access
U33N38B	0.4323	N	Open	0	NAT			0.4323	Decom	0	OR RAP-McKinzey-SW1
U33N38D	0.1019	N	Open	0	NAT			0.1019	Decom	0	Paintball-NW1
U33N38E	0.0847	N	O/C	0	NAT			0.0847	Decom	0	OR RAP-Shown as 09W86-NW1
U33N38F	0.2753	N	UNK	0	NAT			0.2753	Decom	0	NE S1
U33N38G	0.1029	UNK	UNK	0	NAT			0.1029	Decom	0	NE1
U33N42C	0.0181	N	Gate@	0	NAT			0.0181	Decom	0	NW1
U33N42R	1.8040	UNK	Gate@	0	NAT			1.8040	Decom	0	OR RAP- Greasey Loop
U33N42RD	0.0477	N	Gate@	0	NAT			0.0477	Decom	0	OR RAP
U34N05YA	0.0213	N	Gate@	0	NAT			0.0213	Decom	0	SW S28
U34N05YB	0.0328	N	Gate@	0	NAT			0.0328	Decom	0	Musser SW 28
U34N05YC	0.1259	N	Gate@	0	NAT			0.1259	Decom	0	NE32
U34N05YD	0.0330	No	Open	0	NAT			0.0330	Decom	0	
U34N05YE	0.1290	No	Open	0	NAT			0.1290	Decom	0	
U34N22A	0.1520	No	Open	0	NAT			0.1520	Decom	0	
U34N33YA	0.4890	No	Open	0	NAT			0.4890	Decom	0	NE27
U34N34B	0.8210	UNK	Gate@	0	NAT			0.8210	Decom	0	NE18
U34N42B	0.0810	No	Open	0	NAT			0.0810	Decom	0	
U34N42C	0.2370	No	Open	0	NAT			0.2370	Decom	0	
U34N52YAA	0.0580	No	Open	0	NAT			0.0580	Decom	0	
U34N52YB	0.3370	N	Gate@	0	NAT			0.3370	Decom	0	NW33
U34N52YC	0.5820	N	Gate@	0	NAT			0.5820	Decom	0	NW33
U34N52YCA	0.0440	N	Open	0	NAT			0.0440	Decom	0	NW33

Project Level Roads Analysis
Current and Recommended Road System Status

Current Road Status							Recommended Road Status				
Road Number	Road Length	Any Agree.	Road Status	Road Main. Level	Surface	Land Use Desig.		Road Length	Road Status	Road Main. Level	Remarks
U34N52YCB	0.0440	N	Open	0	NAT			0.0440	Decom	0	NW33
U34N52YD	0.9230	N	Open	0	NAT			0.9230	Decom	0	
U34N52YE	0.0550	No	Open	0	NAT			0.0550	Decom	0	NW33
U34N52YF	0.1440	No	Open	0	NAT			0.1440	Decom	0	
U34N52YG	0.0260	No	Open	0	NAT			0.0260	Decom	0	NW33
U34N77A	0.3778	UNK	Open	0	NAT			0.3778	Decom	0	SE 33 Along Browns CR-PUD Access
U34N77AA	0.5555	No	Open	0	NAT			0.5555	Decom	0	SW34
U34N77AAB	0.0292	No	Open	0	NAT			0.0292	Decom	0	Homesite Bypass
U34N77AB	0.0180	No	Open	0	NAT			0.0180	Decom	0	SE33-PUD
U34N77B	0.1566	No	Open	0	NAT			0.1566	Decom	0	Sorensen Water Tank
U34N77C	0.1700	No	Open	0	NAT			0.1700	Decom	0	Cabin Site-SW34
U34N77CA	0.0572	No	Open	0	NAT			0.0572	Decom	0	SW34
U34N77CB	0.0329	No	Open	0	NAT			0.0329	Decom	0	SW34
U34N77D	0.2700	No	Open	2	AGG			0.2700	Open	0	Private Home Access-SE34
U34N95A	0.2216	No	UNK	0	NAT			0.2216	Decom	0	Musser-NE29
U34N95A2	0.0440	No	Closed	0	NAT			0.0440	Decom	0	NW20
U34N95A4	0.0730	No	Closed	0	NAT			0.0730	Decom	0	NW20
U34N95AA	0.4016	UNK	UNK	0	NAT			0.4016	Decom	0	Musser-NE29
U34N95AB	0.0290	N	Open	0	NAT			0.0290	Decom	0	SW33
U34N95B	0.3114	N	UNK	0	NAT			0.3114	Decom	0	Musser-NE29
U34N95C	0.7840	N	Open	0	NAT			0.7840	Decom	0	NW21
U34N95H	0.5623	N	Open	0	NAT			0.5623	Decom	0	Musser SW33
U34N95I	0.2449	N	Open	0	NAT			0.2449	Decom	0	Musser-SE32
U34N95I	0.4830							0.4830			
U34N95J	0.4961	N	Open	0	NAT			0.4961	Decom	0	Musser-NE29
U34N95JA	0.1340	N	Open	0	NAT			0.1340	Decom	0	E1/2, S29
U34N95JAA	0.0390	N	Open	0	NAT			0.0390	Decom	0	E1/2, S29
U34N95K	0.1331	N	Open	0	NAT			0.1331	Decom	0	Musser-NE29
U34N95L	0.0394	N	UNK	0	NAT			0.0394	Decom	0	Musser-SE29
U34N95M	0.2263	N	Open	0	NAT			0.2263	Decom	0	Musser-SE32
U34N95N	0.2879	N	Open	0	NAT			0.2879	Decom	0	Musser-NW20
U34N95O	0.8484	N	UNK	0	NAT			0.8484	Decom	0	Musser-SW20
U34N95P	0.0291	N	UNK	0	NAT			0.0291	Decom	0	Musser-WHERE??
U34N95Q	0.1170	No	Open	0	NAT			0.1170	Decom	0	SW20
U34N95S	0.0330	No	Open	0	NAT			0.0330	Decom	0	NE18
U34N95V	0.3140	Yes	Gate	2	NAT			0.3140	Open	2	Fire Escape Gate-RAC-Add to system
U34N95VC	0.0950	No	Open	0	NAT			0.0950	Decom	0	SESE20
U34N95VCA	0.0680	No	Open	0	NAT			0.0680	Decom	0	SESE20
U34N95VCB	0.0360	No	Open	0	NAT			0.0360	Decom	0	SESE20
U34N95W	0.0620	No	Open	0	NAT			0.0620	Decom	0	NWNW20
U34N95Z	0.0360	No	Open	0	NAT			0.0360	Decom	0	NWNW20
U34N96	0.2900	No	Open	2	NAT			0.2900	Close	1	SE17
U34N96AA	0.1983	UNK	Open	0	NAT			0.1983	Open	2	N. Roundy SE17
U34N96AB	0.0838	UNK	Open	0	NAT			0.0838	Decom	0	N. Roundy SE17
U34N96AC	0.2295	UNK	Open	0	NAT			0.2295	Decom	0	N. Roundy SE17
U34N96AD	0.0421	UNK	Open	0	NAT			0.0421	Decom	0	N.Roundy SE17
U34N96AE	0.0544	UNK	Open	0	NAT			0.0544	Decom	0	N.Roundy SE17

Project Level Roads Analysis
Current and Recommended Road System Status

Current Road Status							Recommended Road Status				
Road Number	Road Length	Any Agree.	Road Status	Road Main. Level	Surface	Land Use Desig.		Road Length	Road Status	Road Main. Level	Remarks
U34N96B	0.2460	No	Closed	0	NAT			0.2460	Decom	0	NE20
U34N96BA	0.0690	No	UNK	0	NAT			0.0690	Decom	0	NE21
U34N96BB	0.1520	No	Open	0	NAT			0.1520	Decom	0	NW21
U34N96BC	0.0540	No	Open	0	NAT			0.0540	Decom	0	NE20
U34N96D	1.0146	No	Barrier	0	NAT			1.0146	Decom	0	N.Roundy-NW21
U34N96E	0.0413	No	Open	0	NAT			0.0413	Decom	0	N.Roundy SW16
U34N96F	0.7025	No	Closed	0	NAT			0.7025	Decom	0	N.Roundy-SE17
U34N96G	0.0400	No	UNK	0	NAT			0.0400	Decom	0	SW21
U34N96H	0.1300	No	UNK	0	NAT			0.1300	Decom	0	NW21
U34N96I	0.3500	No	Open	0	NAT			0.3500	Decom	0	SE17
U34N96J	0.0670	No	Open	0	NAT			0.0670	Decom	0	SW16
U34N96K	0.1400	No	Open	0	NAT			0.1400	Decom	0	SW16
U34N96L	0.1430	No	Open	0	NAT			0.1430	Decom	0	SW16
U3TRI01	0.1271	UNK	Open	0	NAT			0.1271	Decom	0	SE33-PUD
U3TRI01A	0.0568	UNK	Open	0	NAT			0.0568	Decom	0	SE33-PUD
U3TRI02	0.0412	UNK	Open	0	NAT			0.0412	Decom	0	SE33-PUD
U3TRI03	0.5286	UNK	UNK	0	NAT			0.5286	Decom	0	SE32
U3TRI03A	0.2030	UNK	UNK	0	NAT			0.2030	Decom	0	SE32
U3TRI03B	0.1130	UNK	UNK	0	NAT			0.1130	Decom	0	SE32
U3TRI03C	0.0287	UNK	UNK	0	NAT			0.0287	Decom	0	SE32
U3TRI03D	0.0546	UNK	UNK	0	NAT			0.0546	Decom	0	SE32
U3TRI03E	0.0407	UNK	UNK	0	NAT			0.0407	Decom	0	WHERE??
U3TRI03F	0.1554	UNK	UNK	0	NAT			0.1554	Decom	0	SE33-PUD
U3TRI03G	0.0390	UNK	UNK	0	NAT			0.0390	Decom	0	SE32
U3TRI04	0.1450	No	UNK	0	NAT			0.1450	Decom	0	S.Line 21
U3TRI04A	0.0538	No	UNK	0	NAT			0.0538	Decom	0	S.Line 21
U3TRI05	0.1260	No	UNK	0	NAT			0.1260	Decom	0	SW21
U3TRI05A	0.0560	No	UNK	0	NAT			0.0560	Decom	0	S.Half 21
U3TRI06	0.0700	No	Open	0	NAT			0.0700	Decom	0	NE33
								26.1417			
34N47	0.8700	No	PL	0	NAT			0.8700	Decom	2	Planned New Construction-Musser S33
34N47A	0.2900	No	PL	0	NAT			0.2900	Decom	2	" " "
34N87	1.2600	No	PL	0	NAT			1.2600	Restrict	2	Planned New Construction-Browns Mtn-S34
34N87A	0.8900	No	PL	0	NAT			0.8900	Decom	2	" " " " "
34N88	1.2600	No	PL	0	NAT			1.2600	Decom	2	Planned New Construction-The Pond-SE28

Resource Risks and Benefits Table

Project-Level Roads Analysis
Shasta-Trinity National Forest

Road Number	Current Resource Risks (IMPACTS)						**Total Current Environ. Risk Rating**	Current Resource Benefits (ACCESS)								**Total Current Environ. Benefit Rating**
	Aquatic, Riparian	Hydrologic Process	Water Quality	Ecosystem Function	Terrestrial Wildlife	Public Use		Fire Protection	Fuels Management	Air Quality	Ecosystem Function	Commodity Production	Public Use	Social Issues	Access	
33N01	5	5	5			4	**19**	3	1			4			1	**9**
33N38	1	1	2			4	**8**	5	5			5			5	**20**
33N38F	2	3	5			1	**11**	1	1			2			1	**5**
33N39	2	3	3			4	**12**	3	3			2			5	**13**
33N39B	1	1	2			0	**4**	3	3			2			3	**11**
33N39D						4	**4**					1			1	**2**
33N40	1	1	1			0	**3**	3	1			1			1	**6**
33N40A	1	1	1			0	**3**	3	1			1			1	**6**
33N42	5	5	5			3.8	**19**	3	3			3			5	**14**
33N42A	2	2	3			3.3	**10**	3	1			3			1	**8**
33N69	1	1	2			0	**4**	1	3			1			1	**6**
33N73	1	1	1			0	**3**	0	0			1			1	**2**
33N76	1	1	1			0	**3**	3	1			1			3	**8**
34N01Y	1	1	2			3	**7**	3	1			3			5	**12**
34N01YC						1	**1**	1	3			1			5	**10**
34N05Y	1	1	2			3	**7**	3	3			4			1	**11**
34N22	1	2	2			3	**8**	3	3			4			5	**15**
34N24	5	5	5			3	**18**	3	3			1			5	**12**
34N28	1	4	5			0	**10**	3	3			4			1	**11**
34N28A	5	5	5			0	**15**	1	1			3			1	**6**
34N28B	1	1	2			0	**4**	1	1			3			1	**6**
34N33	1	1	1			0	**3**	3	1			2			5	**11**
34N33Y	1	2	3			3	**9**	1	1			3			5	**10**
34N34	1	2	5			3.5	**12**	3	3			4			5	**15**
34N34A	1	1	5			1	**8**	1	1			0			1	**3**
34N41	1	1	2			0	**4**	1	1			3			5	**10**
34N41A	1	1	1			0	**3**	1	1			2			5	**9**
34N41Y	0	1	0			4	**5**	1	1			0			1	**3**
34N42	1	1	1			3	**6**	3	3			5			1	**12**
34N42A	1	1	1			1	**4**	1	1			1			1	**4**
34N52Y.1						3	**3**	3	3			4			1	**11**
34N52Y.2						2	**2**	3	3			2			1	**9**
34N52YA	1	1	3			3	**8**	3	3			4			1	**11**
34N68	1	2	2			2	**7**	3	1			3			5	**12**
34N68A	1	1	1			2	**5**	3	1			2			5	**11**

Resource Risks and Benefits Table

Project-Level Roads Analysis
Shasta-Trinity National Forest

Road Number	Current Resource Risks (IMPACTS)						**Total Current Environ. Risk Rating**	Current Resource Benefits (ACCESS)								**Total Current Environ. Benefit Rating**
	Aquatic, Riparian	Hydrologic Process	Water Quality	Ecosystem Function	Terrestrial Wildlife	Public Use		Fire Protection	Fuels Management	Air Quality	Ecosystem Function	Commodity Production	Public Use	Social Issues	Access	
34N77	1	2	3			3.5	**10**	5	3			4			5	**17**
34N82	1	1	5			1	**8**	3	1			2			1	**7**
34N82A	1	1	5			1	**8**	3	1			2			1	**7**
34N83	1	1	1			1	**4**	3	1			3			5	**12**
34N83A	1	1	1			1	**4**	3	1			2			1	**7**
34N83B	1	1	1			1	**4**	3	1			2			1	**7**
34N89	1	4	5			1	**11**	3	1			2			1	**7**
34N89A	2	5	5			1	**13**	3	1			2			1	**7**
34N95	1	1	2			4	**8**	5	5			5			5	**20**
34N95A	2	2	3			2	**9**	3	3			3			1	**10**
34N95B	1	1	2			1	**5**	1	1			3			1	**6**
34N95C	1	1	3			2	**7**	3	3			3			1	**10**
34N95E	1	2	3			2	**8**	3	5			3			1	**12**
34N95F	1	1	2			2	**6**	1	1			3			1	**6**
34N95G	1	2	2			2	**7**	1	1			3			3	**8**
34N96	5	5	5			3.5	**19**	3	3			5			1	**12**
34N96A	1	2	3			2.5	**9**	3	3			4			1	**11**
34N96B	5	5	5			2.5	**18**	1	1			4			1	**7**
34N96C	5	5	5			2.5	**18**	1	3			3			1	**8**
34N99	5	5	5			4	**19**	1	1			5			1	**8**
							0									**0**
U09W95A	1	1	1			1	**4**	1	1			2			1	**5**
U228A	5	5	5			1	**16**	3	1			2			3	**9**
U230A	5	5	5			1	**16**	1	1			1			1	**4**
U230B						0	**0**	3	1			0			5	**9**
U232A	0	1	1			1	**3**	3	1			2			1	**7**
U232B	0	1	1			1	**3**	1	1			1			1	**4**
U236A	2	2	2			1	**7**	3	3			2			1	**9**
U236AA	5	5	5			1	**16**	1	3			0			1	**5**
U236AB	0	1	1			1	**3**	1	3			0			1	**5**
U236AC	5	5	5			1	**16**	1	3			0			1	**5**
U236AD						1	**1**					0			1	**1**
U33N01A	1	1	1			4	**7**	1	1			1			1	**4**
U33N01B	1	5	2			2	**10**	1	1			1			1	**4**
U33N01BA	1	5	5			2	**13**	1	1			1			1	**4**
U33N01C	1	5	5			3	**14**	1	1			1			1	**4**
U33N01K	3	5	5			1	**14**	1	1			1			1	**4**
U33N38A	1	2	2			1	**6**	3	3			2			1	**9**
U33N38B	5	5	5			2	**17**					1			1	**2**

Resource Risks and Benefits Table

Project-Level Roads Analysis
Shasta-Trinity National Forest

Road Number	Current Resource Risks (IMPACTS)						Total Current Environ. Risk Rating	Current Resource Benefits (ACCESS)								Total Current Environ. Benefit Rating
	Aquatic, Riparian	Hydrologic Process	Water Quality	Ecosystem Function	Terrestrial Wildlife	Public Use		Fire Protection	Fuels Management	Air Quality	Ecosystem Function	Commodity Production	Public Use	Social Issues	Access	
U33N38D	0	1	1			3.5	**6**	3	1			1			1	**6**
U33N38E	1	1	2			2	**6**	3	1			1			1	**6**
U33N38F	1	1	1			2	**5**	1	3			1			1	**6**
U33N38G						2	**2**					1			1	**2**
U33N42C	1	5	5			2	**13**					0			1	**1**
U33N42R	1	1	1			2	**5**	3	3			1			1	**8**
U33N42RD	1	1	1			0	**3**	1	1			0			1	**3**
U34N05YA	1	1	1			3	**6**	1	1			0			1	**3**
U34N05YB						2	**2**	1	1			0			1	**3**
U34N05YC	1	1	1			2	**5**	1	1			2			1	**5**
U34N05YD								1	1			0			1	**3**
U34N05YE								1	1			0			1	**3**
U34N22A								1	1			0			1	**3**
U34N33YA	2	3	4			3	**12**	3	1			2			1	**7**
U34N34B	1	2	2			3	**8**	3	1			2			1	**7**
U34N42B								1	1			0			1	**3**
U34N42C								1	1			0			1	**3**
U34N52YAA								1	1			0			1	**3**
U34N52YB	1	1	1			2	**5**	3	1			2			1	**7**
U34N52YC	1	2	2			2	**7**	1	1			2			1	**5**
U34N52YCA								1	1			0			1	**3**
U34N52YCB								1	1			0			1	**3**
U34N52YD								1	1			0			1	**3**
U34N52YE								1	1						1	
U34N52YF								1	1						1	
U34N52YG								1	1						1	
U34N77A	5	5	5			3	**18**	1	1			2			1	**5**
U34N77AA	5	5	5			3	**18**	1	1			2			1	**5**
U34N77AAB	4	5	5			3	**17**	1	1			0			1	**3**
U34N77AB								1	1						1	
U34N77B	1	2	2			2.5	**8**	1	1			2			1	**5**
U34N77C	1	2	4			2.5	**10**	1	1			2			1	**5**
U34N77CA	1	2	2			2.5	**8**	1	1			0			1	**3**
U34N77CB						2.5	**3**					0			1	**1**
U34N77D	1	1	1			1	**4**	3	1			0			1	**5**
U34N95A	1	1	2			3	**7**	1	1			1			1	**4**
U34N95A2								1	1						1	
U34N95A4								1	1						1	
U34N95AA	1	1	2			2	**6**	1	1			1			1	**4**

Resource Risks and Benefits Table

Project-Level Roads Analysis
Shasta-Trinity National Forest

Road Number	Current Resource Risks (IMPACTS)						Total Current Environ. Risk Rating	Current Resource Benefits (ACCESS)								Total Current Environ. Benefit Rating
	Aquatic, Riparian	Hydrologic Process	Water Quality	Ecosystem Function	Terrestrial Wildlife	Public Use		Fire Protection	Fuels Management	Air Quality	Ecosystem Function	Commodity Production	Public Use	Social Issues	Access	
U34N95AB								1	1						1	
U34N95B	1	1	1			3	**6**	1	1			1			1	**4**
U34N95C								1	1			0			1	
U34N95H	1	2	4			3	**10**	1	3			2			1	**7**
U34N95I	1	2	4			3	**10**	1	3			0			1	**5**
U34N95I								1	1						1	
U34N95J	1	1	2			3	**7**	1	3			2			1	**7**
U34N95JA								1	1						1	
U34N95JAA								1	1						1	
U34N95K	1	1	2			2.5	**7**	1	1			2			1	**5**
U34N95L	1	1	2			2	**6**	1	1			2			1	**5**
U34N95M	1	1	2			2	**6**	1	1			2			1	**5**
U34N95N	1	1	2			2.5	**7**	1	1			2			1	**5**
U34N95O	1	2	2			3	**8**	1	1			2			1	**5**
U34N95P							**0**					0			1	**1**
U34N95Q								1	1			0			1	
U34N95S								1	1						1	
U34N95V								1	1						1	
U34N95VC								1	1						1	
U34N95VCA								1	1						1	
U34N95VCB								1	1						1	
U34N95W								1	1						1	
U34N95Z								1	1						1	
U34N96								1	1						1	
U34N96AA	1	1	2			2.5	**7**	3	1			1			1	**6**
U34N96AB	1	1	2			2.5	**7**	1	1			1			1	**4**
U34N96AC	1	1	2			2.5	**7**	3	1			1			1	**6**
U34N96AD	1	1	2			2.5	**7**	1	1			0			1	**3**
U34N96AE	1	1	2			2.5	**7**	1	1			0			1	**3**
U34N96B								1	1						1	
U34N96BA												0			1	
U34N96BB								1	1						1	
U34N96BC								1	1						1	
U34N96D	1	2	2			2.5	**8**	1	3			0			1	**5**
U34N96E	1	1	2			2	**6**	1	1			0			1	**3**
U34N96F	1	2	2			2.5	**8**	1	3			2			1	**7**
U34N96G												0			1	
U34N96H												0			1	
U34N96I								1	1						1	

Resource Risks and Benefits Table

Project-Level Roads Analysis
Shasta-Trinity National Forest

Road Number	Current Resource Risks (IMPACTS)						**Total Current Environ. Risk Rating**	Current Resource Benefits (ACCESS)								**Total Current Environ. Benefit Rating**
	Aquatic, Riparian	Hydrologic Process	Water Quality	Ecosystem Function	Terrestrial Wildlife	Public Use		Fire Protection	Fuels Management	Air Quality	Ecosystem Function	Commodity Production	Public Use	Social Issues	Access	
U34N96J								1	1						1	
U34N96K								1	1						1	
U34N96L								1	1						1	
U3TRI01	3	3	5			2	**13**	1	1			0			1	**3**
U3TRI01A	3	3	5			2	**13**	1	1			0			1	**3**
U3TRI02	3	3	3			2	**11**	1	1			0			1	**3**
U3TRI03	1	3	5			2	**11**	3	1			2			1	**7**
U3TRI03A	1	2	3			2	**8**	3	1			2			1	**7**
U3TRI03B	1	1	3			2	**7**	1	1			2			1	**5**
U3TRI03C	1	1	2			2	**6**	1	1			0			1	**3**
U3TRI03D	1	1	3			2	**7**	1	1			1			1	**4**
U3TRI03E							**0**					0			1	**1**
U3TRI03F	1	1	3			2	**7**	1	1			1			1	**4**
U3TRI03G	1	1	3			2	**7**	1	1			0			1	**3**
U3TRI04												0			1	
U3TRI04A												0			1	
U3TRI05												0			1	
U3TRI05A								1	1			0			1	
U3TRI05A												0			1	
U3TRI06								1	1						1	
34N47	1	1	2			2	**6**	3	3			2			1	**9**
34N47A	1	1	2			2	**6**	3	3			2			1	**9**
34N87	1	1	2			2	**6**	3	3			2			1	**9**
34N87A	1	1	2			2	**6**	3	3			2			1	**9**
34N88	1	1	2			2	**6**	3	3			2			1	**9**

Project Level Roads Analysis
Management Opportunities and Their Predicted Effects on the Resources

Road Number	Management Opportunities						Effects of Opportunities on the Resources												
	Repair or Upgrade	Decom	Restrict Travel	Change Mtc. Lvl.	Relocate	No action	Aqua, Rip	Hydro Process	Water Qual.	Eco Funct	Terr Wldf	Fire Prot.	Fuels Mgt	Air Qual	Com. Prod.	Public Use	Social	Change in Maint. Costs	Notes
33N01						X						0	0		0	0			
33N38			X									0	0		0	0			Install gate
33N38F		X										0	0		-	0			UNK
33N39						X						0	0		0	0			SPI, fuel break acces
33N39B						X						0	0		0	0			SPI/RW
33N39D		X										-	-		-	-			UNK
33N40						X						0	0		0	0			Bone Yard
33N40A						X						0	0		0	0			Bone Yard
33N42						X						0	0		0	0			OR RAP
33N42A		X										-	0		-	-			OR RAP
33N69						X						0	0		0	0			OR RAP
33N73						X						0	0		0	0			OR RAP
33N76						X						0	0		0	0			OR RAP
34N01Y						X						0	0		0	0			SPI
34N01YC						X						0	0		0	0			SPI, fuel treatment ac
34N05Y	X											+	+		+	+			
34N22						X						0	0		0	0			SPI
34N24						X						0	0		0	0			SPI
34N28	X											+	+		+	+			PUD access
34N28A		X										-	0		-	0			PUD access
34N28B		X										-	0		-	0			Plantation access
34N33						X						0	0		0	0			SPI, Plantation acces
34N33Y						X						0	0		0	0			SPI
34N34						X						0	0		0	0			SPI
34N34A			X									-	0		0	-			Micro Access
34N41						X						0	0		0	0			SPI
34N41A						X						0	0		0	0			SPI
34N41Y						X						0	0		0	0			Rush Cr. Vista
34N42						X						0	0		0	0			SPI

Project Level Roads Analysis
Management Opportunities and Their Predicted Effects on the Resources

Road Number	Management Opportunities						Effects of Opportunities on the Resources												
	Repair or Upgrade	Decom	Restrict Travel	Change Mtc. Lvl.	Relocate	No action	Aqua, Rip	Hydro Process	Water Qual.	Eco Funct	Terr Wldf	Fire Prot.	Fuels Mgt	Air Qual	Com. Prod.	Public Use	Social	Change in Maint. Costs	Notes
34N42A		X										-	0		-	0			
34N52Y.1	X											+	+		+	+			Gate & Rock, escape
34N52Y.2		X										-	-		-	-			Slump
34N52YA	X											+	+		+	+			Road to OHV Trail
34N68						X						0	0		0	0			SPI
34N68A						X						0	0		0	0			SPI
34N77	X											+	+		+	+			Private home access
34N82						X						0	0		0	0			Steep-Needs maint
34N82A						X						0	0		0	0			Overgrown
34N83						X						0	0		0	0			SPI
34N83A		X										-	0		-	0			Bermed-Overgrown
34N83B		X										-	0		-	0			Bermed-Overgrown
34N89		X										-	0		-	0			UNK
34N89A		X										-	0		-	0			UNK
34N95	X											+	+		+	+			Surface Rock
34N95A						X						0	0		0	0			
34N95B		X										-	0		-	0			
34N95C		X										-	-		-	+			Road to OHV Trail, fu
34N95E			X									0	0		0	0			Fuel break road
34N95F		X										-	-		-	0			
34N95G						X						0	0		0	0			SPI
34N96	X											+	+		+	+			Rock dips
34N96A	X											+	+		+	+			Rock dips
34N96B		X										-	0		-	-			
34N96C		X										-	-		-	-			
34N99						X						0	0		0	0			E. Weaver CG
U09W95A		X										-	0		-	0			
U228A						X						0	0		0	0			Home Access
U230A		X										-	0		0	-			
U230B						X						0	0		0	0			SPI Only Rd.
U232A		X										-	0		-	-			

Project Level Roads Analysis
Management Opportunities and Their Predicted Effects on the Resources

Road Number	Management Opportunities						Effects of Opportunities on the Resources												
	Repair or Upgrade	Decom	Restrict Travel	Change Mtc. Lvl.	Relocate	No action	Aqua, Rip	Hydro Process	Water Qual.	Eco Funct	Terr Wldf	Fire Prot.	Fuels Mgt	Air Qual	Com. Prod.	Public Use	Social	Change in Maint. Costs	Notes
U232B		X										-	0		0	0			
U236A			X									0	0		-	-			Improve for Fire only,
U236AA		X										-	-		0	-			
U236AB		X										-	-		0	-			
U236AC		X										-	-		0	-			
U236AD		X										0	0		0	-			
U33N01A		X										0	0		0				OR RAP
U33N01B		X										0	0		0	-			OR RAP
U33N01BA		X										0	0		0	-			OR RAP
U33N01C		X										0	0		0	-			OR RAP
U33N01K		X										0	0		0	-			OR RAP
U33N38A						X						0	0		0	0			PVT Access
U33N38B		X										-	-		0	0			OR RAP
U33N38D		X										-	0		0	-			
U33N38E		X										-	-		0	0			OR RAP
U33N38F		X										-	-		0	-			
U33N38G		X										0	0		0	-			
U33N42C		X										0	0		0	0			
U33N42R		X										-	-		0	0			
U33N42RD		X										0	0		0	0			
U34N05YA		X										0	0		0	-			
U34N05YB		X										0	0		0	-			
U34N05YC		X										0	0		-	-			
U34N05YD		X										0	0		0				
U34N05YE		X										0	0		0				
U34N22A		X										0	0		0				
U34N33YA		X										-	0		-	-			
U34N34B		X										-	0		-	-			
U34N42B		X										0	0		0				
U34N42C		X										0	0		0				
U34N52YAA		X										0	0		0				
U34N52YB		X										-	0		-	-			
U34N52YC		X										0	0		-	-			

Project Level Roads Analysis
Management Opportunities and Their Predicted Effects on the Resources

Road Number	Management Opportunities						Effects of Opportunities on the Resources												
	Repair or Upgrade	Decom	Restrict Travel	Change Mtc. Lvl.	Relocate	No action	Aqua, Rip	Hydro Process	Water Qual.	Eco Funct	Terr Wldf	Fire Prot.	Fuels Mgt	Air Qual	Com. Prod.	Public Use	Social	Change in Maint. Costs	Notes
U34N52YCA		X										0	0		0				
U34N52YCB		X										0	0		0				
U34N52YD		X										0	0		0				
U34N52YE		X										0	0						
U34N52YF		X										0	0						
U34N52YG		X										0	0						
U34N77A		X										-	0		-	-			PUD-Decom beyond
U34N77AA		X										-	0		-	-			
U34N77AAB		X										0	0		0	0			
U34N77AB		X										0	0						
U34N77B		X										-	0		-	0			
U34N77C		X										-	0		-	-			
U34N77CA		X										-	0		0	0			
U34N77CB		X										-	0		0	0			
U34N77D	X											+	+		0	+			Home Access
U34N95A		X										0	0		0	+			Road to OHV Trail
U34N95A2		X										0	0						
U34N95A4		X										0	0						
U34N95AA		X										0	0		0	-			
U34N95AB		X										0	0						
U34N95B		X										0	0		0	+			Road to OHV Trail
U34N95C		X										0	0		0				
U34N95H		X										-	-		-	-			Fuels access
U34N95I		X										-	-		0	-			Fuels access
U34N95I		X										0	0						
U34N95J		X										-	-		-	+			Road to OHV Trail
U34N95JA		X										0	0						
U34N95JAA		X										0	0						
U34N95K		X										0	0		-	-			
U34N95L		X										0	0		-	0			
U34N95M		X										0	0		-	0			
U34N95N		X										0	0		-	-			
U34N95O		X										0	0		-	-			

Project Level Roads Analysis
Management Opportunities and Their Predicted Effects on the Resources

Road Number	Management Opportunities						Effects of Opportunities on the Resources												
	Repair or Upgrade	Decom	Restrict Travel	Change Mtc. Lvl.	Relocate	No action	Aqua, Rip	Hydro Process	Water Qual.	Eco Funct	Terr Wldf	Fire Prot.	Fuels Mgt	Air Qual	Com. Prod.	Public Use	Social	Change in Maint. Costs	Notes
U34N95P		X										0	0		0	-			
U34N95Q		X										0	0		0				
U34N95S		X										0	0						
U34N95V		X										0	0						
U34N95VC		X										0	0						
U34N95VCA		X										0	0						
U34N95VCB		X										0	0						
U34N95W		X										0	0						
U34N95Z		X										0	0						
U34N96		X										0	0						
U34N96AA	X											+	+		0	+			fire escape route
U34N96AB		X										0	0		0	0			
U34N96AC		X										-	0		0	-			fire escape route
U34N96AD		X										0	0		0	0			

Roads Analysis
Current and Recommended

Road System Status
Shasta-Trinity National Forest

Current Trail Status								Recommended Trail Status			
Trail Number	Trail Length	Any Agree.	Trail Status	Trail Main. Level	Surface	Land Use Desig.		Trail Length	Trail Status	Trail Main. Level	Remarks
09W23	1.8953	N	EXIST	3	NAT			1.8953	EXIST	3	EAST WEAVER CREEK
09W84	0.4	N	EXIST	3	NAT			0.4	EXIST	3	WEST WEAVER - Refer to Oregon RAP
09W85	4.645	N	EXIST	3	NAT			4.645	EXIST	3	GREASY LOOP
09W86	0.2489	N	EXIST	3	NAT			0.2489	EXIST	3	SYDNEY GULCH
09W87	1.9397	N	EXIST	3	NAT			1.9397	EXIST	3	WEAVER BASIN
09W88	0.49	N	EXIST	3	NAT			0.49	EXIST	3	TEACHER ROCK
09W89	0.3512	N	PLANNED	3	NAT			0.3512	EXIST	3	TEACHER ROCK BYPASS - Planned
09W91	0.27	N	EXIST	3	NAT			0.27	EXIST	3	UPPER TEN CENT GULCH
09W92	0.8461	N	EXIST	3	NAT			0.8461	EXIST	3	HOWE DITCH
09W94	2.217	N	EXIST	3	NAT			2.217	EXIST	3	JACKASS RIDGE
09W95	1.2	N	EXIST	3	NAT			1.2	EXIST	3	DAY RANCH
09W96	0.4	N	EXIST	3	NAT			0.4	EXIST	3	RAINBOW HANSEN
09W97	1.549	N	EXIST	3	NAT			1.549	EXIST	3	MUSSER HILL
09W98	0.7	N	EXIST	3	NAT			0.7	EXIST	3	MUSSER HILL SPUR
09W99	0.144	N	EXIST	3	NAT				EXIST	3	SHASTA SPRING
10W12	0.5793	N	EXIST	2	NAT			0.5793	EXIST	2	DOLLY DITCH
UT09W85A	0.0262	N/A	USER	N/A	NAT			0.262	DECOM	N/A	WVBP1 OHV - Sydney Gulch / 33N42, OHV User Built, Decomission
UT09W85B	0.3248	N/A	USER	N/A	NAT			0.3248	DECOM	N/A	WVBP1 OHV - Sydney Gulch / 33N42, OHV User Built, Decmission
UT09W85BA	0.0372	N/A	USER	N/A	NAT			0.0372	DECOM	N/A	WVBP1 OHV - Sydney Gulch. OHV User Built, Decomission
UT09W85BB	0.0412	N/A	USER	N/A	NAT			0.0412	DECOM	N/A	WVBP1 OHV - Sydney Gulch, OHV User Built, Decomission
UT09W87A	1.5063	N/A	USER	N/A	NAT			1.5063	DECOM	N/A	WVBP1OHV - Jaclass Ridge, Decommission above UT09W87B, No Action below UT09W87B
UT09W87AA	0.2143	N/A	USER	N/A	NAT			0.2143	DECOM	N/A	WVBP1 OHV - Jackass Ridge trail, excessively steep grade, Decomission and build Planned
UT09W87AB	0.0424	N/A	USER	N/A	NAT			0.0424	DECOM	N/A	WVBP1 OHV - Jackass Ridge, spur trail, Decomission
UT09W87B	0.5903	N/A	USER	N/A	NAT			0.5903	EXIST	N/A	WVBP1OHV - Jackass Flat, Add segment below UT09W95A to WBT system, above No Action
UT09W87C	0.0963	N/A	USER	N/A	NAT			0.0963	DECOM	N/A	WVBP1 OHV - E.F. Five Cent Gulch, access to OHV impact areas, Decomission
UT09W87D	0.0311	N/A	USER	N/A	NAT			0.0311	DECOM	N/A	WVBP1 OHV - Garden Gulch, spur connecting 09W87 to UT33N38F, Decomission
UT09W88A	1.1062	N/A	USER	N/A	NAT			1.1062	PVT.	N/A	WVBP1 OHV - Garden Gulch, access to Al Broder Camp, Private Property, No Action
UT09W95A	0.3654	N/A	USER	N/A	NAT			0.3654	EXIST	N/A	WVBP1OHV - Jackass Flat, Add to Weaver Basin Trail system
UT09W97A	0.1935	N/A	USER	N/A	NAT			0.1935	DECOM	N/A	WVBP1 OHV - East Weaver to Musser Hill, Decomission
UT09W97B	0.1446	N/A	USER	N/A	NAT			0.1446	EXIST	N/A	WVBP1 OHV - East Weaver to Musser Hill, Excessively steep grade, used for Bike Race
UT09W99A	0.0325	N/A	USER	N/A	NAT			0.0325	DECOM	N/A	WVBP1 OHV - Shasta Spring, OHV User Created, Decomission
UT09W99B	0.0774	N/A	USER	N/A	NAT			0.0774	DECOM	N/A	WVBP1 OHV - Shasta Spring, OHV User Created, Decomission
UT09W99C	0.0492	N/A	USER	N/A	NAT			0.0492	DECOM	N/A	WVBP1 OHV - Shasta Spring, OHV User Created, Decomission
UT09W99D	0.0418	N/A	USER	N/A	NAT			0.0418	DECOM	N/A	WVBP1 OHV - Shasta Spring, OHV User Created, Decomission
UT09W99E	0.0149	N/A	USER	N/A	NAT			0.0149	DECOM	N/A	WVBP1 OHV - Shasta Spring, OHV User Created, Decomission
UT10W12	0.8242	N/A	USER	N/A	NAT				DECOM	N/A	WVBP1 OHV - Dolly Ditch / TAW boundary, Decomission
UT10W12A	0.4589	N/A	USER	N/A	NAT			0.4589	DECOM	N/A	WVBP1 OHV - Munger Gulch, Decomission

Roads Analysis
Current and Recommended

Road System Status
Shasta-Trinity National Forest

Trail Number	Trail Length	Any Agree.	Trail Status	Trail Main. Level	Surface	Land Use Desig.		Trail Length	Trail Status	Trail Main. Level	Remarks
UT228A	0.7523	N/A	USER	N/A	NAT			0.7523	PVT.	N/A	WVBP1 OHV - East Weaver, SPI, Bike Race route
UT228AA	0.0583	N/A	USER	N/A	NAT			0.0583	PVT.	N/A	WVBP1 OHV - East Weaver, SPI, Bike Race route
UT236A	0.7583	N/A	USER	N/A	NAT			0.7583	DECOM	N/A	WVBP1 OHV - Howe Ditch segment, no OHV use, no action
UT33N38A	0.3818	N/A	USER	N/A	NAT			0.3818	DECOM	N/A	WVBP1 OHV - Garden Gulch, Chinese Camp trail, Decomission
UT33N38AA	0.088	N/A	USER	N/A	NAT			0.088	DECOM	N/A	WVBP1 OHV - Gardedn Gulch, spur, Decomission
UT33N38B	0.4543	N/A	USER	N/A	NAT			0.4543	DECOM	N/A	WVBP1 OHV - Low Gap, inside TAW, Decomission
UT33N38C	0.4079	N/A	USER	N/A	NAT			0.4079	DECOM	N/A	WVBP1 OHV - Low Gap S23, 1987 fire line, extension of UT33N38D, Decomission
UT33N38D	0.7211	N/A	USER	N/A	NAT			0.7211	DECOM	N/A	WVBP1 OHV - Low Gap S24, 1987 fire line, extension of UT33N38C, Decomission
UT33N38F	0.6374	N/A	USER	N/A	NAT			0.6374	DECOM	N/A	WVBP1 OHV - Easter Avenue access, old Red Hill road, Decomission
UT34N28A	1.579	N/A	USER	N/A	NAT			1.579	DECOM	N/A	WVBP1 OHV - Little Browns Creek, Decomission
UT34N68A	0.4333		USER	N/A	NAT			0.4333	DECOM	N/A	WVBP1 OHV - Munger Gulch S 25, S 26, Decomission
UT34N77CA	0.087		USER	N/A	NAT			0.087	DECOM	N/A	WVBP1 OHV - Browns Mtn., SW1/4 S 34, in Drainage, Decomisssion
UT34N77CAA	0.033		USER	N/A	NAT			0.033	DECOM	N/A	WVBP1 OHV - Browns Mtn., SW1/4 S 34, in Drainage, Decomission
UT34N95AA	0.6701		USER	N/A	NAT			0.6701	SUP	N/A	WVBP1 OHV - East Branch Homeowners foot-trail, Special Use Permit or Decomission
UT34N95AB	0.0526		USER	N/A	NAT			0.0526	DECOM	N/A	WVBP1 OHV - East Branch Homeowners foot-trail, in Drainage, Decomission
UT34N95AC	0.0518		USER	N/A	NAT			0.0518	SUP	N/A	WVBP1 OHV - East Branch Homeowners foot-trail, Special Use Permit or Decomission
UT34N95B	1.045		USER	N/A	NAT			1.045	EXIST	N/A	WVBP1 OHV - La Grange Ditch, Historical, Bike Race
UT34N95C	0.2169		USER	N/A	NAT			0.2169	DECOM	N/A	WVBP1 OHV - Upper East Branch, SE 1/4 S 18, Decomission
UT34N95CB	0.0287		USER	N/A	NAT			0.0287	DECOM	N/A	WVBP1 OHV - Upper East Branch, SE 1/4 S 18, Decomission
UT34N95D	0.0586		USER	N/A	NAT			0.0586	DECOM	N/A	WVBP1 OHV - Upper East Branch, SE 1/4 S 18, Decomission
UT34N96A	0.1077		USER	N/A	NAT			0.1077	DECOM	N/A	WVBP1 OHV - Bear Gulch S 17, Decomisson
UT34N96AA	0.0052		USER	N/A	NAT			0.0052	DECOM	N/A	WVBP1 OHV - Bear Gulch S 17, spur off UT34N96A, Decomission
UT34N96BA	0.118		USER	N/A	NAT			0.118	DECOM	N/A	WVBP1 OHV - Bear Gulch, Decomission
UT3TRI04	0.0862		USER	N/A	NAT			0.0862	DECOM	N/A	WVBP1 OHV - Crotten, Decomission

Appendix B

Erosion Hazard Ratings for bare (red) and vegetated slopes (blue).

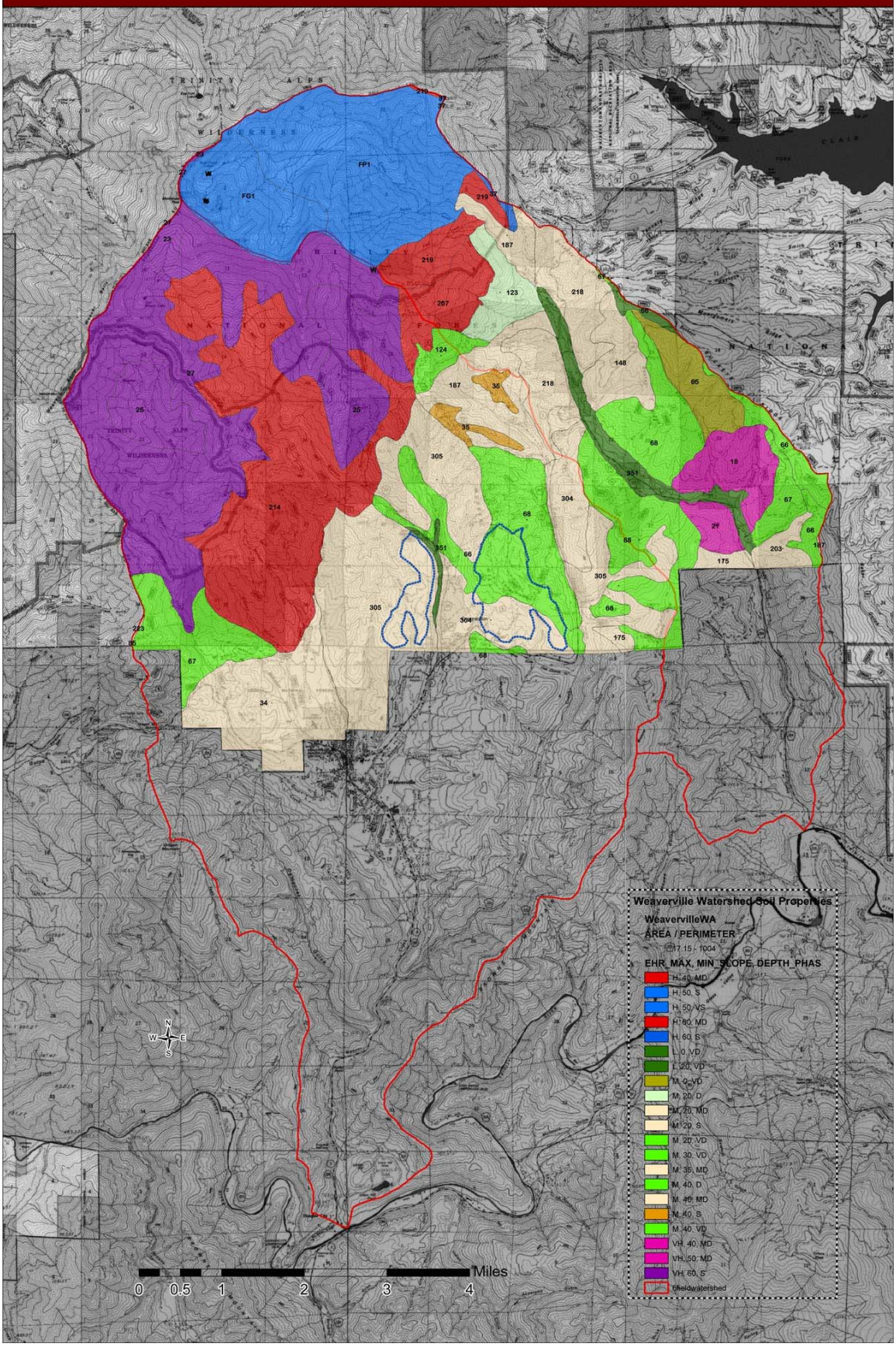
% Slope	Texture	Erodibility	Water Movement	Runoff Production	Runoff Production Rating	Slope	Runoff Energy Rating	Soil Cover %	Soil Cover Rating	**Erosion Hazard Rating**	**Rating**
Chaix											
40 - 60%	3	3	3	10	3.33	50	0.5	0-10	5	**25.0**	High
vegetated	3	3	3	10	3.33	50	0.5	50-70	2	**10.0**	Moderate
60 - 80%	3	3	3	10	3.33	70	0.7	0-10	5	**35.0**	V. High
vegetated	3	3	3	10	3.33	70	0.7	50-70	2	**14.0**	Moderate
Chawankee											
40 - 60%	3	2	3	11	3.67	50	0.5	0-10	5	**18.3**	High
vegetated	3	2	3	11	3.67	50	0.5	50-70	2	**7.3**	Moderate
60 - 80%	3	2	3	11	3.67	70	0.7	0-10	5	**25.7**	High
vegetated	3	2	3	11	3.67	70	0.7	50-70	2	**12.8**	Moderate
Deadwood											
20 - 40%	3	2	3	10	3.33	50	0.5	0-10	5	**10.0**	Moderate
vegetated	3	2	3	10	3.33	50	0.5	50-70	2	**4.0**	Moderate
40 - 60%	3	2	3	10	3.33	70	0.7	0-10	5	**16.7**	High
vegetated	3	2	3	10	3.33	70	0.7	50-70	2	**6.7**	Moderate
Forbes											
20 - 40%	4	4	3	9	3.00	50	0.5	0-10	5	**18.0**	High
vegetated	4	4	3	9	3.00	50	0.5	50-70	2	**7.2**	Moderate
40 - 60%	4	4	3	9	3.00	70	0.7	0-10	5	**30.0**	V. High
vegetated	4	4	3	9	3.00	70	0.7	50-7	2	**12.0**	Moderate
Goulding											
40 - 60%	3	2	3	11	3.50	50	0.5	0-10	5	**16.2**	High
vegetated	3	2	3	11	3.50	50	0.5	50-70	2	**5.5**	Moderate
60 - 80%	3	2	3	11	3.50	70	0.7	0-10	5	**22.1**	High
vegetated	3	2	3	11	3.50	70	0.7	50-70	2	**9.7**	Moderate
Holland											
40 - 60%	3	3	3	9	3.00	50	0.5	0-10	5	**22.5**	High
vegetated	3	3	3	9	3.00	50	0.5	50-70	2	**9.0**	Moderate
60 - 80%	3	3	3	9	3.00	70	0.7	0-10	5	**31.5**	V. High
vegetated	3	3	3	9	3.00	70	0.7	50-70	2	**12.6**	High
Ishi Pishi											
40 - 60%	3	2	4	10	3.33	50	0.5	0-10	5	**16.7**	High
vegetated	3	2	4	10	3.33	50	0.5	50-70	2	**6.7**	Moderate
60 - 80%	3	2	4	10	3.33	70	0.7	0-10	5	**23.3**	High
vegetated	3	2	4	10	3.33	70	0.7	50-70	2	**9.7**	Moderate

% Slope	Texture	Erodibility	Water Movement	Runoff Production	Runoff Production Rating	Slope	Runoff Energy Rating	Soil Cover %	Soil Cover Rating	**Erosion Hazard Rating**	**Rating**
Marpa											
40 - 60%	3	3	2	8	2.67	50	0.5	0-10	5	**20.0**	High
vegetated	3	3	2	8	2.67	50	0.5	50-70	2	**8.0**	Moderate
60 - 80%	3	3	2	8	2.67	70	0.7	0-10	5	**28.0**	High
vegetated	3	3	2	8	2.67	70	0.7	50-70	2	**10.2**	Moderate
Nenus											
40 - 60%	3	2	2	8	2.67	50	0.5	0-10	5	**13.3**	High
vegetated	3	2	2	8	2.67	50	0.5	50-70	2	**5.3**	Moderate
60 - 80%	3	2	2	8	2.67	70	0.7	0-10	5	**18.7**	High
vegetated	3	2	2	8	2.67	70	0.7	50-70	2	**7.5**	Moderate
Soulajule											
20 - 40%	4	3	3	9	3.00	50	0.5	0-10	5	**13.5**	High
vegetated	4	3	3	9	3.00	50	0.5	50-70	2	**5.4**	Moderate
40 - 60%	4	3	3	9	3.00	70	0.7	0-10	5	**22.5**	High
vegetated	4	3	3	9	3.00	70	0.7	50-70	2	**10.9**	Moderate

An erosion hazard rating (EHR) of 1 to 4 is low, 4 to 12 is moderate, 13 to 29 is high, and greater than 29 is very high. Soil cover can be any combination of duff mat, litter, fine organic materials (<3 in. dia.), coarse organic materials (>3 in. dia.), live vegetation in contact with soil, or rock fragments (>3/4 in. dia.).

This table shows (in red) when you change the cover amounts (removal by fire) that the erosion hazard is doubled (a factor of 2.5). It assumes a natural vegetative cover of 50 to 70% and the effect of complete vegetative cover removal leaving only 0 to 10% (hot intensity fire). Some soils can handle this without increasing erosion too much (Deadwood, Goulding, and Nenus). This is due to the rock content of the soil and rocky cover. Others are dependent of soil cover and without it come unraveled (Chaix, Chawankee, Forbes, Holland, and Soulajule). Areas of concern are the western 1/3 of the watershed and the Musserhill area above Weaverville.

Weaverville Watershed Erosion Hazard



Appendix C

The following tables document the ERA disturbance coefficients and sediment budget erosion rates used as part of the analysis.

Table 1. ERA disturbance factors for harvest history.

RxSys	Dist Factor
4111/420	0.25
4111/430	0.17
4113/420	0.30
4113/430	0.20
4131/420	0.20
4131/430	0.15
4143/420	0.22
4143/430	0.16

Explanation
4111 = patch clearcut
4113 = stand clearcut
4131 = shelterwood seed cut
4143 = overstory removal
420 = tractor yarding
430 = cable yarding

Table 2. ERA disturbance factors for proposed action harvest.

RxSys	Dist Factor
T/H	0.05
T/S	0.15
T/T	0.15

Explanation
T = thin from below 40 to 60 percent canopy closure
H = helecopter yarding
S = skyling yarding
T = mechanical yarding

Table 3. ERA disturbance factors for proposed action site treatment.

Site Prep	Dist Factor
HP-BP	0.01
TJP-BP	0.21
TOS	0.05
TOS1	0.1
WTY	0.01

Explanation
HP-BP = handpile and burn
TJP-BP = mechanical pile and burn
TOS = treat on site with mechanical harvester
TOS1 = treat on site with steep or adverse skid
WTY = whole tree yard

Table 4. ERA slope position, slope steepness, and adjacency to riparian areas weighting factors for proposed action harvest and roads.

Slp/RR	Factor
L/N	1.1
L/Y	1.5
M/N	0.9
M/Y	1.3
U/N	0.8
U/Y	1.1

Explanation
L = lower slope
M = middle slope
L = lower slope
Y = within or adjacent to riparian reserve
N = not within or adjacent to riparian reserve

Appendix D

15% Late-Successional and Old-Growth Retention Analysis and Recommendations

for the

Weaverville 5th Field Watershed

The distribution of old-growth stands throughout the landscape is an important component of ecosystem diversity, and plays a significant role in providing for biological and structural diversity across the landscape. (Record of Decision for the NW Forest Plan, page C-44)

Prepared by _____ Date_____
Thomas A. Quinn updated
Wildlife Biologist
Trinity River Management Unit
Shasta-Trinity National Forest

INTRODUCTION
(Impatient readers are referred to the Recommendations section on the last page of this document.)

This document presents my analysis of the current condition of late-successional and old-growth conifer habitat within the Weaverville 5th field watershed and recommendations for meeting and maintaining future options to meet the intent of the ***provide for retention of old-growth fragments in watersheds where little remains*** standard and guideline (S&G, ROD page C-44).

I used two GIS databases for this analysis:

1) I used the *Shasta-Trinity Land and Resource Management Plan (Forest Plan) database (**LMP-90 database**)* to assess Forest Service land within the watershed. I updated this database to reflect the affects of the Oregon Fire (late summer of 2001) using aerial photographs taken shortly after the fire.
2) I used the *Remote Sensing Lab Database (**RSL database**)* to assess Bureau of Land Management land within the watershed.

Intent of the S&G
The intent of this standard and guideline is stated in the first paragraph of the S&G on page C-44 of the Record of Decision for the Northwest Forest Plan; e.g., *to protect ecologically significant patches and fragments of old-growth habitat that provide refugia for old-growth associated species* (memorandum from the Regional Ecosystem Office dated October 24, 1997). Our discretion to retain a variety of stand ages to meet the intent of the S&G should be applied **before** federal forest lands reach the 15 percent level of late-successional forest. Management discretion and options to select stands for retention and protection within a watershed only exist prior to late-successional forest reaching the 15 percent level. Old-growth stands would be retained and protected to meet the S&G in most instances; however, based on an assessment, younger (i.e., mature, late-successional) stands could be retained while older stands could be harvested (memorandum from the Regional Forester dated September 14, 1999).

DEFINITIONS & ASSUMPTIONS

- ***Federal Forest Land*** – Federal land that is now, or is capable of becoming, at least 10 percent stocked with forest trees (i.e., conifers) and that has not been developed for nontimber use. This acreage is the base (denominator) used to calculate the 15 percent retention S&G. **Within the watershed I assume Forest Service land of the forest types (LMP-90 database "*Vegtype1*") Douglas-fir, mixed conifer, ponderosa/Jeffrey pine, and white fir and Bureau of Land Management land Wildlife Habitat Relations vegetation types (RSL database "*WHRTYPE*") Douglas-fir, Klamath mixed conifer, ponderosa pine, and montane hardwood/conifer qualify as Federal Forest Land.**

- ***Late-Successional Forest*** **-** Forest seral stages that include old-growth and mature age classes.

    - ***Old-Growth*** – A forest stand usually at least 180-220 years old with moderate to high canopy closure; a multilayered, multispecies canopy dominated by large overstory trees; high incidence of large trees, some with broken tops and other indications of old and decaying wood; numerous snags; and heavy accumulations of wood, including large logs on the ground. **Within the watershed I assume all size class 4 (or greater) stands with a canopy closure of G or N or canopy closure D or M are currently old-growth** (LMP-90 database *"Vegsize"* and *"Vegden"; RSL database "Vegsize" and "whrdensity"*).

    - ***Mature Stand*** – A mappable (>10 acres) stand of trees for which the annual rate of growth has peaked; generally greater than 80 years old but not yet old-growth. Mature stands generally contain trees with a smaller average diameter, less age class variation, and less structural complexity than old-growth stands of the same forest type. **Within the watershed I assume all size class 3 stands are mature stands. Because the definition of "mature" does not include a canopy closure criterion, I include size class 4 stands with an S or P canopy as mature.** Older mature stands with relatively high canopy closure (e.g., *"Vegden"* G or *"whrdensity"* D and to a lesser extent N or M) often provide suitable habitat for species associated with old-growth forests.

LMP-90 Database Assumptions

The Shasta-Trinity Land and Resource Management Plan (Forest Plan) database (LMP-90 database) is the best existing and available tool for vegetative analysis of Forest Service land within an area as large as the Weaverville Watershed. Using this database to analyze existing vegetative conditions as they relate to LSOG ecosystems requires a number of basic assumptions that long-term local experience suggests are valid for analyses at this scale. The information available in the LMP-90 database represents aerial photo interpretation from 1975 photos. The interpretation was conducted with purely timber production interests in mind. In 1990 and 1992 the database was updated to include recent harvest units (i.e., plantations) and stand replacing fires. Stand attributes in the database (the codes included in the LMP-90 database are included in parentheses) I used to infer potential and existing late-successional forest conditions were: **vegetation type** (LMP-90 database *Vegtype1*), **crown size** (LMP-90 database *Vegsize*), **canopy closure** (*Vegden*).

- **Vegetation Type**: I assume that within the Weaverville Watershed only "commercial conifer" types typically have the potential to provide habitat for species associated with old-growth conifer forests. That is to say, only these types move through the successional stages resembling those described on pages B-2 through B-4 in the ROD and develop LSOG stand structure and composition as described on page B-2 (and the Glossary) of the ROD. Within the watershed these types include Douglas-fir,

mixed conifer, ponderosa/Jeffrey pine, and white fir. Nonconifer and noncommercial conifer types almost never achieve the size, canopy closure, or generally complex vertical structure associated with old-growth habitat.

- **Vegsize** (crown diameter size class): I assume that the size classes included in the LMP-90 and RSL databases are a reasonable indicator of general stand age and their use is the only currently available tool for estimating seral stage development over large areas. I also use size classes as the major indicator of the level of decadence within stands (e.g., snags, logs, broken-top trees, etc.) since decadence is largely a function of stand age. That is to say, stands with larger trees are typically older than stands with smaller trees. Size class 4 (or greater) are typically old enough to have developed these attributes of old-growth conifer forests. Stands in size class 3 on sites highly capable of growing trees often are at least 21 inches dbh (diameter breast height) considering growth since 1975. Generally, if these stands are a result of natural regeneration (e.g., having developed after a stand replacing fire as opposed to past clearcutting) they include legacies from the previous stands (e.g., large trees, snags, logs, etc.) and likely provide at least some of the ecological roles of old-growth.

  Crown Size Classes (both LMP-90 & RSL databases):
  - **0** = shrub, forb, grass, noncommercial conifer, hardwood, and nonvegetated (no LSOG potential).
  - **1** = 0-5 foot crown diameter, seedling sapling; stand establishment stage; includes most contemporary plantations.
  - **2** = 6-12 foot crown diameter, poles; growth and maturation with little or no natural thinning; includes minor acreages of contemporary plantations.
  - **3** = 13-24 foot crown diameter, small to medium timber; continued growth and maturation and beginning natural thinning (current mature forest).
  - **4 or greater** = >24 foot crown diameter, large sawtimber; transition stage (current old-growth forest).

- **Vegden**: Moderate to dense canopy closure is typical of LSOG in the Weaverville Watershed. Local experience strongly suggests that canopy closure classes N & G or M & D typify current LSOG habitat. These classes were originally assigned based on predominant crown cover of only commercial conifer overstory species. When the understory component is included along with 20 years of growth these two classes commonly have a total canopy closure above 60 percent. In addition, the understory increases the complexity of vertical structure (an important attribute of LSOG in the area). Infrequently, class P and S stands may also provide LSOG conditions but would require stand-by-stand field verification.

  "Vegden" Canopy Closure Classes:
  - **S** = <20%
  - **P** = 20-39%
  - **N** = 40-69%
  - **G** = ≥70%

RSL Database Assumptions

Existing vegetation coverages were produced by the USDA Forest Service Remote Sensing Lab according to Regional vegetation mapping standards (FGDC compliant at existing definitions). Existing vegetation layers are tiled by ecological section/subsection as defined by the *Ecological Units of California* (Goudey and Smith, 1994). Vegetation tiles are aggregated by vegetation zone defined within the original CALVEG document. A staewide tile coverage and a statewide vegetation zone coverage (caltile94_1, calzone98_2) are provided for spatial reference.

Questions concerning the data or method/s of capture should be directed to:

USDA Forest Service
Region 5 Remote Sensing Lab
1920 20th Street
Sacramento, CA 95814

I applied the same general assumptions to the RSL database as used for the LMP-90 database.

- **whrtype**: I used this field to query for Federal Forest Land. The Wildlife Habitat Relations vegetation types that typically achieve the size, canopy closure, or generally complex vertical structure associated with old-growth habitat within the Weaverville Watershed include: Douglas-fir, Klamath mixed conifer, ponderosa pine, and montane hardwood/conifer. These types thus qualify as Federal Forest Land.

- **Vegsize** (crown diameter size class): I used this field to query for relative stand age. These size classes are the same as those described for the LMP-90 database.

- **whrdensity**: For this analysis "whrdensity" classes were lumped in with the following LMP-90 database "Vegden" classes.

  "whrdensity" Canopy Closure Classes:
  - S = 10-24% lumped in with LMP-90 class S for this analysis
  - **P** = 25-39% lumped in with LMP-90 class P for this analysis
  - M = 40-59% lumped in with LMP-90 class N for this analysis
  - D = ≥60% lumped in with LMP-90 class G for this analysis

Relative LSOG Habitat Quality

In general old-growth habitat quality can be listed from higher to lower quality as follows:

RELATIVE OLD-GROWTH HABITAT QUALITY RELATED TO SIZE CLASS AND CANOPY CLOSURE

4G	4N	3G	3N	4P	3P	4S	3S	remaining federal forest land

CURRENT CONDITIONS

Current conditions are reported in LMP 90 database terminology.

The Weaverville Watershed includes 20,533 acres of federal forest land (Figure 1). Table 1, Figure 2, and the attached map present the current conditions within the Weaverville Watershed related to size class and canopy closure. Old-growth (4N/G) comprises only 2,300 acres or roughly 11 percent of this land; the watershed is dominated by 12,937 acres of mature (i.e., late-successional) forest (63 percent of the federal forest land). Figure 3 displays the proportion of old-growth (4N/G), mature forest that has high enough canopy closure (i.e., G or N) to provide at least that aspect of old-growth habitat as well as the remaining federal forest land within the watershed.

Table 1. Size Class and Canopy Closure distribution within the Weaverville 5th field watershed. Includes only federal land that is now, or is capable of becoming, at least 10 percent stocked with forest trees (i.e., conifers) and that has not been developed for nontimber use.

Size Class	Canopy Closure				
	G	N	P	S	Total
≥4	1,864	436	141	40	2,481
3	5,131	3,813	2,492	1,501	12,937
2	2,495	726	494	304	4,019
1	18	1,035	18	25	1,096

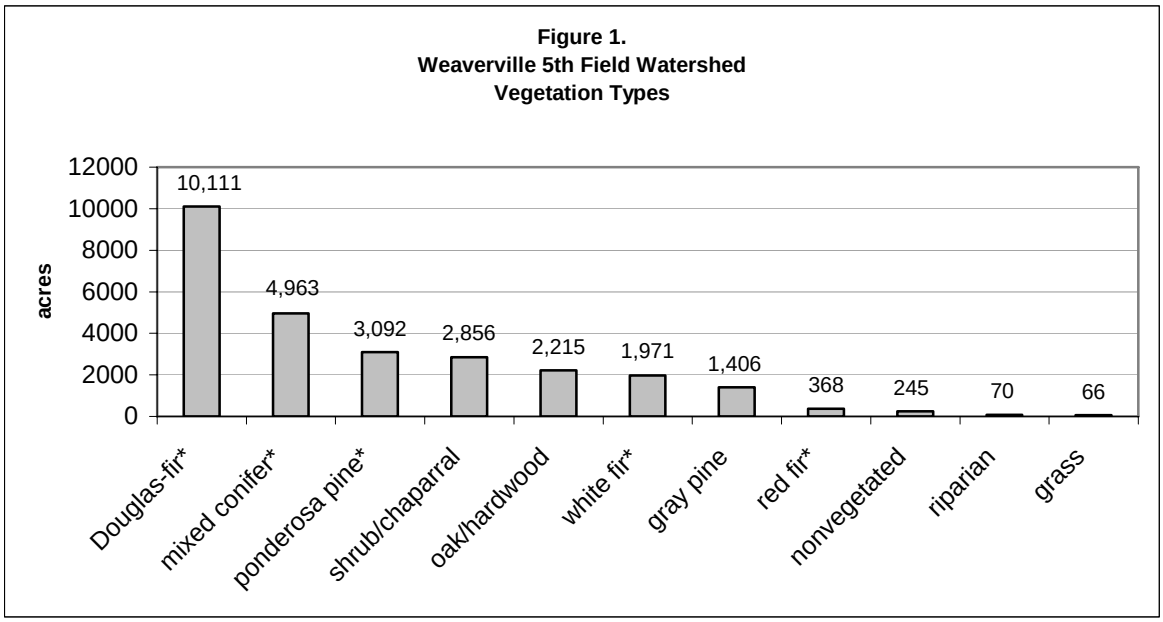
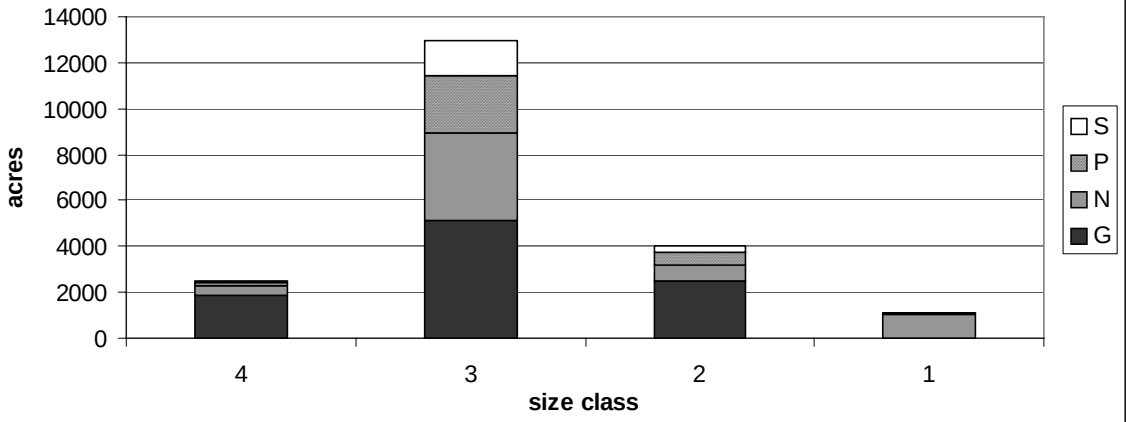
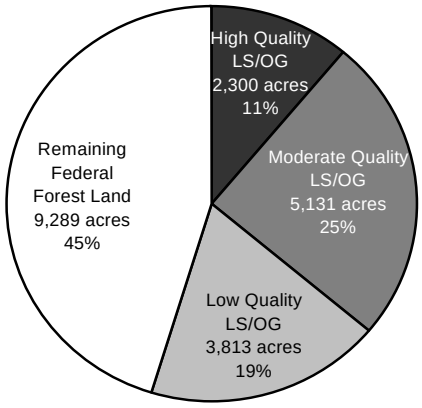


Figure 2.
Weaverville 5th Field Watershed
size class and canopy closure



Based upon a total of 20,533 "federal forest acres".

Figure 3.
Weaverville 5th Field Watershed
Late-Successional & Old-Growth (LS/OG)



LS/OG Relative Quality:
High = 4G & 4N
Moderate = 3G
Low = 3N

Percentages based upon a total of 20,533 "federal forest acres".

RECOMMENDATIONS

At this time I recommend the following to meet the intent of the 15 percent retention standard and guideline and to maintain our options for meeting this S&G into the future within the Weaverville Watershed:

1. **The GIS databases used for this analysis are an appropriate "coarse grain' tools for landscape level (i.e., 5th field watershed) analyses. At the project**

level, individual stands proposed for treatment should be examined to determine what ecological role they are filling related to old-growth habitat.

2. **Defer timber harvesting in all 4G and 4N stands (2,300 acres). These stands are likely the highest quality old-growth habitat and currently comprise only 11 percent of the watershed. Timber harvesting may become appropriate within these stands that lie within MATRIX when we can demonstrate that other 3G stands are meeting the ecological roles of old-growth habitat.**

3. **Prescriptions designed to reduce fuel ladders within 4G and 4N stands may be appropriate in strategically located areas where community fire protection is a concern. Prescriptions should be designed to maintain LSOG conditions to the extent practicable. *For example Unit #3 in the Browns Integrated Project Area*.**

Appendix E

Deer Habitat Conditions & Recommendations
for the
Weaverville 5th Field Watershed & Browns Integrated Project Area

Thomas A. Quinn
Wildlife Biologist
Trinity River Management Unit
Shasta-Trinity National Forest

INTRODUCTION

The creation of Trinity and Lewiston Reservoirs in 1963 inundated over 700,000 acres of land, much of it deer winter range habitat. This habitat loss was to be compensated for by increasing the carrying capacity of remaining habitats (USFWS 1975). Given the current legal, political, scientific and economic climate it is unrealistic to plan significant forage habitat creation projects such as clear-cutting existing forest habitats. Rather we must focus on maintaining and improving existing foraging habitat (Boroski 1998).

HABITAT DEFINITIONS & CONDITIONS

Deer habitat conditions are analyzed under the following basic criteria: cover habitat, foraging habitat, winter range, summer range and the ratio of cover/foraging habitat. As an edge species, black-tailed deer use areas where forest, shrub, and grassland habitats intersperse to meet foraging, breeding, and cover requirements. Since deer consistently feed in areas either contiguous to cover, or where food and cover occur together, the interspersion of food and cover affects the suitability of areas for deer (Boroski 1998). The same databases were used as in the ***15% Late-Successional and Old-Growth Retention Analysis and Recommendations for the Weaverville 5th Field Watershed*** (see project file). Slope steepness and aspect were not available for this rough preliminary analysis.

Cover Habitat

Cover habitat moderates environmental extremes that deer must face on a year-round basis. In the winter, tree crowns can intercept considerable amounts of snow, making it easier for deer to move about and find food. Wide, deep tree crowns intercept more snow than do thin narrow crowns. The denser the canopy the more snow is intercepted and wide deep crowns associated with older conifers are the most efficient at intercepting snow. The forest canopy acts as a shield by deer radiational heat loss to the open sky, especially at night. Conifer habitat can provide areas where air movement is reduced thereby protecting deer from the chill factor associated with low temperatures and increasing wind speed. In the heat of summer, conifer habitat can provide cool, moist areas for deer. Conifer habitat also provides security habitat (cover used by deer to conceal themselves). This is not to say that other habitat types (e.g., oak) do not provide cover habitat, but rather that conifer habitat's main role in the area is cover.

For this analysis relatively dense conifer habitat is considered deer cover habitat except for plantations, which are foraging habitat. General LMP-90 database habitat types used as "cover" in this analysis include: **Douglas-fir, Ponderosa pine, mixed conifer and white fir** with an "N" or "G" canopy closure (LMP-90 database).

Foraging Habitat

Year-round access to food is critical to deer survival and reproductive success. Deer reach their best condition during the summer and fall with abundant, high quality feed. If the foraging habitat conditions are not good, deer enter winter with reduced fat reserves

and have an increased chance of mortality during the stressful winter months. Adequate foraging habitat during winter is also critical.

For this analysis **sparse conifer habitat** (canopy closure "S" and "P"), **plantations**, **chaparral, hardwood, grass,** and **riparian** vegetation types (LMP-90 database) are considered foraging habitat. Leaf litter and individual oaks within conifer stands can provide deer forage. Most of the existing chaparral (and brush-dominated) foraging habitat is decadent and thus too thick to allow deer access and too woody and thus no longer providing nutritious browse (Gartner 1991). Much of the hardwood (i.e., acorn-producing) foraging habitat is overly dense and at risk to loss from wildfire. Individual oaks (especially black oak) within cover habitat are being shaded out by a dense conifer canopy and will likely drop out of the stands in the relatively near future.

Winter Range (and habitat ratio)
Winter range is defined as the area below roughly 4,000 feet elevation where snow depths are not extreme. Winter is the most critical season for deer. During winter deer must cope with the worst environmental conditions (i.e., adequate cover habitat needed) while consuming the poorest quality food (i.e., adequate foraging habitat needed).

Winter range deer habitat within the Weaverville 5th Field Watershed is currently not providing optimum habitat conditions for deer assuming a rough ideal deer habitat ratio of 40% cover and 60% foraging (Thomas el al. 1979). The winter range cover to forage ration in the watershed is currently 60% cover (10,862 acres) to 40% forage (7,307 acres). The Browns Integrated Project Area lies largely within winter range where the current ratio is 58% cover (5,526 acres) to 42% forage (4,083 acres). Again, much of the existing foraging habitat is in relatively poor condition.

Summer Range (and habitat ratio)
Summer range is defined as the area above roughly 4,000 feet elevation although roughly 20% of the deer population are "resident" and stay in the summer range year-round (Boroski 1998). Deer reach their best condition during the summer and fall with abundant, high quality feed. If the foraging habitat conditions are not good, deer enter winter with reduced fat reserves and have an increased chance of mortality during the stressful winter months.

Summer range deer habitat within the Weaverville 5th Field Watershed is currently close to providing optimum habitat conditions for deer assuming a rough ideal deer habitat ratio of 40% cover and 60% foraging (Thomas el al. 1979). The summer range cover to forage ration in the watershed is currently 38% cover (3,699 acres) to 62% forage (5,918 acres). A small portion of the Browns Integrated Project Area lies within summer range where the current ratio is 41% cover (527 acres) to 59% forage (757 acres). Again, much of the existing foraging habitat is in relatively poor condition.

Figures 1 and 2 display current conditions compared to optimal conditions related to the amount (acres) of cover and foraging habitat within the Weaverville 5th Field Watershed and Browns Project Area respectively.

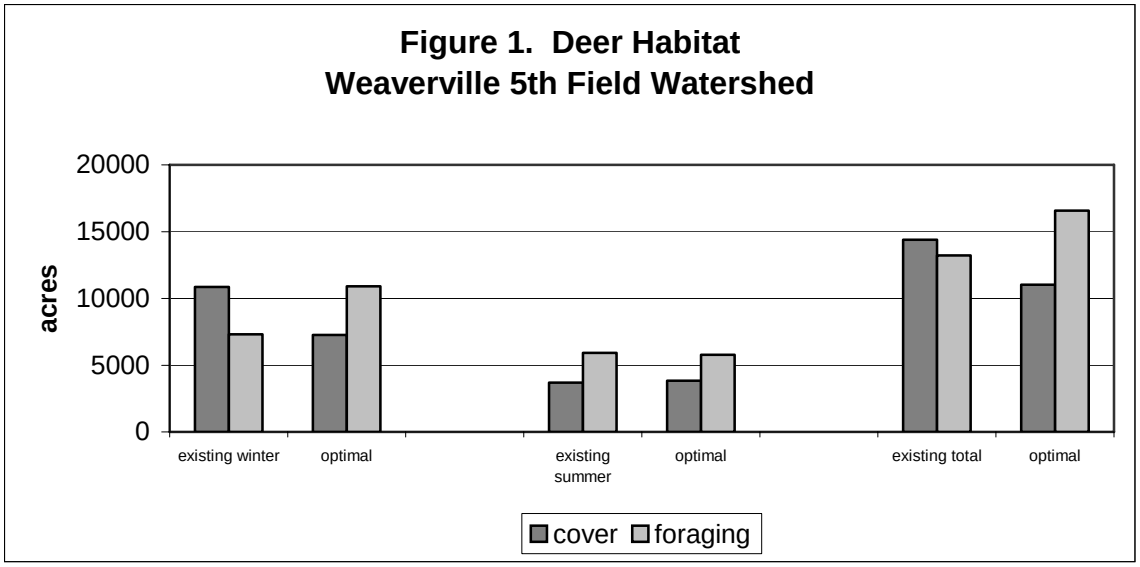


Figure 1. Deer Habitat
Weaverville 5th Field Watershed
acres
20000
15000
10000
5000
0
existing winter
optimal
existing summer
optimal
existing total
optimal
cover
foraging

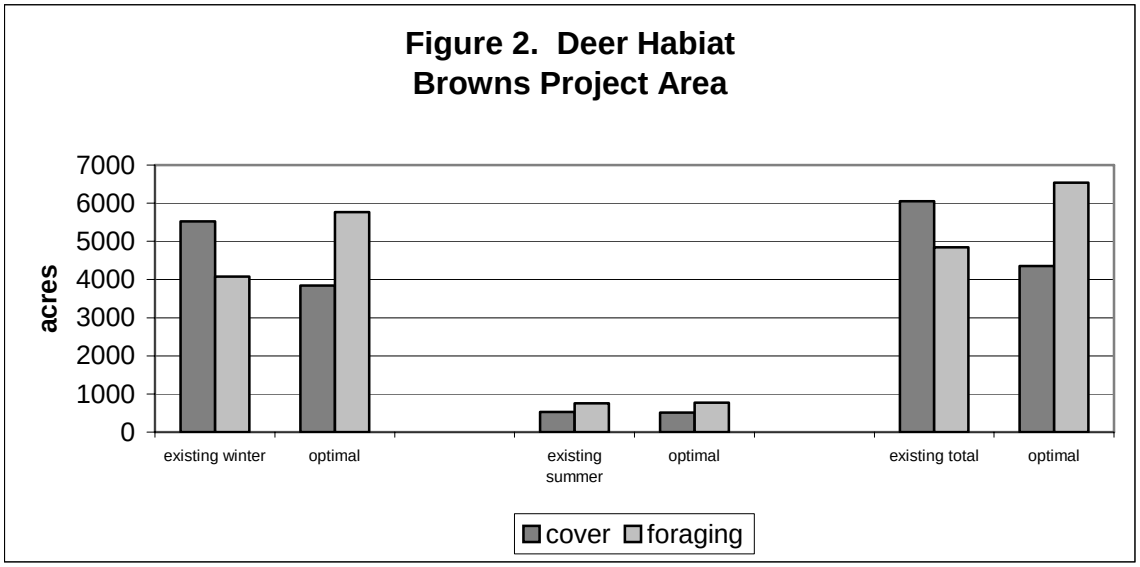


Figure 2. Deer Habiat
Browns Project Area
acres
7000
6000
5000
4000
3000
2000
1000
0
existing winter
optimal
existing summer
optimal
existing total
optimal
cover
foraging

RECOMMENDATIONS

At this time I recommend the following to maintain and improve deer habitat within the Weaverville Watershed:

1. **The GIS databases used for this analysis are an appropriate "coarse grain' tools for landscape level (i.e., 5th field watershed) analyses. At the project level, individual areas proposed for treatment should be examined to determine current conditions and appropriate treatments related to deer habitat.**

2. **Defer timber harvesting in all 4G and 4N (i.e., old-growth) stands (2,300 acres). With the large deep-crowned conifers, these stands are likely the highest quality deer cover habitat and currently comprise only 11 percent of the watershed. Timber harvesting may become appropriate within these stands that lie within MATRIX when we can demonstrate that other younger stands are meeting the ecological roles of old-growth habitat.**

3. **Utilize prescribed burning or mechanical methods (e.g., mastication) within existing decadent foraging habitat to stimulate new nutritious growth and improve access for deer (see Gartner 1991).**

4. **Thin around existing viable black oaks within conifer stands to maintain and improve acorn production.**

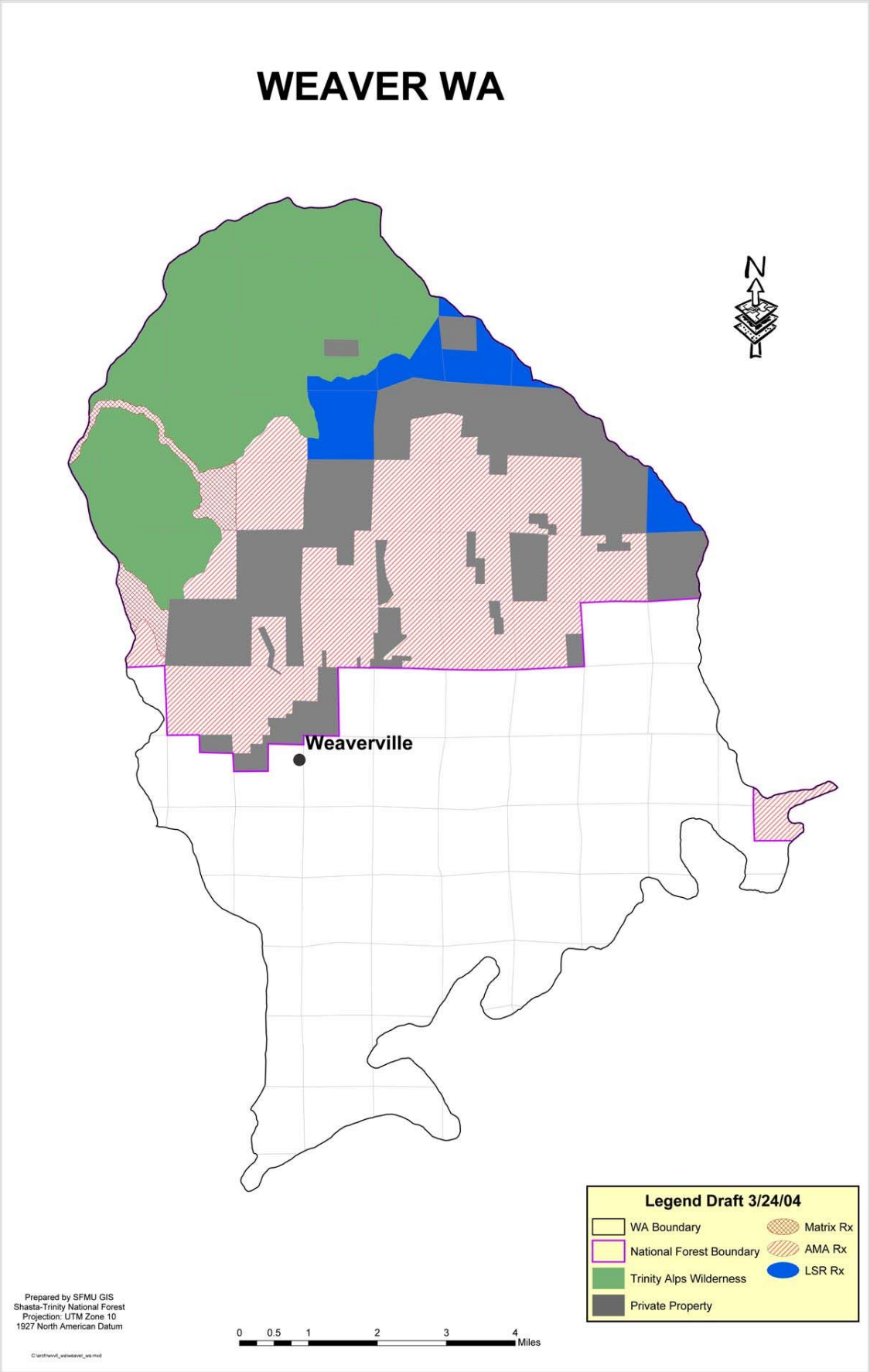
5. **Give priority to treatments within deer winter range.**

REFERENCES:

Gartner, Rosemary A. (analyst and editor), 1991. Weaverville deer herd winter range habitat plan prepared for United States Department of Interior Fish and Wildlife Service and Bureau of Reclamation Trinity River Basin Field Office Weaverville California.

Thomas, J.W., H. Black, Jr., R.J. Pederson. 1979. Deer and elk. Pages 104-127 in J.W. Thomas, ed. Wildlife habitats in managed forests – the Blue Mountains of Oregon and Washington. USDA For. Serv. Agric. Handb. 553. 512pp.

U.S. Fish and Wildlife Service. 1975. Deer loss compensation program resulting from Trinity River Division, Central Valley Project, California: A report to the Trinity River Basin Fish and Wildlife Task Force. U.S. Fish and Wildl. Serv., Portland, Oreg. 30pp.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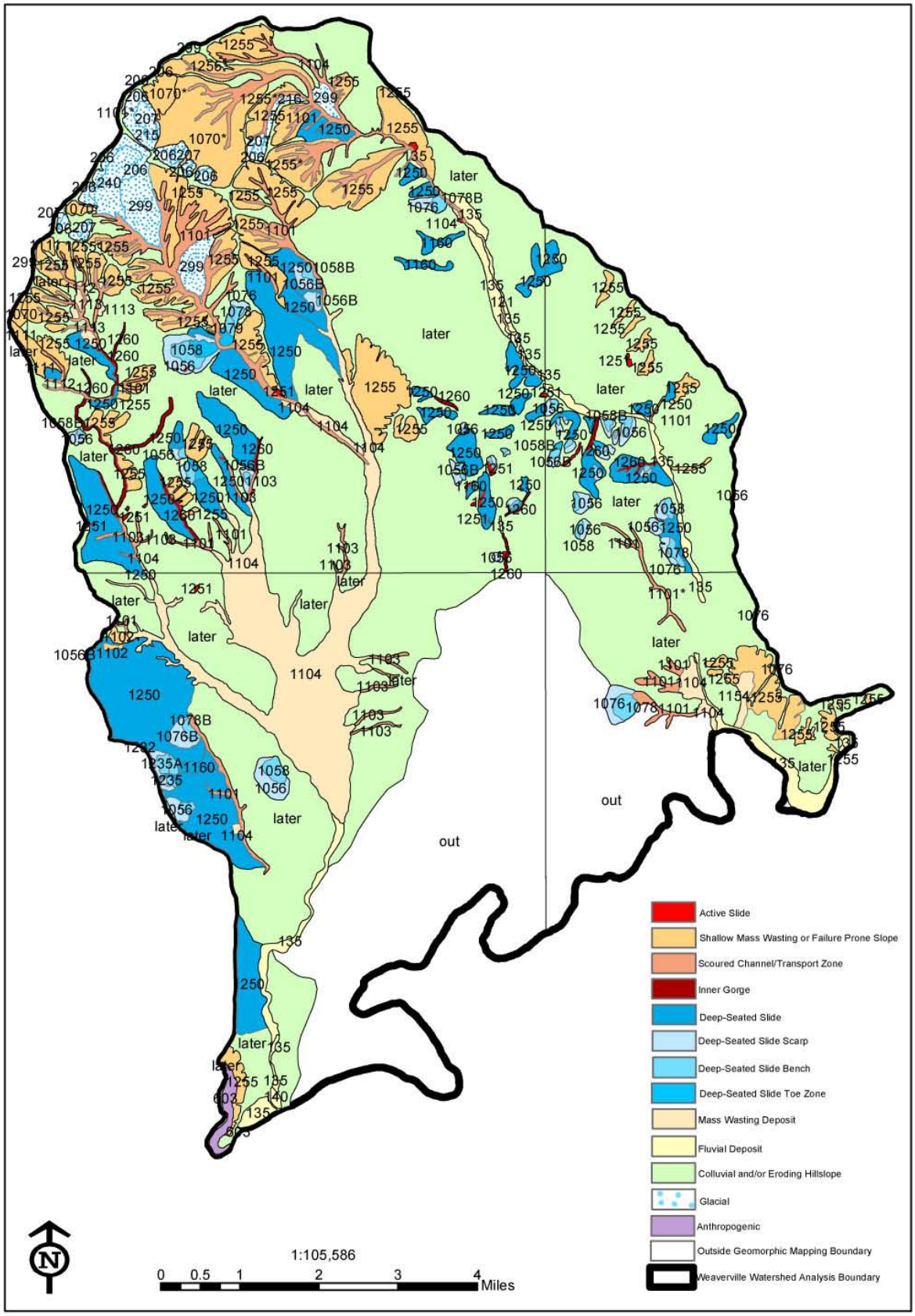
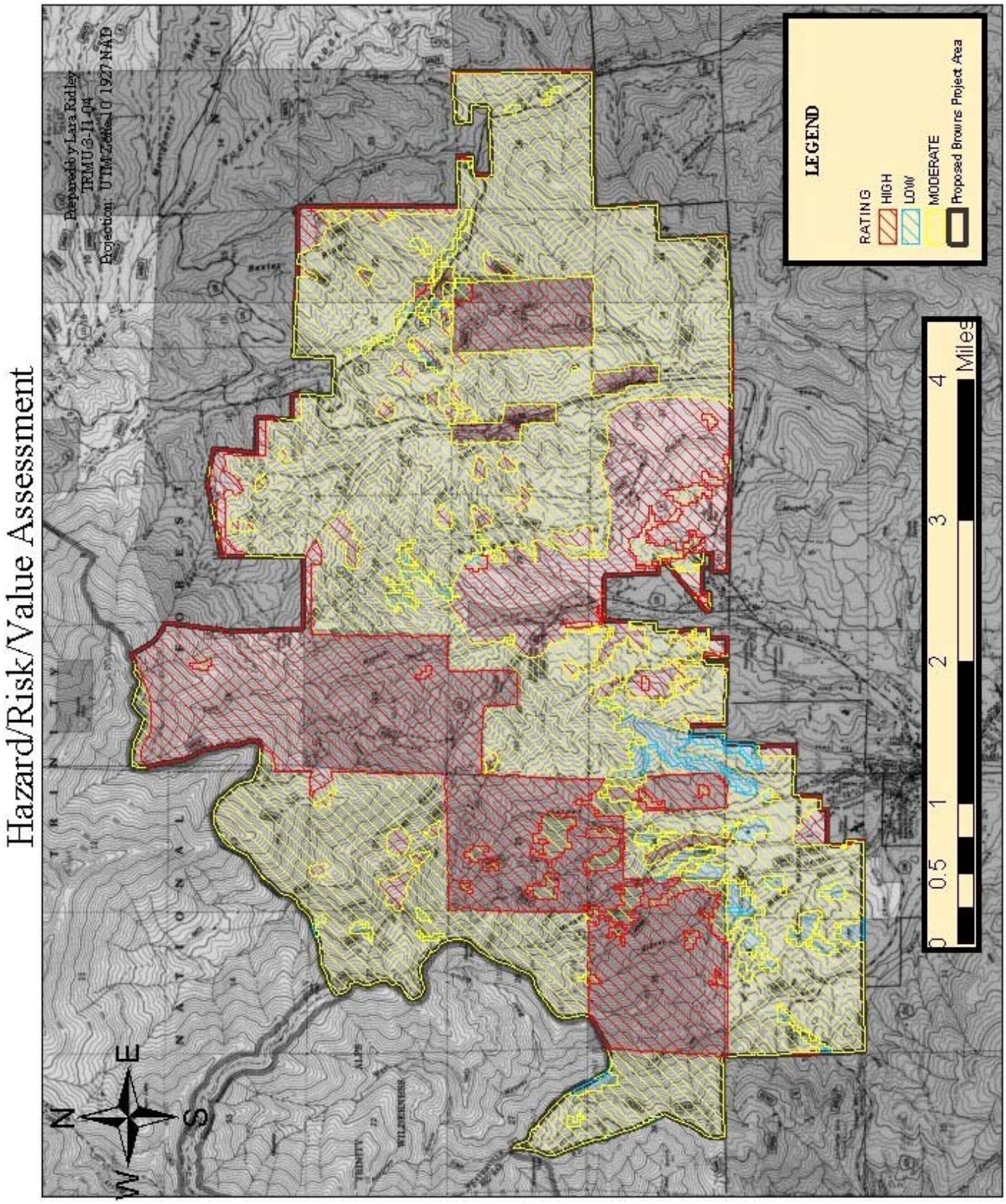
GEOMORPHIC MAP FOR THE WEAVERVILLE WATERSHED ANALYSIS

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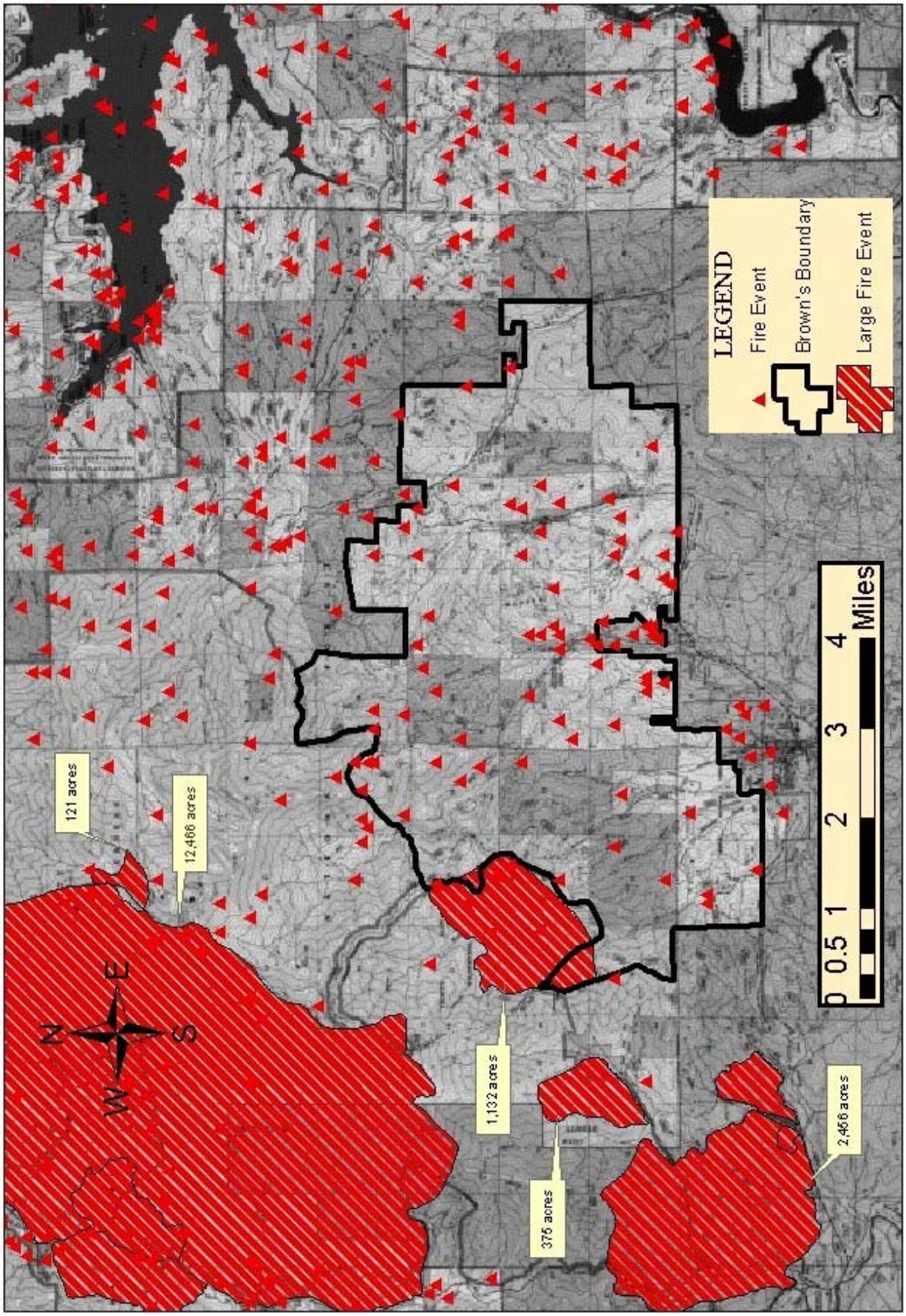

EBASCO ENVIRONMENTAL

Trinity River Basin Restoration Program

WEST WEAVER CREEK

Fish Habitat Assessment

Prepared for:

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

January 1990

EBASCO ENVIRONMENTAL
A Division of Ebasco Services, Inc.

TRINITY RIVER BASIN RESTORATION PROGRAM
WEST WEAVER CREEK FISH HABITAT ASSESSMENT

Prepared For:

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
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January 1990

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ACKNOWLEDGEMENTS

A number of individuals contributed to this report. Alan B. Brainerd, Ted M. Frink, and Lizette F. Cook assisted in data collection. Data processing support was provided by Lizette F. Cook and Diane S. Moore. Word processing was done by Sarah Busing and Elizabeth Boorman. Richard M. Sitts, Ph.D., was the project manager for the Trinity River fish habitat assessments, and Robert Mohn was the program manager for the Basic Ordering Agreement with the Bureau of Reclamation, under which Ebasco provided support to several different types of projects thoughout California.

Ebasco Environmental appreciates this opportunity to provide support to the Trinity River Basin Restoration Program. We appreciate particularly the direction, review and responsiveness of Ed Solbus of the Bureau of Reclamation, and of Mike Stempel and Joe Krakker of the U.S. Fish and Wildlife Service.

1.0 INTRODUCTION

1.1 PURPOSE

The Trinity River Basin Restoration Program began in 1984 with enactment of Public Law 98-541. The project emphasis is restoration and maintenance of fish and wildlife resources within the Trinity River basin at historic levels prior to the construction of the Trinity River Division of the Central Valley Project. The Restoration Project's annually-updated three-year action plan guides and prioritizes various improvement efforts. Objectives in the plan include quantifying physical aspects of existing salmon and steelhead habitat in major tributaries, and recommending habitat enhancements where habitat deficiencies may limit salmon and steelhead production. This study meets this objective for the West Weaver Creek tributary of the Trinity River basin.

1.2 WEST WEAVER CREEK

1.2.1 Physical Characteristics

West Weaver Creek is one of two major tributaries to Weaver Creek (Figure 1.2-1). Weaver Creek drains into the Trinity River approximately 6 miles downstream of the Weaver/West Weaver confluence. West Weaver Creek flows in a southerly direction from its headwaters on the southern slopes of Monument Peak to its confluence with Weaver Creek in the town of Weaverville. The upper segment of West Weaver Creek flows through a narrow channel with steep, forested banks. The lower mile of West Weaver Creek flows through areas of terraced mine tailings and scattered residential development.

The gradient along the 4.4 miles in the study area averages 4.3% as the stream descends from an elevation of 2,953 to 1,936 feet (Figure 1.2-2). Substrates are dominated by cobble and gravel throughout the study area.

No major tributaries enter West Weaver Creek within the study area.

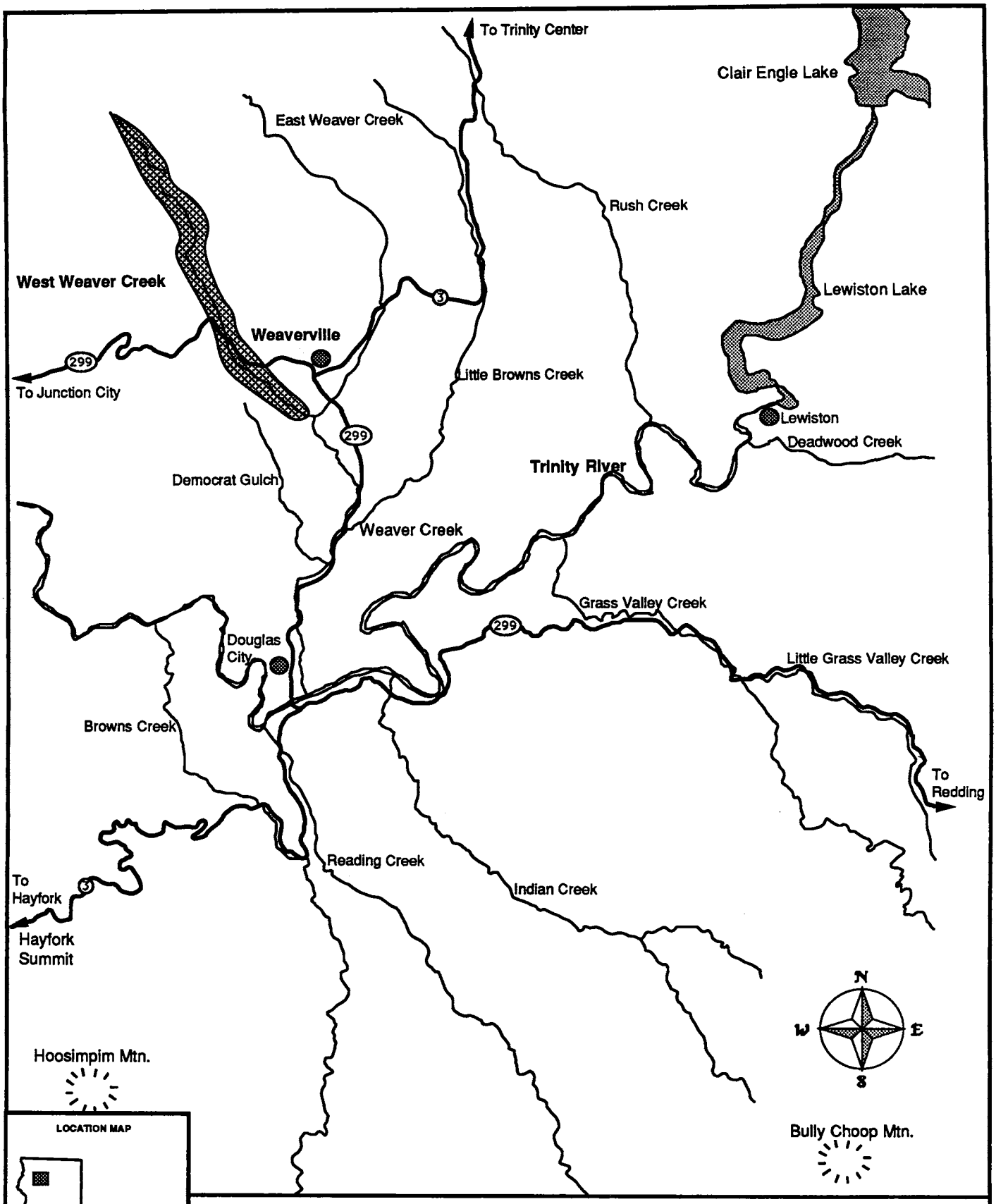


Figure 1.2-1. Location Map

West Weaver Creek Study Area

Scale 1/2" = 1.12 miles

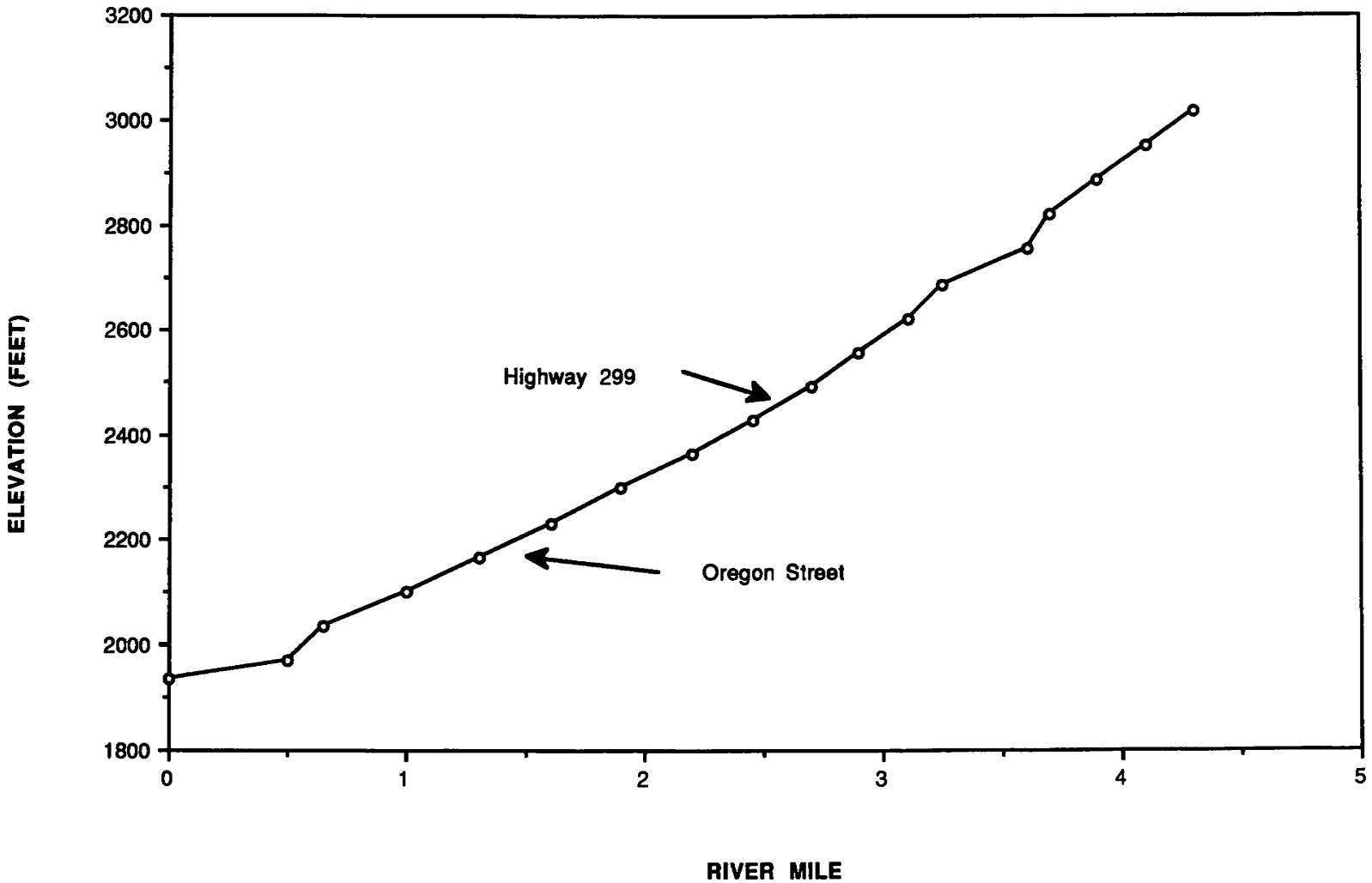


Figure 1.2-2. West Weaver Creek channel gradient.

1.2.2 Vegetation

The area along the lower mile of West Weaver Creek is thickly vegetated with annual grasses, willows (Salix spp.), and other brush species, with open stands of conifers higher on the slopes. The riparian belt is primarily alder (Alnus rubra), blackberry (Rhubus vitifolius), and willows. As the stream elevation increases in the middle and upper portions of the study area, the channel becomes more confined and has a closed canopy of alder, with ponderosa pine (Pinus ponderosa), digger pine (Pinus sabiniana), douglas fir (Pseudotsuga menzesii) and poison oak (Rhus diversiloba) dominant on the slopes.

1.2.3 Fish Fauna

The dominant life stage and species of fish found in West Weaver Creek is age 0+ winter-run steelhead (Oncorhynchus mykiss, formerly Salmo gairdneri). Populations of age 0+ coho salmon (O. kisutch), hereafter referred to as "coho", are present also.

Other fish species inhabiting West Weaver Creek include speckled dace (Rhinicthys osculus), three spined stickleback (Gasterosteus aculeatus), and Klamath small-scale sucker (Catostomus rimiculus).

2.0 METHODS

This habitat assessment of West Weaver Creek involved four steps. First, physical habitat data on 4.4 miles of stream was collected and summarized with regard to available habitat. Second, biological sampling of each habitat type was conducted to quantify habitat utilization. Third, habitat use was related to habitat availability in order to identify less utilized habitat types and other conditions that may limit fish production. Fourth, measures to enhance West Weaver Creek habitat and thereby increase production were identified and recommended.

2.1 HABITAT TYPES

Habitat unit identification utilized 22 habitat type classifications as defined and modified by McCain et al. (unpublished) for northern California streams from the stream habitat classification system developed by Bisson et al. (1981) (Table 2.1-1). The methodology follows the draft field guide developed by the Six Rivers National Forest (Overton et al. In preparation). Further refinements to this methodology and "calibration" to other studies of this type was achieved via attendance by Ebasco Environmental personnel at the United States Forest Service (USFS) training course held near Gasquet, California on May 23-24, 1989. Channel typing was conducted using the classification system of Rosgen (1985).

West Weaver Creek fish habitat was typed between July 27 and August 2, 1989. The West Weaver Creek survey extended from the confluence with Weaver Creek in Weaverville (T33N, R10W, S13NE) to river mile (RM) 4.4 (T35N, R10W, S27SE), approximately 2.0 miles upstream of the Highway 299 crossing (Figure 1.2-1).

Habitat unit quantification consisted of measurements made within the wetted area of each habitat type and estimation of related physical characteristics. The minimum length of measured habitat units was one-to-two times as long as the mean channel width (wetted width). Channel

TABLE 2.1-1

NORTHERN CALIFORNIA STREAM HABITAT TYPES*

Habitat	Number	Abbreviation
Riffles		
Low gradient	1	LGR
High gradient	2	HGR
Cascade	3	CAS
Pools		
Secondary channel	4	SCP
Backwater		
Boulder formed	5	BWPBO
Root wad formed	6	BWPRW
Log formed	7	BWPLOG
Trench	8	TRP
Plunge	9	PLP
Lateral scour		
Log formed	10	LSPLOG
Root wad formed	11	LSPRW
Bedrock formed	12	LSPBED
Boulder formed	20	LSPBO
Edgewater	18	EGW
Dammed	13	DPL
Main channel	17	MCP
Channel confluence	19	CCF
Corner	22	CRP
Flat water		
Glide	14	GLD
Pocket water	21	POW
Run	15	RUN
Step run	16	SRN

* From McCain et al. (unpublished). Modified in this study to include unit type numbers 17, 19 and 22 in the pool classification.

measurements were made with hip chains (string machines) and tape measures by teams of two people. Habitat type measurements included unit lengths (to the nearest foot) between the determined habitat breaks, mean channel widths (to the nearest 0.5 foot) calculated from two to five evenly spaced measurements along the habitat unit, and average habitat depths (to the nearest 0.1 foot) calculated from three to five evenly spaced measurements across the wetted stream channel. Maximum depth was measured for pools, while mean pool depth was calculated by dividing maximum pool depth by two. Pool depths in large units with a localized deep spot were calculated with multiple measurements across the stream channel. Depth of the pool tail crest was measured at the mid-point of the thalweg. Braided or split channels of the same habitat type were measured separately and a combined channel average width calculated.

Ocular estimates of percent noon shade over wetted areas were estimated to the nearest 10% for each habitat type. This was done by facing to the south and viewing at about 15° from vertical.

Total cover in pools was ocularly estimated to the nearest 10%. Cover composition was classified by type and recorded as percent of total cover. Cover types include large and small woody debris, boulders, overhanging vegetation, white water, bedrock ledges, and undercut banks. A cover complexity rating of 1 (low), 2 (medium), or 3 (high) was assigned on the basis of cover type, size, variety and degree of submersion.

Percent of each of six substrate size classes was ocularly estimated and recorded to the nearest 10% for all habitat units. Estimated embeddedness was recorded to the nearest 10% for spawning areas, pool tails or low gradient riffles. Percent stream area of exposed (i.e., above the water surface) substrates in spawning riffles was recorded to the nearest 10%.

Time and water temperature were recorded every fifth habitat unit.

Spawning habitat in wetted portions of the stream was identified based on substrate composition and expected water depth and velocity in riffles,

glides and pool tails during the spawning season (Reiser and Bjornn 1979; Raleigh et al. 1984), and quantified as a percent of habitat unit area. Potential spawning areas on dry banks or gravel bars that would be inundated at higher flows were noted and quantified by measuring the length and width of the area(s).

Documentation consisted of field data sheets with information as to stream name, location, date and time of survey, field crew members, habitat unit number and type, and physical measurements. A field data sheet for habitat typing is provided in Appendix A. All field data was entered into a dBASE III+ database file, structured as delineated in Appendix B, and utilized to generate various data summaries.

2.2 HABITAT UTILIZATION

Direct observation estimates (Hankin and Reeves 1988) with face mask and snorkel were made in approximately 20% of the habitat units of each habitat type to quantify use by anadromous salmonids. Habitat units to be sampled were randomly selected as follows:

> When the first unit of each habitat type was encountered on the creek, a number (n) between one and five was randomly selected. The nth unit of this habitat type was sampled. Thereafter, every fifth additional occurrence of this specific habitat type was sampled. If the number of habitat units of a given habitat type encountered in a study reach was expected to be less than five, then the second occurrence of that habitat type was sampled.

If a particular unit could not be sampled due to physical constraints, such as thick vegetation or average depths of 0.2 feet or less, then the next unit of that habitat type was sampled. Particularly long habitat units were subsampled.

Direct observations involved one or two divers, depending on the width of the channel, swimming upstream through the habitat unit. Species, estimated

age class or size, and number of anadromous salmonids were recorded on field data sheets such as the one provided in Appendix A. Replicate counts were made each time with a goal of obtaining counts that were within 10% of each other. Depending on the width of stream and habitat unit type, replicate counts were made by either multiple divers observing all fish, or by a single pass by each of two different divers.

Salmonids were identified by key characteristics defined in Fry (1973) and Moyle (1976). Steelhead characteristics include small black spots on dorsal and caudal fins, white and black bands at the tips of dorsal and anal fins, parr marks which are more oval than elongated, a red band along the lateral line, the base of anal fin insertion being shorter than longest anal fin ray, and caudal fins more rounded and less deeply forked than salmon. Coho characteristics include clear dorsal and caudal fins, elongated parr marks taller and narrower than spaces between them, base of anal fin insertion normally longer than the longest anal fin ray, and concave shaped anal fin.

Since rainbow trout and steelhead are considered conspecific (Moyle 1976), they were not differentiated for fish up to age 2+. Also, there are no migration barriers between West Weaver Creek and the ocean, and the creek is known to support anadromous fish. Therefore, any O. mykiss observed were recorded as steelhead.

Estimates of age 0+ fish abundance were calculated by averaging the number of fish observed by each diver. Estimates for age 1+ and age 2+ steelhead were calculated by averaging the number of similarly sized fish observed by each diver; if distinctly larger or smaller fish were observed by one diver and not the other, these individuals were added to the total estimate.

Direct observation efficiency was calibrated for an individual unit of each class of habitat types, i.e. runs, pools, and riffles. For each of these habitat units, the separate steelhead and coho abundance estimates from direct observations were compared with those from electrofishing. Calibration units were considered representative of their general classification, and conducive to effective sampling by both electrofishing

and direct observation. Extremely deep, wide, or brushy units were avoided due to potential bias with one or the other of the methods.

Electrofishing was conducted with a Smith-Root backpack electrofisher using a multiple-pass depletion method. A sampling area was blocked off with one-quarter-inch mesh nets and repeat passes made to remove as large a percentage of the population as possible. A minimum of three passes was made in each sampling area. For each pass, captured anadromous salmonids were counted, identified to species and size class, and returned to the stream. An electrofishing data sheet is presented in Appendix A.

Separate population estimates for each species and life stage of anadromous salmonid for each sampling site were computed from electrofishing data. The Zippin method (Platts et al. 1983) was used when two conditions were met: enough fish of each species were caught in each of the three or more passes, and a regression of the number of fish caught during each pass to the cumulative number caught after each pass had a negative slope. In cases where the Zippin method could not be used, a minimum type of estimate was made by summing the number of fish captured.

Direct observation and electrofishing estimates yield efficiencies ranging from 0.51 to 0.77 for age 0+ steelhead, depending on habitat type (Table 2.2-1). A greater percentage of steelhead were observed in the pool and step run than in the riffle.

Steelhead lengths were recorded in 0.39-inch (10 mm) increments, and age classes assigned using a combination of several methods. A length frequency distribution was constructed from fish collected during electrofishing surveys, and age classes assigned based on breaks in the frequency distribution. In addition, scale samples collected during electrofishing were used to confirm the age class delineations, and data from other studies in the Trinity River basin were obtained (C. Wilson, pers. comm., 1989; D. Cross, pers. comm., 1989). Age 0+ steelhead were less than 3.94 inches (100 mm) total length (TL), age 1+ steelhead were 3.9 to 6.3 inches (100-160 mm) TL, and age 2+ steelhead were 6.7 to 8.7 inches (170-220 mm) TL.

TABLE 2.2-1

DIRECT OBSERVATION EFFICIENCIES IN WEST WEAVER CREEK

Habitat				Electrofishing		Direct Observation	
Type*	Class	Species	Age	Estimated Population	95% Confidence Interval	Fish Counted	Efficiency**
LGR	Riffle	Steelhead	0+	37	34-40	19	0.51
LGR	Riffle	Steelhead	1+	4	-	1	0.25
LSP	Pool	Steelhead	0+	21	20-22	17	0.77
LSP	Pool	Steelhead	1+	2	-	1	0.50
SRN	Run	Steelhead	0+	64	64†	43	0.67
SRN	Run	Steelhead	1+	3	-	2	0.67

* SRN=Step run; LSP=Lateral scour pool; LGR=Low gradient riffle

** Efficiency is the ratio of direct observation counts to electrofishing estimates.

† Confidence interval is less than one due to capture of the entire population.

2.3 LIMITING FACTORS

A habitat electivity index was used to identify potentially limiting habitat types. The index quantifies the relationship between the proportion of fish in a particular habitat type and the proportion of that habitat type among all habitat types sampled. Electivities (D) were calculated from the formula of Jacobs (1974),

$$D = \frac{r-p}{(r+p) - 2rp}$$

where r is the proportion of the fish counted in a particular habitat type relative to the total count among all habitat types, and p is the areal proportion of the habitat type among all habitat types sampled. Electivity approaches +1 when a large proportion of the fish population is in a small-proportion habitat type. Electivity approaches -1 when a small proportion of fish are in a large-proportion habitat type. Electivity equals zero when the proportion of the fish population in a particular habitat type equals the proportion of that habitat type. Habitat types with strongly positive electivities presumably provide more optimal physical and/or biological conditions for juvenile salmonids, while habitat types with strongly negative electivities lack important attributes.

Estimates of potential salmonid production from spawning areas were compared to age 0+ standing crop estimates to indicate if spawning habitat areas might be limiting. Standing crop estimates were made by summing the products of habitat type area and age 0+ density for each habitat type in the creek. Habitat types that were not sampled due to infrequent occurrence were assumed to have age 0+ density equal to the average for the entire study area.

Other potentially limiting factors related to environmental requirements were observed and recorded during the survey. These included water temperatures, migration barriers, water diversions, water quality problems, and sediment input areas.

2.4 HABITAT ENHANCEMENTS

Habitat enhancement areas were identified based on three criteria: low electivity, low density, and other adverse habitat conditions. Potentially limiting habitats were identified as those with the lowest electivities for age 0+ steelhead or coho. Half-mile stream sections with frequent negative electivity habitat units were identified from a frequency distribution as candidate enhancement reaches. Further, consideration was given to other potential limiting factors, and marginal instream or riparian conditions identified in the field notes.

Extreme positive and negative electivity habitat types were compared. These comparisons identified key differences in habitat attributes that could cause the differences in steelhead and coho use. These comparisons examined differences in substrates, unit area, channel widths, depths, shading, instream cover and pool cover complexity.

Key habitat attributes absent from the negative electivity habitat types were used as a basis for determining enhancement structures that could create or imitate these attributes. Enhancement structures considered included those reviewed by Province of British Columbia, Ministry of Environment (PBCME) (1980); Hall and Baker (1982); Reeves and Roelofs (1982); and Rosgen (1985).

Rosgen (1985) channel typing data was used to guide habitat enhancement option decisions. General enhancement structure types were reviewed for their compatibility with the Rosgen stream classification recommendations to ensure that chosen enhancements would be stable and provide long term benefits for anadromous fish (Rosgen and Fittante 1986).

Recommended enhancement reaches in the West Weaver Creek study area were identified. These reaches had to contain frequent low-electivity habitat types or other limiting factors that could be enhanced by modifications meeting Rosgen (1985) standards. The recommended reaches had to be accessible and enhancement could not involve apparent major adverse environmental impacts.

Enhancement benefits in terms of anadromous fish production were determined by calculating the percent increase in the number of fish expected within the study area. This calculation is based on increasing the fish density of low electivity habitat units in the enhancement areas to a level equal to the current average density for the entire study area. Estimated costs for implementation were based on Ebasco Environmental's habitat enhancement experience. Key elements in the cost consideration included the length of stream enhanced, an average of about 40 habitat enhancement structures per mile, and an average cost of about $400 per structure.

3.0 RESULTS

3.1 HABITAT TYPES AND OTHER CONDITIONS

3.1.1 Habitat Types

Seventeen (17) of the 22 different habitat types were identified in West Weaver Creek. The mean width of West Weaver Creek habitat units ranged from 2 to 34 feet and averaged 9.8 feet; mean unit depths ranged from 0.2 feet to 2.2 feet and averaged 0.7 feet.

Physical habitat data for the West Weaver Creek study area is summarized in Table 3.1-1. The most frequent habitat types were step runs, pocket water and low gradient riffles (26%, 17%, and 14%, respectively) (Table 3.1-1 and Appendix Figure C3.1-1). Root wad lateral scour pools and plunge pools were the most common pool types (7% each). These five habitat types comprise 71% of habitat units observed in West Weaver Creek.

West Weaver Creek habitat area was dominated by step runs, pocket water and low gradient riffles (45%, 21%, and 16%, respectively) (Table 3.1-1 and Appendix Figure C3.1-2). These three habitat types comprise 82% of the total area. Main channel, dammed, and plunge pools were the dominant pool types (3% each of the total habitat area).

West Weaver Creek habitat volume was dominated by step runs, pocket water and low gradient riffles (43%, 19% and 11%, respectively) (Table 3.1-1 and Appendix Figure C3.1-3). These three habitat types comprise 73% of the total stream volume. Pool habitat volume was dominated by dammed pools and plunge pools (6% and 5% of total habitat volume, respectively).

Step run-pocket water complexes were the dominant West Weaver Creek habitat type group, totalling 65% of the total habitat area and 63% of the total habitat volume (Table 3.1-1). These unit types were typically separated from each other by a low gradient riffle or pool. There was a wide variety

Table 3.1-1
West Weaver Creek Study Area Physical Habitat Summary

HABITAT TYPE *	UNITS	PERCENT OF TOTAL UNITS	TOTAL AREA (SQUARE FEET)	PERCENT OF TOTAL AREA	TOTAL VOLUME (CUBIC FEET)	PERCENT OF TOTAL VOLUME	AVERAGE DEPTH (FEET)	SIDE CHANNEL UNITS	UTILIZATION SAMPLING AREA (SQUARE FEET)	UNITS SAMPLED FOR UTILIZATION
LGR	33	13.7	36,371	16.3	14,600	10.8	0.4	0	5,809	6
HGR	15	6.2	9,231	4.1	4,839	3.6	0.5	0	999	3
CAS	8	3.3	2,382	1.1	1,948	1.4	0.7	0	168	1
RUN	1	0.4	252	0.1	176	0.1	0.7	0	152	1
SRN	62	25.7	99,884	44.7	58,182	43.2	0.6	2	19,929	13
GLD	3	1.2	1,884	0.8	657	0.5	0.4	0	710	1
POW	42	17.4	45,969	20.6	25,946	19.3	0.6	0	10,029	8
MCP	15	6.2	6,597	2.9	5,563	4.1	0.9	0	1,329	3
LSPBED	9	3.7	2,465	1.1	2,623	1.9	1.0	0	390	2
LSPBO	3	1.2	1,078	0.5	853	0.6	0.8	0	336	1
LSPLOG	2	0.8	626	0.3	608	0.5	1.1	1	626	2
LSPRW	16	6.6	3,613	1.6	2,852	2.1	0.8	0	704	3
DPL	8	3.3	5,671	2.5	7,440	5.5	1.1	0	1,738	2
PLP	18	7.5	5,637	2.5	6,632	4.9	1.1	0	821	3
TRP	4	1.7	1,401	0.6	1,459	1.1	1.1	0	182	1
SCP	1	0.4	247	0.1	148	0.1	0.6	1	0	0
BWPBO	0	--	--	--	--	--	--	--	--	--
BWPLOG	0	--	--	--	--	--	--	--	--	--
BWPRW	0	--	--	--	--	--	--	--	--	--
EGW	0	--	--	--	--	--	--	--	--	--
CCF	1	0.4	332	0.1	133	0.1	0.4	0	0	0
CRP	0	--	--	--	--	--	--	--	--	--
TOTALS	241	99.7	223,640	99.9	134,659	99.8	--	4	43,967	50

*See Table 2.1-1 for habitat type abbreviations.

of pools, with 10 of the 15 pool types represented in West Weaver Creek. There were no backwater or corner pools.

3.1.2 Other Conditions

West Weaver Creek pool cover averaged 9% for all pools. The dominant cover type was large woody debris (Table 3.1-2 and Appendix Figure C3.1-4). Cover composition varied among pool types, although the major pool types demonstrated good cover diversity by having some of each of the seven cover types (Table 3.1-2). Plunge pools had more white water cover than other pool types, and lateral scour pools had the greatest amount of large woody debris.

Shade was abundant in the West Weaver Creek study area, ranging from 29% in the lower 0.5 miles to 65% in the middle and upper sections of the creek. Shade averaged 50% for the entire study area.

West Weaver Creek substrate was dominated by cobble and gravel (38% and 33%, respectively) (Table 3.1-3 and Appendix Figure C3.1-5). Variation in substrate composition between pools, flat water (including step runs, glides, and pocket water), and riffles (including cascades) is depicted in Table 3.1-3 and Appendix Figure C3.1-6. Pool substrates were dominated by gravel, cobble and sand (29%, 26% and 24%, respectively). Flat water substrates were dominated by cobble and gravel (41% and 32%, respectively), and riffle substrates were dominated by gravel and cobble (38% and 36%, respectively). Substrate embeddedness for low gradient riffles and pool tails averaged 28%.

About 4% (9,553 square feet) of the low-flow wetted area of West Weaver Creek was considered suitable spawning habitat for anadromous salmonids. An additional area of approximately 2,120 square feet of spawnable substrates were located on floodplains or gravel bars probably inundated by the higher flows which occur during the spawning season.

The Rosgen channel type classification for West Weaver Creek is "B3" in the lower 3.0 miles. This section of West Weaver Creek fits this classification

TABLE 3.1-2

WEST WEAVER CREEK COVER COMPOSITION BY POOL TYPE

	Percent Pool Cover Composition						
Pool Type	Overhanging Vegetation	Small Woody Debris	Large Woody Debris	White Water	Boulders	Bedrock Ledges	Undercut Banks
All pools	14.5	7.6	33.0	17.9	11.0	3.7	12.3
Lateral scour	18.6	6.5	55.7	3.1	9.1	1.0	5.9
Main channel	23.6	11.1	33.4	6.8	8.4	1.7	15.1
Plunge	2.4	5.0	21.4	43.7	15.9	3.2	8.3

TABLE 3.1-3

PERCENT COMPOSITION OF WEST WEAVER CREEK SUBSTRATE

	Habitat Type			
Substrate	All	Pools	Flat Water	Riffles
Fines	0.7	5.3	0.1	0.0
Sand	12.4	23.7	11.1	10.0
Gravel	32.7	28.6	31.9	37.6
Cobble	38.0	25.7	40.9	36.4
Boulder	10.4	5.5	11.6	9.7
Bedrock	5.7	11.2	4.4	6.3

because the dominant substrate types are cobble and gravel, and channel gradients range from 1.25 to 3.50%. This type of channel is moderately entrenched and well confined with a sinuosity factor of 1.3 to 1.7 and a width to depth ratio ranging from 8 to 20. Also, the unconsolidated banks of coarse cobble formed along West Weaver Creek due to mining activity are typical of "B3" channel types (Rosgen 1985). The upper 1.3 miles of West Weaver Creek are an "A3" channel type. The proportion of bedrock and boulder increases, and gradients are above 4%.

West Weaver Creek stream bank stability was poor in many areas due to sloughing of slopes and bank cutting. The low flow channels exhibited moderate to highly active bank-cutting and sloughing where flows had shifted the channel within cobble-gravel deposits. These deposits are a source of fine sediments to lower West Weaver Creek as channel migration occurs during high flow periods.

Stream temperatures measured in West Weaver Creek during the survey in late July and early August averaged 66.6°F and ranged from 52.0°F to 76.0°F. Late August temperatures should have been warmer due to increased summer air temperatures. The warmest temperatures were recorded within 0.7 RM of the Weaver Creek confluence. This stream section is adjacent to mine tailing areas and is not as well shaded as other parts of West Weaver Creek.

Numerous low-flow barriers to migration of salmonids in the lower 3.0 miles of West Weaver Creek were created by construction of small cobble dams. Presumably, these dams are washed out during high winter flows, allowing upstream migration of spawning adults and emigration of juveniles.

The culvert located under Oregon Street is a potential barrier for coho, since age 0+ coho were observed in the pool immediately below the culvert and in other units downstream, but not in any units above it. Steelhead were observed upstream of the Oregon Street culvert and the Highway 299 tunnel.

Debris jams and small waterfalls form small barriers with increasing frequency above RM 3.3. Steelhead passage through each of these barriers is highly dependent upon annual hydraulic and hydrologic conditions at each site. A waterfall 7 feet high with no jump pool under normal flow conditions is located at RM 4.4. This waterfall was considered a barrier under all but the most extreme hydrologic conditions, and the habitat survey was concluded at this location.

Four diversions for irrigation or domestic uses were counted, including two screened pipes from 1.5 to 2.5 inches in diameter between RM 1.0 and RM 1.1. One unscreened diversion ditch at RM 0.6, and one screened diversion at RM 3.2 were noted also.

3.2 HABITAT UTILIZATION

Fifty (50) habitat units were sampled for utilization in West Weaver Creek. A total of 2,107 steelhead and 15 coho were counted. Ninety-three (93) percent of the juvenile steelhead population were age 0+, while 6% were age 1+. A total of 1,962 age 0+, 131 age 1+, and 14 age 2+ steelhead were counted.

The age 2+ steelhead, comprising 0.7% of the steelhead population, were primarily observed as single individuals in a habitat unit and were widely distributed throughout the study area. Due to their small sample size, data for this age class was not analyzed further and has been omitted from selected summary tables and figures.

Coho were observed in five habitat units in the lower 1.4 miles of West Weaver Creek, but were not observed above the Oregon Street culvert. Due to their small sample size and restricted distribution, data for this species has been omitted from selected summary tables and figures.

Density estimates are provided in Table 3.2-1 and Appendix Figures C3.2-1 and C3.2-2 (Appendix Table C3.2-1 contains normalized density estimates). Age 0+ steelhead densities generally were greatest for the run and the

Table 3.2-1
West Weaver Creek Salmonid Density by Habitat Type

Habitat Type	Sample Units	Age 0+ Steelhead			Age 1+ Steelhead			Total Density*	
		Density		Number of Fish Observed	Density		Number of Fish Observed		
		Fish/ 1000 Ft^2	Fish/ m^2		Fish/ 1000 Ft^2	Fish/ m^2		Fish/ 1000 Ft^2	Fish/ m^2
LGR	6	21	0.23	120	1	0.01	7	22	0.24
HGR	3	29	0.31	29	3	0.03	3	32	0.34
CAS	1	42	0.44	7	0	0	0	42	0.44
RUN	1	87	0.94	22	8	0.09	2	95	1.02
SRN	13	53	0.57	1,056	3	0.03	55	56	0.60
GLD	1	49	0.53	35	0	0	0	49	0.53
POW	8	37	0.40	367	0	0	5	37	0.40
MCP	3	51	0.55	68	10	0.11	13	64	0.69
LSPBED	2	62	0.67	24	10	0.11	4	75	0.81
LSPBO	1	54	0.58	18	3	0.03	1	57	0.61
LSPLOG	2	56	0.60	35	11	0.12	7	67	0.72
LSPRW	3	53	0.57	37	13	0.14	9	72	0.78
DPL	2	51	0.55	91	6	0.06	11	64	0.69
PLP	3	50	0.54	41	15	0.16	12	69	0.74
TRP	1	66	0.71	12	11	0.12	2	82	0.88
AVERAGE**	--	44.5	0.48	--	3.0	0.03	--	48.2	0.52
TOTAL	50	--	--	1,962	--	--	131	--	--

* Includes age 2+ steelhead and age 0+ coho.

** (Number of salmonids in all habitat types/Total biological survey area) x 1000

(Habitat type codes: LGR= Low gradient riffle; HGR= High gradient riffle; CAS = Cascade; RUN= Run; SRN= Step run; GLD= Glide; POW= Pocket water; MCP=Main channel pool; LSPBED= Lateral scour pool bedrock formed; LSPBO= Lateral scour pool boulder formed; LSPLOG = Lateral scour pool log formed; LSPRW= Lateral scour pool root wad formed; DPL= Dammed pool; PLP = Plunge pool; TRP= Trench pool.)

trench pool, and least for low and high gradient riffles. Densities for age 1+ steelhead were greatest for plunge pools and root wad lateral scour pools. Age 1+ steelhead densities were lowest for pocket water, the glide, and the cascade.

3.3 LIMITING FACTORS

3.3.1 Habitat Types

Electivity estimates are provided in Table 3.3-1 and Appendix Figures C3.3-1 and C3.3-2.

Age 0+ steelhead electivity for any habitat type was moderate at best. Electivities were most positive for the run, the trench pool, and step runs.

Age 0+ steelhead electivities were most negative for riffles and pocket water (Table 3.3-1). Each of these unit types probably lacks some combination of physical and/or biological attributes which are important to juvenile steelhead. Riffles and pocket water, for example, may provide less cover from predators due to their relatively shallow depths compared to other habitat types (0.5 feet versus 0.8 feet). Since cover is important to juvenile salmonids for predator avoidance (Reiser and Bjornn 1979), the lower electivity of these habitat types may be reflecting their cover deficiencies.

The lack of strong positive or negative electivities for age 0+ steelhead indicates that the habitat type composition of West Weaver Creek may not be a limiting factor for this life stage. This is because the population was distributed between habitat types in roughly the same proportion as the habitat type occurrence, as indicated by moderate ($\pm$ 0.30) electivity for only one of the habitat types (low gradient riffles) which was sufficiently numerous to be sampled more than once.

Age 1+ steelhead electivity was most positive for the plunge and root wad lateral scour pools. Electivities were moderate for runs, and other pool types.

Table 3.3-1

West Weaver Creek Steelhead Electivities by Age Class

Habitat Type	Units Sampled	Electivity	
		Age 0+	Age 1+
LGR	6	-0.40	-0.46
HGR	3	-0.21	0.01
CAS	1	-0.03	-1.00
RUN	1	0.33	0.46
SRN	13	0.17	-0.07
GLD	1	0.05	-1.00
POW	8	-0.12	-0.76
MCP	3	0.07	0.56
LSPBED	2	0.16	0.56
LSPBO	1	0.09	0.00
LSPLOG	2	0.12	0.59
LSPRW	3	0.08	0.64
DPL	2	0.07	0.37
PLP	3	0.06	0.68
TRP	1	0.19	0.56

(Habitat type codes: LGR = Low gradient riffle; HGR = High gradient riffle; CAS = Cascade; RUN = Run; SRN = Step run; GLD = Glide; POW = Pocket water; MCP = Main channel pool; LSPBED = Lateral scour pool bedrock formed; LSPBO = Lateral scour pool boulder formed; LSPLOG = Lateral scour pool log formed; LSPRW = Lateral scour pool root wad formed; DPL = Dammed pool; PLP = Plunge pool; TRP = Trench pool.)

Age 1+ steelhead electivities were most negative for the glide, the cascade, and pocket water. Avoidance of glides and pocket water may be due to shallow depth or lack of cover. Age 1+ steelhead demonstrate much lower electivities for pocket water than do age 0+ fish. This differential avoidance of pocket water may be due to the larger size of age 1+ fish and the resultant lack of energy-efficient locations for the larger fish to hold (Bachman 1984; Fausch 1984).

3.3.2 Other Conditions

Other potentially limiting conditions considered included spawning area, water temperatures, sediment loads, migration barriers, water diversions, and poor water quality.

The amount of spawning habitat in West Weaver Creek may be limiting. A conservative estimate of the number of spawning steelhead and coho which could be supported in West Weaver Creek is 56 pairs, which could produce 8,400 age 0+ young. These estimates are based on: a wetted spawning area of 9,553 square feet at low flows plus 25 percent of the 2,120 square feet of spawnable bank area, an average redd area of 45 square feet (Combs 1971; Reiser and Bjornn 1979; PBCME 1980), 25% of the spawning area being used for redd construction (Burner 1951), 3,000 eggs/redd (Combs 1971; Moyle 1976; PBCME 1980), and a 5% survival rate from eggs to age 0+ juveniles (PBCME 1980). The estimated 8,400 age 0+ steelhead and coho which could be produced is 86% of the observed standing crop of 9,742 age 0+ fish. This indicates that spawning is more efficient than estimated (i.e., smaller redds or greater utilization of total spawning area), and/or production is greater than estimated (e.g., higher survival or more eggs per redd).

West Weaver Creek spawning area could vary from one year to the next depending on hydrological conditions. Flows of sufficient magnitude would cleanse and loosen the armored gravels and increase the usable spawning area.

West Weaver Creek water temperatures in late July and early August exceeded the 68°F recommended maximum temperature (Reiser and Bjornn 1979; Raleigh et al. 1984) for maintenance of rainbow trout populations in the lower mile of the study area. These temperatures occur most frequently in unshaded or shallow areas and probably limit salmonid production in short sections of the stream near the Weaver Creek confluence.

There is considerable sediment loading in West Weaver Creek, as evidenced by areas of bank erosion, substrate embeddedness in riffles and pool tails and armoring of gravels. Armoring of gravels reduces potential spawning area, and high sediment loading may decrease hatching success if it persists during the incubation period. The average embeddedness of spawning areas (29%) exceeded the recommended limit of percent fines by volume (25%) for salmonid incubation cited in Reiser and Bjornn (1979).

The culvert under Oregon Street at RM 1.45 is a barrier to upstream migration of coho. No age 0+ coho were observed upstream of the culvert, despite the upstream availability of preferred habitat types such as plunge pools and root wad scour pools. Potential migration barriers to steelhead occur upstream of RM 3.0. Most of these barriers are log jams that prohibit migration at low flows, but may be surmountable during high flows. A 7-foot high waterfall with no jump pool at RM 4.4 is considered a barrier under all but the most extreme hydrologic conditions.

Two major water diversion ditches are located at RM 0.6 and RM 3.2. The ditch at RM 0.6 is on the right bank and is unscreened. Flows in the creek above this ditch are noticeably higher. The diversion at RM 3.2 is the largest on West Weaver Creek. It is located on the left bank and flows through sections of pipe, flumes, and ditches. A fish screen and trap apparently maintained by the California Department of Fish and Game is located further down the diversion.

There were no notable water quality problems in West Weaver Creek.

3.4 RECOMMENDED HABITAT ENHANCEMENTS

West Weaver Creek areas meeting the enhancement criteria of frequent low-electivity habitat units and low salmonid density are apparent in Figures 3.4-1 and 3.4-2, respectively. Low electivity habitat unit areas were frequent from RM 0.0 to 1.5, RM 2.5 to 3.0, and RM 4.0 to 4.5. Low density areas for age 0+ steelhead occurred between RM 0.0 and 0.5, and between RM 3.5 and 4.5. Low density areas for age 1+ steelhead occurred between RM 0.5 and 1.0 and between RM 3.0 and 3.5. Stream areas which could be enhanced by erosion control measures are located between RM 0.5 and RM 1.5.

Installation of enhancement structures is a primary means of shifting habitat composition and controlling erosion. Instream enhancement structures rated as fair to good on the basis of stability, longevity, and actual habitat modifications produced in the "B3" channel type (Rosgen and Fittante 1986) in the lower 3.0 miles of West Weaver Creek include the following:

- Low stage check dams
- Bank placed boulders
- Floating or half-log cover structures
- Submerged large woody debris and boulder cluster series

Other structures successfully installed on West Weaver Creek between RM 2.5 and RM 3.0, or similar local streams include:

- Wire basket gabion, log or boulder "V" or "K" weirs
- Single or double gabion, log or boulder wing deflectors
- Gabion, log or boulder channel constrictors

These selected enhancement structures follow design criteria that are compatible with the stream channel morphology and hydrology (Reeves and Roelofs 1982; Rosgen 1985). Thus, properly placed enhancement structures will create the planned habitat changes, will be stable over a range of

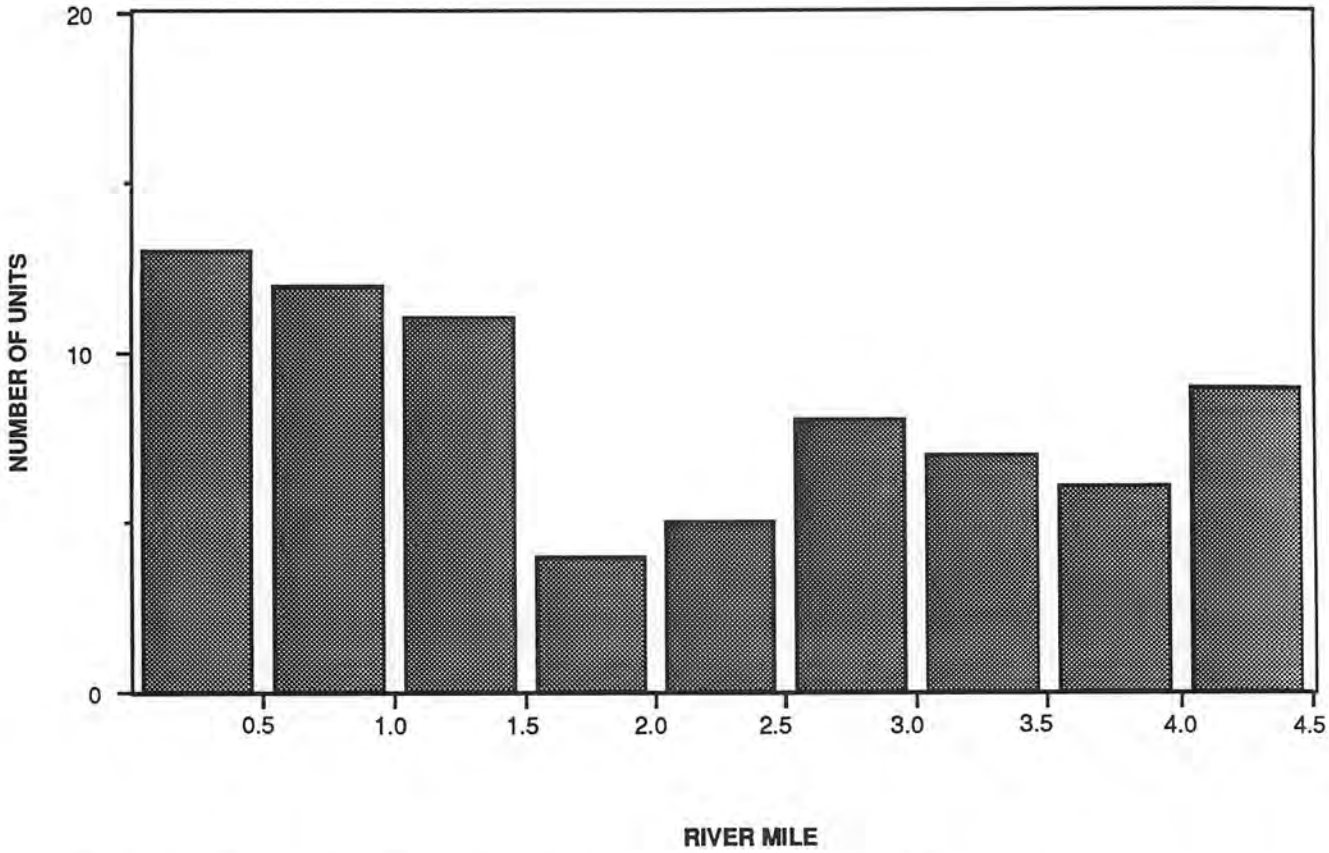


Figure 3.4-1. Frequency of negative electivity habitat units (low gradient riffles and pocket water) in West Weaver Creek.

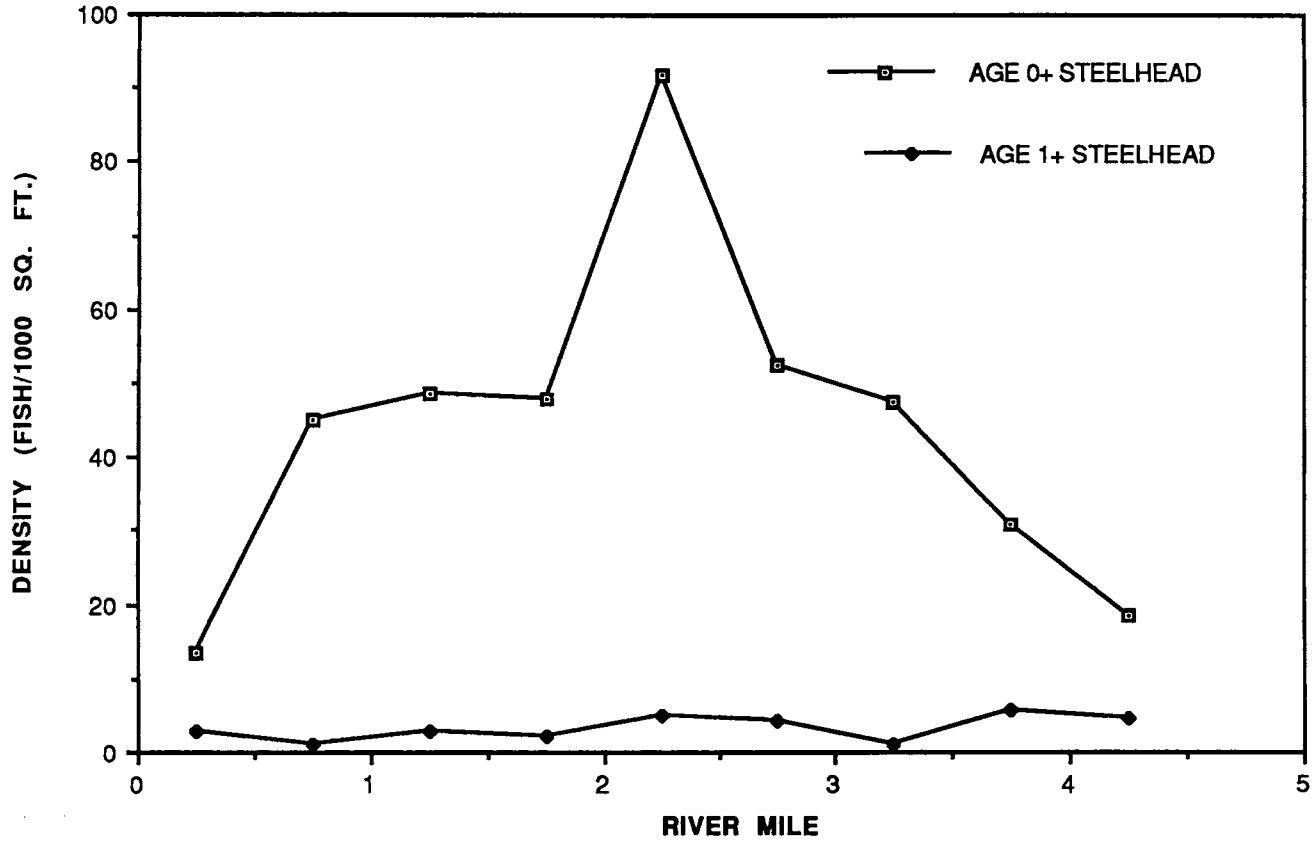


Figure 3.4-2. Density of West Weaver Creek steelhead.

flows, and will provide long term benefits to salmonid production. Proper design criteria will minimize adverse environmental impacts, including stream degradation or loss of the structure from high flows or channel shifts.

Soil erosion or bank erosion control measures are recommended in addition to instream structures. These control measures include the following:

- Willow mats or boughs
- Log cribs
- Boulder riprap
- Willow plantings

These measures are recommended to help reduce sediment input to West Weaver Creek, which adversely affects spawning gravels and salmonid production by causing embeddedness, armoring of gravels, suffocation of incubating eggs and decreased food production.

Habitat enhancements from recommended structures and channel modifications are described in Table 3.4-1. Each structure type provides more cover, adds diversity, and creates conditions similar to run, lateral scour pool and plunge pool habitats which juvenile steelhead preferred in West Weaver Creek.

The recommended habitat enhancement areas and appropriate measures, are summarized in Table 3.4-2.

Enhancement criteria were met between the confluence and RM 0.5 because low gradient riffles and pocket water were common in this area, age 0+ steelhead densities were low, and there were areas of armored gravels. Enhancement structures that would benefit salmonids in this section include wing deflectors and channel constrictors to create lateral scour and channel deepening; boulder clusters, half-log or floating log gabion covers, or large submerged wood debris would add complex cover, shade and habitat diversity. Boulder or gabion weirs and check dams could be installed for spawning gravel stabilization and plunge pool formation which creates

TABLE 3.4-1

RECOMMENDED STRUCTURES, RESULTING CHANNEL MODIFICATIONS, AND ENHANCEMENTS

Structure Type	Resulting Channel Modification	Enhancements
"V" or "K" weirs, low stage check dams	Spawning gravel stabilization; downstream plunge pool	Provides spawning areas; increases pool depth for holding, rearing; white water and depth cover for predator avoidance.
Single/double wing deflectors	Stream channel scour, deepening; bank protection	Provides deeper channel for feeding lanes and backwater pools for holding and rearing; spawning gravel deposits; bank protection preventing sediment input to stream.
Channel constrictors	Stream channel scour, deepening; bank protection	Creates deep channel for feeding lane; increases depth for predator avoidance; bank protection preventing sediment input to stream.
Floating log and half-log covers; submerged large woody debris	Increase instream cover; depth increase from scour	Provides cover for predator avoidance; high velocity barrier; increased cover providing visual isolation and niche availability.
Boulder cluster series	Increase instream structure or cover; localized depth increase from scour; flow deflection for bank protection	Provides cover for predator avoidance; high velocity barrier; increased cover providing visual isolation and niche availability; bank protection preventing sediment input to stream.
Willow mats; log cribs or boulder riprap	Erosion control, bank protection	Reduces or prevents sediment input to stream.

TABLE 3.4-2
WEST WEAVER CREEK STUDY AREA HABITAT ENHANCEMENT RECOMMENDATIONS

Location (River Mile)	Habitat Limitation	Habitat Unit(s) Recommended For Improvement	Access*	Potential Improvement Measure(s)	Adverse Environmental Impacts	Approximate Cost ($1,000s)	Annual Indices of Potential Fishery Benefit: Increase in Age 0+ Steelhead and Coho Populations		
							Percent**	Individuals†	
								Steelhead	Coho
0.0 - 0.5	Habitat composition Armored spawning gravels	1 - 30	Excellent	Channel constrictors Boulder clusters Wing deflectors Weirs Check dams Log covers Woody debris	Streambed disturbance	$10-15	3	232	30
0.5 - 1.0	Habitat composition	31 - 63	Good	Channel constrictors Boulder clusters Wing deflectors Weirs Check dams	Streambed disturbance	$10-15	1	112	20
	Streambank erosion	31 - 63	Good	Revegetation Riprap Log cribs	None	$ 5-10	+***	+	+
1.0 - 1.5	Habitat composition	64 - 88	Good	Weirs Wing deflectors Channel constrictors Check dams	Streambed disturbance	$10-15	2	160	28
	Streambank erosion	64 - 88	Excellent	Riprap Boulder clusters Willow plantings	None	$ 5-10	+	+	+
1.5	Barrier	87	Excellent	Culvert alteration	None	$ 5-10	1	+	112
					Total	$45-75	7	504	190

* Some of the land is privately owned, but permission for access has been granted. Excellent access areas have relatively flat terrain and adjacent roads. Good access areas have somewhat steeper terrain and/or nearby roads.

** Percent is based on increased individuals relative to the total estimates for the study area during July and August of 1989.

*** + = Reasonably accurate benefits cannot be calculated.

† Excludes age 0+ steelhead and coho that emigrated prior to May and June.

additional depth, cover, and holding areas. Armored gravels could be loosened by heavy equipment operating in the stream channel or other enhancements, or by ripping of the streambed areas where armoring is severe.

Enhancement criteria were met between the RM 0.5 and RM 1.0 because of frequent low electivity habitat units, low densities of age 1+ steelhead, and numerous erodible or eroding banks. Appropriate enhancement structures include boulder or gabion weirs in "V" or "K" configuration for spawning gravel stabilization and plunge pool formation which creates additional depth, cover, and holding areas. Enhancement measures also could include boulder clusters or half-log structures downstream of weirs for additional cover in the resulting plunge pools. Bank stabilization utilizing boulder riprap with willow plantings, staked willow boughs or willow brush-bundle mats, or log cribs would reduce sediment input and provide a foothold for vegetation that would eventually increase shading. Single boulders or boulder clusters placed in a line would deflect flows away from eroding banks, and provide additional bank stabilization and instream cover complexity.

Enhancement criteria were met from RM 1.0 to RM 1.5 due to frequent low electivity habitat units and erodible or eroding stream banks. Enhancement structures for this area include boulder, gabion, or log channel constrictors from both banks. These would provide bank protection as well as increased stream velocities in short sections that would scour and deepen the channel. Boulder clusters or half-log or floating log covers could be placed in conjunction with channel constrictors to provide additional cover. Double wing deflectors of boulders, logs, or gabions could be constructed on alternating banks to create artificial meanders and lateral scour. Sites for deflectors would have to be carefully analyzed to reduce the potential for bank erosion opposite each structure, and to provide for extra bank protection in critical areas.

Erodible banks in this section should be stabilized to reduce sediment input to the stream utilizing boulder riprap, log cribs, willow boughs or mats,

and by planting vegetation on suitable stream banks. Boulder clusters and log structures could be placed in conjunction with deflectors to increase instream cover.

The coho barrier at the Oregon Street culvert is recommended for analysis to determine if cost effective changes could be made to enable passage of coho to upstream areas. The culvert contains baffles to aid in migration once the fish enter it. The jump pool at the bottom of the culvert is adequate during the summer when a cobble dam raises the water surface elevation of the pool. Washout of the cobble dam during high flows may lower the jump pool elevation to the point where it no longer allows adequate entry to the culvert.

Once the Oregon Street culvert is passable, coho could migrate an additional mile upstream to the Highway 299 tunnel at RM 2.5. An analysis is needed to determine whether this tunnel (which contains baffles) is a coho barrier.

Access to recommended enhancement areas on West Weaver Creek is good to excellent. In most cases, access may only require permission to cross privately owned land. Minor road construction or improvement of existing access roads may be necessary in some locations.

The approximate one-time cost for implementation all recommendations in Table 3.4-2 amounts to $45,000 to $75,000. The estimated annual benefit index for age 0+ steelhead and coho is about 694.

4.0 DISCUSSION

Habitat enhancement recommendations focus on shifting the habitat composition of West Weaver Creek so that it is more favorable for spawners and age 1+ steelhead, and removing barriers to upstream migration of coho. Age 1+ steelhead demonstrate the strongest negative electivities, and spawning habitat is potentially limiting due to armored gravels and low availability of areas with adequate gravels and hydraulic conditions. Implementation of the enhancements will shift areas with negative electivity habitat types to a lower percentage of the total area, and therefore increase the percent area of more preferred habitats. Elimination of barriers to coho will open up additional areas of West Weaver Creek to this species.

Enhancement recommendations for West Weaver Creek center around modifying pocket water and low gradient riffles, and making channel alterations that will increase the density of steelhead in these areas. These habitat types had low juvenile steelhead densities and electivities. Enhancement structures placed in these habitat types would create pools utilized by steelhead and coho for cover, respite from high velocities, and predator avoidance (Everest et al. 1986). Several of the pool types which could be created by structures demonstrate high electivity by juvenile steelhead in West Weaver Creek and age 0+ coho in other creeks. Other habitat types could be enhanced by the addition of woody debris such as branches, logs or root wads to create cover that is preferred by steelhead and coho (Hartman 1965; Chapmann and Bjornn 1969; Bustard and Narver 1975; Bryant 1983; Sedell et al. 1984).

Variations in habitat type preference from one stream to another occur due to a number of physical, temporal or biological factors, including the size and nature of the stream, the age structure and size of the fish population, food availability, interspecific competition, time of year, flow, etc. Other variations in preference between and within streams appear due to the effect of differing sample sizes of fish or habitat units.

The results of this study indicate the juvenile steelhead have the highest electivity for most pool types. This result is consistent with data from Canyon Creek (USFS 1989) which indicate that the highest utilization occurred almost exclusively in pools. Data from Bisson et al. (1981, 1988) indicate that age 0+ steelhead prefer faster water habitats, including riffles, cascades and runs, and age 1+ steelhead prefer trench, plunge and lateral scour pools. Variations in results between these different studies indicate that electivity will differ in response to site or study specific factors.

The mean density of age 0+ steelhead in West Weaver Creek is greater than that for many tributaries to the Trinity River, although it is lower than Deadwood Creek and Democrat Gulch (Table 4-1). These densities indicate that West Weaver Creek conditions may be favorable for age 0+ steelhead.

The mean density of age 1+ steelhead for West Weaver Creek is about average for Trinity River tributaries surveyed. These results may indicate that despite favorable conditions for age 0+ steelhead, West Weaver Creek habitat is relatively less preferable for older fish.

The mean density of age 0+ coho for West Weaver Creek cannot be calculated for the entire study area due to the migration barriers. The frequent occurrence of habitat types preferred by coho, however, indicates that this species could utilize more of West Weaver Creek.

A comparison of potential annual benefits and one-time costs between West Weaver Creek and other Trinity River tributaries for age 0+ steelhead and coho indicates that the greatest enhancement emphasis might first be placed on other creeks. The potential annual benefit indices, one-time costs, and ratios of these are presented in Table 4-2. The potential benefit index per unit cost is greater for most other creeks than for West Weaver Creek at this level of analysis. More refined comparisons may yield areas in many streams with greatest benefit per unit cost.

TABLE 4-1

SALMONID DENSITIES IN TRINITY RIVER BASIN TRIBUTARIES

Location	Source	Survey Year	Density [Fish/1,000 square feet (Fish/Square meter)]					
			Age 0+ Steelhead		Age 1+ Steelhead		Age 0+ Coho	
			Mean	Range*	Mean	Range*	Mean	Range*
West Weaver Creek	This study	1989	45 (0.48)	21-53 (0.23-0.57)	4 (0.03)	0-3 (0-0.03)	N/A**	N/A
Weaver Creek	Ebasco Env. 1990a	1989	26 (0.28)	13-55 (0.14-0.59)	0 (0)	1-4 (0.01-0.04)	1 (0.01)	N/A
Salt Creek	Ebasco Env. 1990b	1989	17 (0.18)	3-76 (0.03-0.82)	0 (0)	0-2 (0-0.02)	N/A	N/A
Lower Hayfork Ck.	Ebasco Env. 1990c	1989	5 (0.05)	N/A	3 (0.03)	N/A	N/A	N/A
Upper Hayfork Ck.	Ebasco Env. 1990c	1989	6 (0.06)	2-35 (0.02-0.38)	0 (0)	0 (0)	N/A	N/A
Reading Creek	Ebasco Env. 1990d	1989	51 (0.55)	8-59 (0.09-0.64)	4 (0.04)	2-11(0.02-0.12)	1 (0.01)	0-10 (0-0.11)
East Weaver Creek	Ebasco Env. 1990e	1989	24 (0.26)	17-28 (0.18-0.30)	2 (0.03)	1-3 (0.01-0.03)	2 (0.03)	0-1 (0-0.01)
Deadwood Creek	Ebasco Env. 1990f	1989	51 (0.55)	42-64 (0.45-0.69)	N/A	N/A	46 (0.50)	25-109 (0.32-1.17)
Dutch Creek	Ebasco Env. 1990g	1989	30 (0.33)	N/A	2 (0.03)	N/A	9 (0.10)	N/A
Democrat Gulch	Ebasco Env. 1990h	1989	58 (0.62)	N/A	N/A	N/A	N/A	N/A
Connor Creek	Ebasco Env. 1990i	1989	4 (0.04)	2-4 (0.02-0.04)	5 (0.05)	3-6 (0.03-0.06)	N/A	N/A
Canyon Creek	USFS 1989	1988	16 (0.17)	4-26 (0.04-0.28)	5 (0.05)	2-9 (0.02-0.09)	0 (0)	0-1 (0-0.01)
E.Fork of N.Fork Trinity River	USFS 1989	1988	34 (0.37)	-***	7 (0.08)	-	7 (0.08)	-

* For habitat unit types with five or more observations.
** N/A = Not applicable. Species of life stage absent or insufficient number of sample units to generate estimate.
*** Data not available.

TABLE 4-2

COMPARISON OF ENHANCEMENT COSTS AND BENEFIT INDICES

Creek	Source	Approximate One-time Cost ($1,000s)	Annual Benefit Index*	Benefit Indices Per Unit Cost**
West Weaver	This study	$ 45 - 75	964	9 - 15
Weaver	Ebasco Env. 1990a	$ 55 - 95	1,004	11 - 18
Salt	Ebasco Env. 1990b	$ 75 - 135	5,368	40 - 72
Hayfork	Ebasco Env. 1990c	$151 - 239	1,889	8 - 13
Reading	Ebasco Env. 1990d	$ 1 - 2	3,799	1,900 - 3,799
East Weaver	Ebasco Env. 1990e	$ 62 - 101	1,863	18 - 30
Deadwood	Ebasco Env. 1990f	$ 71 - 140	5,225	37 - 74
Dutch	Ebasco Env. 1990g	$ 15 - 20	1,335	67 - 89
Democrat Gulch	Ebasco Env. 1990h	$ 31 - 65	1,223	19 - 39
Connor	Ebasco Env. 1990i	$ 15 - 30	5,085	170 - 339

* Annual Benefit Index = Number of Additional Age 0+ Salmonids per Year.

** Benefit Index Per Unit Cost = Annual Benefit Index/Approximate One-Time Cost ($1,000s).

Benefits of West Weaver Creek habitat enhancement recommendations will be retained under higher flows. This is because habitat unit types of low electivity such as pocket water and low gradient riffles, would be modified into higher electivity units (e.g. root wad lateral scour pools, plunge pools and runs) during periods of increased flow. During subsequent low flows, the composition is expected to maintain the increased frequency of pools and runs, resulting in greater utilization of West Weaver Creek.

Recommended enhancement areas should be assessed in greater detail prior to planning specific structures or enhancement activities. This is because each potential site will vary according to its hydraulic, geologic, and biological character. Specific enhancements should be based on detailed mapping and biological assessments of selected habitat units in West Weaver Creek.

Detailed field observations and data analyses for West Weaver Creek indicate that a number of investigations are critical to further ensure success and to refine the type and location of potential habitat enhancement structures. One such investigation is a detailed assessment of the barrier potential of the Oregon Street culvert and Highway 299 tunnel. Modification of these structures could greatly enhance utilization of the stream by coho and perhaps steelhead. In addition, a survey of the timing, location, and extent of spawning and escapement in West Weaver Creek would provide a quantitative basis to determine whether or not spawning areas are fully utilized or need further enhancement. An outmigrant trapping study would indicate which time periods are critical for juvenile fish and which are not. These results would be useful for developing a quantitative relationship between spawning, incubation, and outmigrant production.

Additional biological sampling of infrequent habitat types with potentially high steelhead or coho densities such as lateral scour or trench pools should be made to ensure success of enhancements which create similar conditions. Each of these studies would aid in developing a comprehensive approach to management of the fisheries resource in West Weaver Creek, and contribute to the goal of restoring steelhead production of the Trinity River basin to historical levels.

5.0 REFERENCES

Bachman, R.A. 1984. Foraging behavior of free-ranging wild and hatchery brown trout in a stream. Transactions of the American Fisheries Society 113:1-32.

Bisson, P.A., J.L. Nielsen, R.A. Palmason and L.E. Grove. 1981. A system of naming habitat types in small streams, with examples of habitat utilization by salmonids during low stream flow. Symposium on Acquisition and Utilization of Aquatic Habitat Inventory Information. Portland, Oregon, October 28-30.

Bisson, P.A., K. Sullivan and J.L. Nielsen. 1988. Channel hydraulics, habitat use, and body form of juvenile salmon, steelhead, and cutthroat trout in streams. Transactions of the American Fisheries Society 117:262-273.

Bryant, M.D. 1983. The role and management of woody debris in West Coast salmonid nursery streams. North American Journal of Fisheries Management 3:322-330.

Burner, C.J. 1951. Characteristics of spawning nests of Columbia River salmon. U.S. Fish and Wildlife Service Fishery Bulletin. 61(52):97-110.

Bustard, D.R. and D.W. Narver. 1975. Aspects of the winter ecology of juvenile coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri). Journal of the Fisheries Research Board of Canada 32:667-680.

Chapman, D.W. and T.C. Bjornn. 1969. Distribution of salmonids in streams, with special reference to food and feeding. Pages 153-176 in T.G. Northcote, editor. Symposium on Salmon and Trout in Streams. H.R. MacMillan Lectures in Fisheries. University of British Columbia, Vancouver, British Columbia, Canada.

Combs, T. 1971. The Steelhead Trout. Northwest Salmon Trout Steelheader Company. Portland, Oregon.

Cross, D. 1989. Personal communication on October 2, 1989. Unit Fisheries Biologist for USFS, Shasta Trinity National Forest.

Ebasco Environmental. 1990a. Weaver Creek fish habitat assessment. Report for the Trinity River Basin Restoration Program. Sacramento, California.

Ebasco Environmental. 1990b. Salt Creek fish habitat assessment. Report for the Trinity River Basin Restoration Program. Ebasco Environmental, Sacramento, California.

Ebasco Environmental. 1990c. Hayfork Creek fish habitat assessment. Report for the Trinity River Basin Restoration Program. Sacramento, California.

Ebasco Environmental. 1990d. Reading Creek fish habitat assessment. Report for the Trinity River Basin Restoration Program. Sacramento, California.

Ebasco Environmental. 1990e. East Weaver Creek fish habitat assessment. Report for the Trinity River Basin Restoration Program. Sacramento, California.

Ebasco Environmental. 1990f. Deadwood Creek fish habitat assessment. Report for the Trinity River Basin Restoration Program. Sacramento, California.

Ebasco Environmental. 1990g. Dutch Creek fish habitat assessment. Report for the Trinity River Basin Restoration Program. Sacramento, California.

Ebasco Environmental. 1990h. Democrat Gulch fish habitat assessment. Report for the Trinity River Basin Restoration Program. Sacramento, California.

Ebasco Environmental. 1990i. Connor Creek fish habitat assessment. Report for the Trinity River Basin Restoration Program. Sacramento, California.

Everest, F.H., G.H. Reeves, J.R. Sedell, D.B. Hohler, and T. Cain. 1986. The effects of habitat enhancement on steelhead trout and coho salmon production, habitat utilization, and habitat availability in Fish Creek, Oregon, 1983-86. Annual Report. prepared for BPA, Division of Fish and Wildlife. Portland, Oregon.

Fausch, K.D. 1984. Profitable stream positions for salmonids: relating specific growth rate to net energy gain. Canadian Journal of Zoology 62:441-451.

Fry, D.H. 1973. Anadromous fishes of California. The Resources Agency, Department of Fish and Game.

Hall, J.D. and C.O. Baker. 1982. Rehabilitating and enhancing stream habitat: 1. Review and evaluation. In: Influence of Forest and Rangeland Management on Anadromous Fish Habitat in the Western United States and Canada. USDA, Forest Service, Gen. Tech. Rep. PNW-138.

Hankin, D.G. and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45(5):834-844.

Hartman, G.F. 1965. The role of behavior in the ecology and interaction of underyearling coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri). Journal of the Fisheries Research Board of Canada 22:1031-1081.

Jacobs, J. 1974. Quantitative measurement of food selection: a modification of the forage ratio and Ivlev's electivity index. Oecologia 14:413-417.

McCain, M., D. Fuller, L. Decker, K. Overton. (Unpublished.) Habitat typing in northern California. U.S. Forest Service, Six Rivers National Forest. Eureka, California.

Moyle, P.B. 1976. Inland Fishes of California, University of California Press.

Overton, K. and others. (In preparation.) Field guide to habitat mapping in northern California. U.S. Forest Service, Six Rivers National Forest. Eureka, California.

Platts, W.S., W.F. Meagahan and G.W. Minshall. 1983. Methods for evaluation of stream, riparian and biotic conditions. U.S. Forest Service Technical Report INT-138.

Province of British Columbia, Ministry of Environment (PBCME), 1980. Stream enhancement guide.

Raleigh, R.F., T. Hickman, R.C. Solomon and P.C. Nelson. 1984. Habitat suitability information: Rainbow trout. U.S. Fish and Wildlife Service. FWS/OBS-82/10.60.

Reeves, G.H. and T.D. Roelofs. 1982. Rehabilitating and enhancing stream habitat: 2. Field applications. In: Influence of Forest and Rangeland Management on Anadromous Fish Habitat in the Western United States and Canada. USDA, Forest Service, Gen. Tech. Rep. PNW-140.

Reiser, D.W., and T.C. Bjornn. 1979. Habitat requirements of anadromous salmonids. In: Influence of Forest and Rangeland Management on Anadromous Fish Habitat in the Western United States and Canada. USDA, Forest Service, Gen. Tech. Rep. PNW-96.

Rosgen, D.L. 1985. A stream classification system. In: In Riparian Ecosystems and Their Management: Reconciling conflicting uses. Paper presented at a symposium April 16-18, Tucson, Arizona.

Rosgen, D.L. and B.L. Fittante. 1986. Fish habitat structures - a selection guide using stream classification. Proceedings of the Fifth Trout Stream Habitat Improvement Workshop, August 12-14, 1986. Pennsylvania Fish Commission.

Sedell, J.R., F.J. Swanson, and S.V. Gregory. 1984. Evaluating fish response to woody debris. In: T.J. Hassler ed. Proceedings Pacific Northwest Stream Habitat Management Workshop. October 10-12, Arcata, California. Amer. Fish. Soc. Western Div.

United States Forest Service, 1989. Habitat typing report: Canyon Creek, 1988. Shasta Trinity National Forest.

Wilson, C. 1989. Personal communication on October 5, 1989. Biologist for CDFG, Redding.

APPENDIX A

FIELD DATA SHEETS

STREAM HABITAT TYPING SURVEY DATA SHEET

Data Sheet # _____

STREAM / DRAINAGE _____

PAGE _____ of _____

DATE _____/_____/_____

TEAM: _____

WEATHER:

LONG _____ _____' _____" LAT _____ _____' _____" TIME START/END _____/_____

T._____ R._____ S._____ COUNTY TRINITY QUAD _____

HABITAT UNIT #					
HABITAT TYPE					
SIDE CHANNEL HAB. TYPE					
LENGTH					
WIDTH					
$\bar{X}$ WIDTH					
DEPTH					
$\bar{X}$ DEPTH					
MAX. POOL DEPTH					
DEPTH @ POOL TAIL CREST					
STREAM SHADE %					
POOL INSTREAM COVER					
TOTAL %					
UNDERCUT BANKS %					
SWD (<1 ft) %					
LWD (d>1 ft,RW) %					
TERR. VEGT. (h<1 ft ⊻ %					
WHITEWATER %					
BOULDERS (d>1 ft) %					
BEDROCK LEDGES %					
POOL COVER COMPLEXITY					
SUBSTRATE COMPOSITION					
BEDROCK %					
BOULDER >1 ft %					
COBBLES >3"-1 ft %					
GRAVEL >.25"-3" %					
SAND .04"-.25" %					
FINES < .04" %					
RIFFLE-POOLTAIL EMBEDDED %					
RIFFLE EXPOSED SUBSTRATE %					
TIME/TEMPERATURE (every 5th unit)					
PERCENT SPAWNABLE %					
COMMENTS					

6/89 TMF ENVIROSPHERE

DIRECT OBSERVATION DATA SHEET

Data Sheet # _____

STREAM / DRAINAGE _____ PAGE _____ of _____

DATE _____/_____/_____

TEAM: _____ WEATHER:

LONG _____ _____' _____" LAT _____ _____' _____" TIME START/END _____/_____

T._____ R._____ S._____ COUNTY _____

WATER TEMP / TIME _____/_____ HABITAT UNIT # _____ REACH WIDTH _____

_____/_____ HABITAT TYPE _____ REACH LENGTH _____

_____/_____

MULTIPLE DIVERS, 1 PASS _____ 1 OR MORE DIVERS, MULTIPLE PASSES _____

DIVER	SPECIES	NUMBER	LENGTH (mm)	PASS #

COMMENTS :

5/89 TMF ENVIROSPHERE

ELECTROFISHING DATA SHEET

STREAM / DRAINAGE ______ / ______ PAGE ______ of ______

DATE ____ / ____ / ____

TEAM: ______________________________

WEATHER:

LONG ______ ______' ______" LAT ______ ______' ______" TIME START/END ______/______

T.______ R.______ S.______ COUNTY ______________________

WATER TEMP / TIME ______/______ HABITAT UNIT # ______ REACH WIDTH ______

______/______ HABITAT TYPE ______ REACH LENGTH ______

______/______

	PASS #1		PASS #2		PASS #3	
BAT TIME	______	______	______	______	______	______
SPECIES	LENGTH (mm)	WT. (g)	LENGTH (mm)	WT. (g)	LENGTH (mm)	WT. (g)

5/89 TMF ENVIROSPHERE

APPENDIX B

DATABASE STRUCTURE

TABLE B-1
DATABASE STRUCTURE

Field	Field Name	Type	Width	Dec
1	STREAM	Character	10	
2	DATE	Date	8	
3	FORMNUMBER	Character	6	
4	TEAM	Character	11	
5	LONGITUDE	Character	9	
6	LATITUDE	Character	9	
7	CHANNELTYP	Character	3	
8	GRADIENT	Numeric	4	2
9	USGSQUAD	Character	18	
10	TOWNRNGSEC	Character	15	
11	COUNTY	Character	7	
12	UNITMEASUR	Character	7	
13	UNITNUMBER	Numeric	6	2
14	UNITTYPE	Numeric	2	
15	UNITABBREV	Character	6	
16	SIDECHANNL	Numeric	2	
17	MEANLENGTH	Numeric	4	
18	CUMLENGTH	Numeric	7	
19	MEANWIDTH	Numeric	5	2
20	MEANDEPTH	Numeric	4	1
21	MAXDEPTH	Numeric	4	1
22	POOLTCREST	Numeric	4	1
23	SHADE	Numeric	3	
24	PCT_PCOVER	Numeric	3	
25	PCT_BANK	Numeric	3	
26	PCT_SWD	Numeric	3	
27	PCT_LWD	Numeric	3	
28	PCT_VEG	Numeric	3	
29	PCT_WWATER	Numeric	3	
30	PCT_BLDCOV	Numeric	3	
31	PCT_BEDCOV	Numeric	3	
32	CVRCOMPLEX	Numeric	1	
33	PCT_BEDRCK	Numeric	3	
34	PCT_BOULDR	Numeric	3	
35	PCT_COBBLE	Numeric	3	
36	PCT_GRAVEL	Numeric	3	
37	PCT_SAND	Numeric	3	
38	PCT_FINES	Numeric	3	
39	PCT_EMBEDD	Numeric	2	
40	EXPOSUBSTR	Numeric	2	
41	PCT_SPAWN	Numeric	3	
42	TEMP_F	Numeric	4	1
43	BIOSAM	Character	1	
44	O_STEELHD	Numeric	3	
45	I_STEELHD	Numeric	3	
46	T_STEELHD	Numeric	3	
47	O_CHINOOK	Numeric	2	
48	O_COHO	Numeric	2	
49	I_COHO	Numeric	2	
50	NOTES	Character	99	
51	NOTES2	Character	99	
52	NOTES3	Character	99	
TOTAL		**	522	

APPENDIX C

FIGURES AND TABLES

FIGURES AND TABLES

Abbreviations used for habitat types in the figures and tables are listed below.

Habitat Type	Abbreviation
<u>Riffles</u>	
Low gradient	LGR
High gradient	HGR
Cascade	CAS
<u>Pools</u>	
Secondary channel	SCP
Backwater	
Boulder formed	BWPBO
Root wad formed	BWPRW
Log formed	BWPLOG
Trench	TRP
Plunge	PLP
Lateral scour	
Log formed	LSPLOG
Root wad formed	LSPRW
Bedrock formed	LSPBED
Boulder formed	LSPBO
Edgewater	EGW
Dammed	DPL
Main channel	MCP
Channel confluence	CCF
Corner	CRP
<u>Flat water</u>	
Glide	GLD
Pocket water	POW
Run	RUN
Step run	SRN

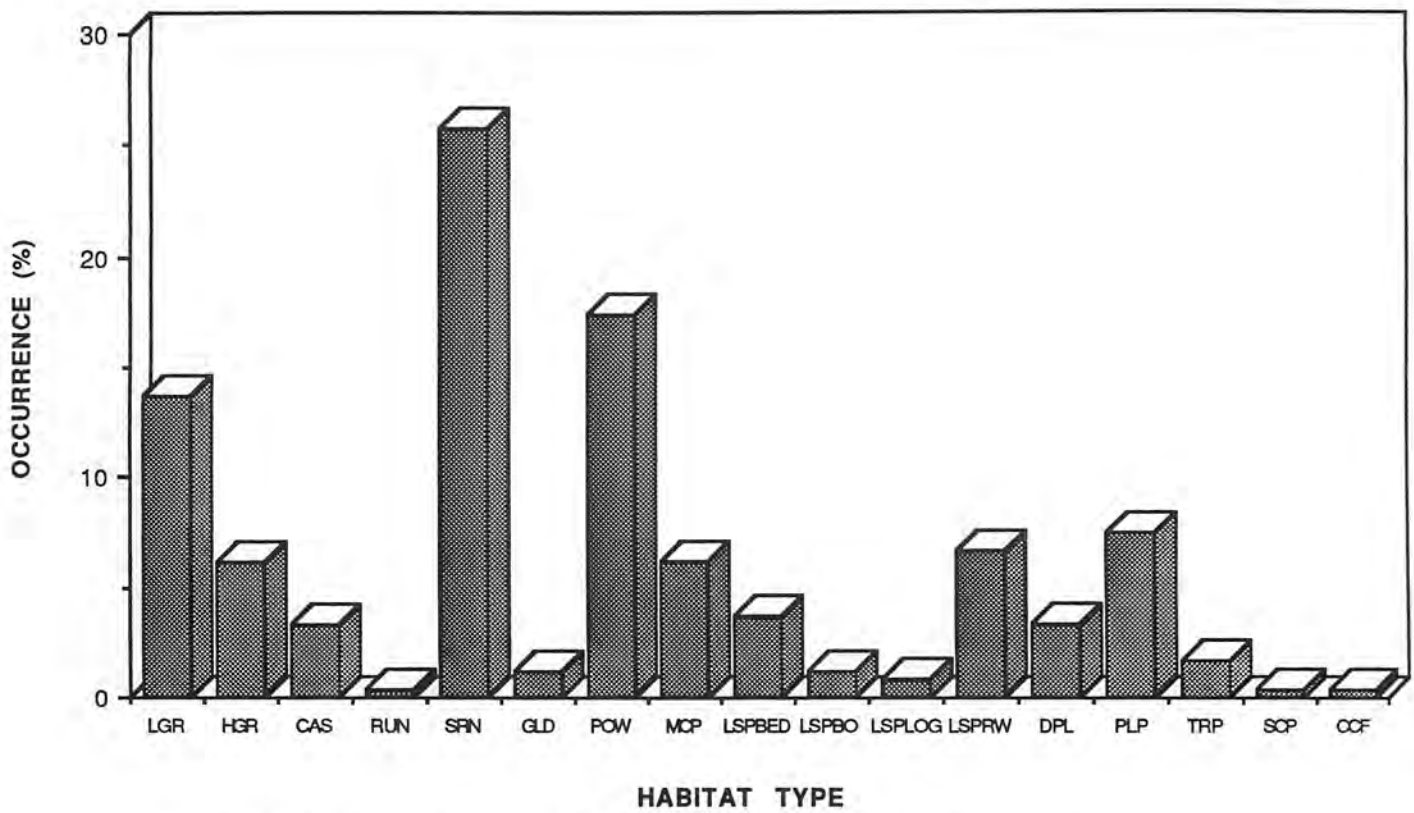


Figure C3.1-1. Percent occurrence of West Weaver Creek habitat unit types.

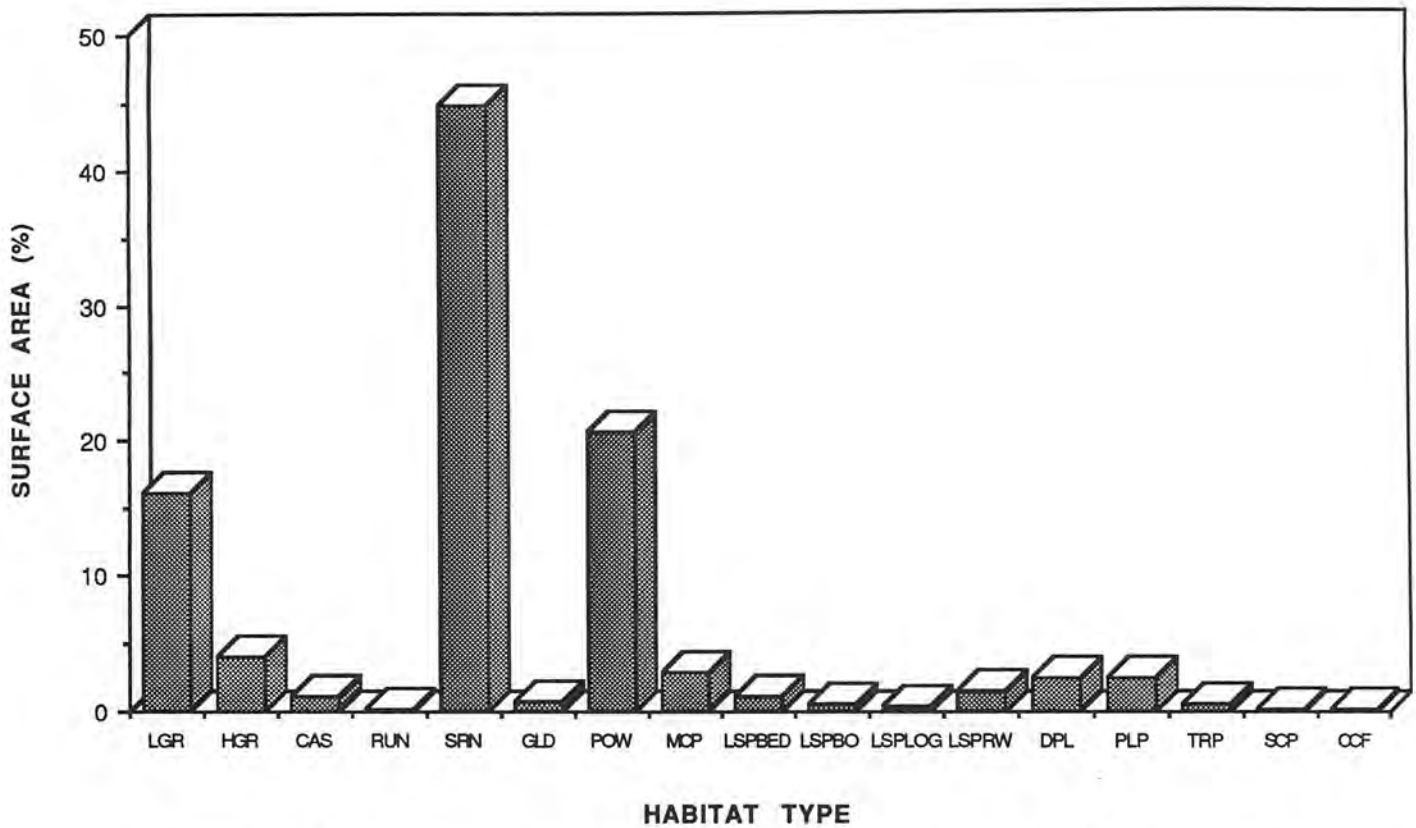


Figure C3.1-2. West Weaver Creek habitat type surface areas as percent of total stream surface area.

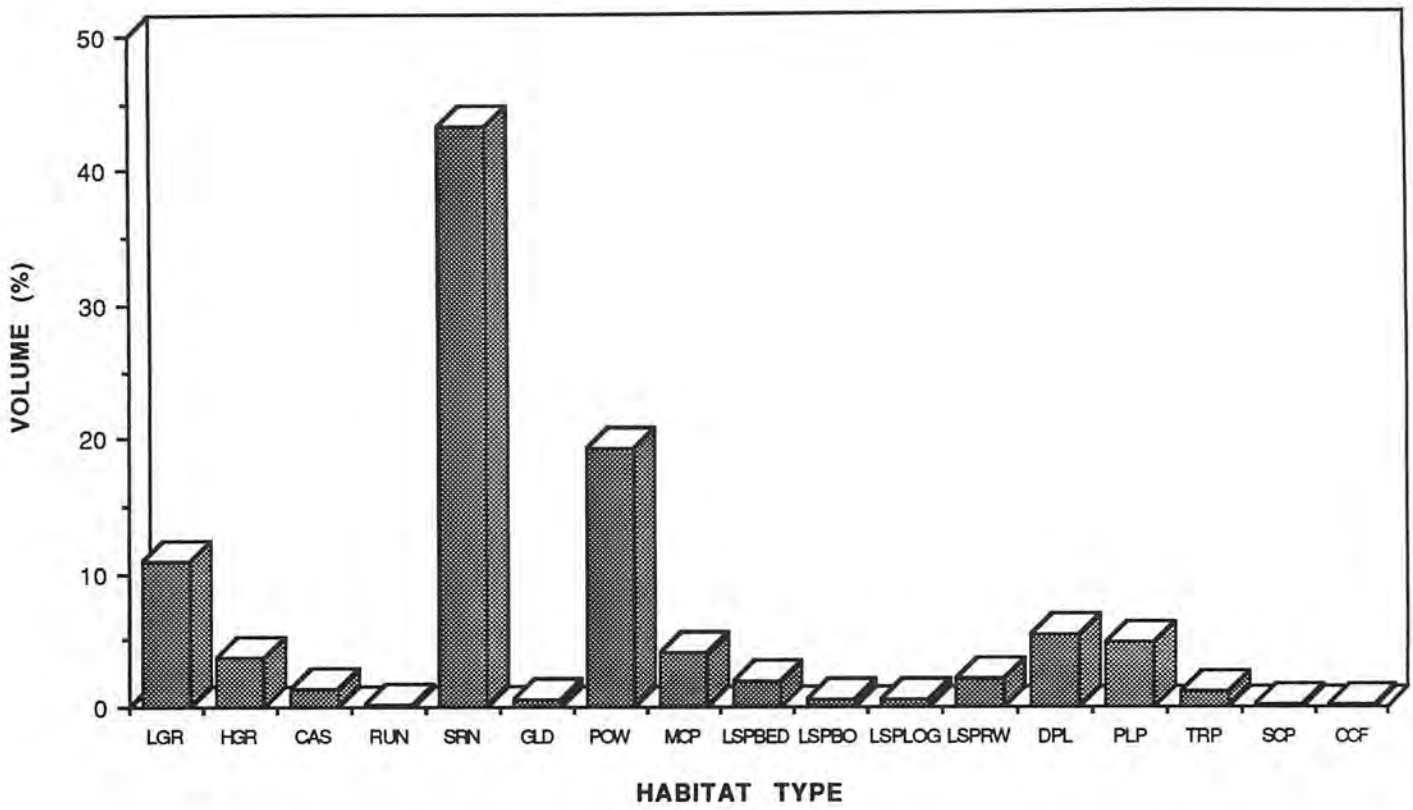


Figure C3.1-3. West Weaver Creek habitat type distribution by water volumes as percent of total stream volume.

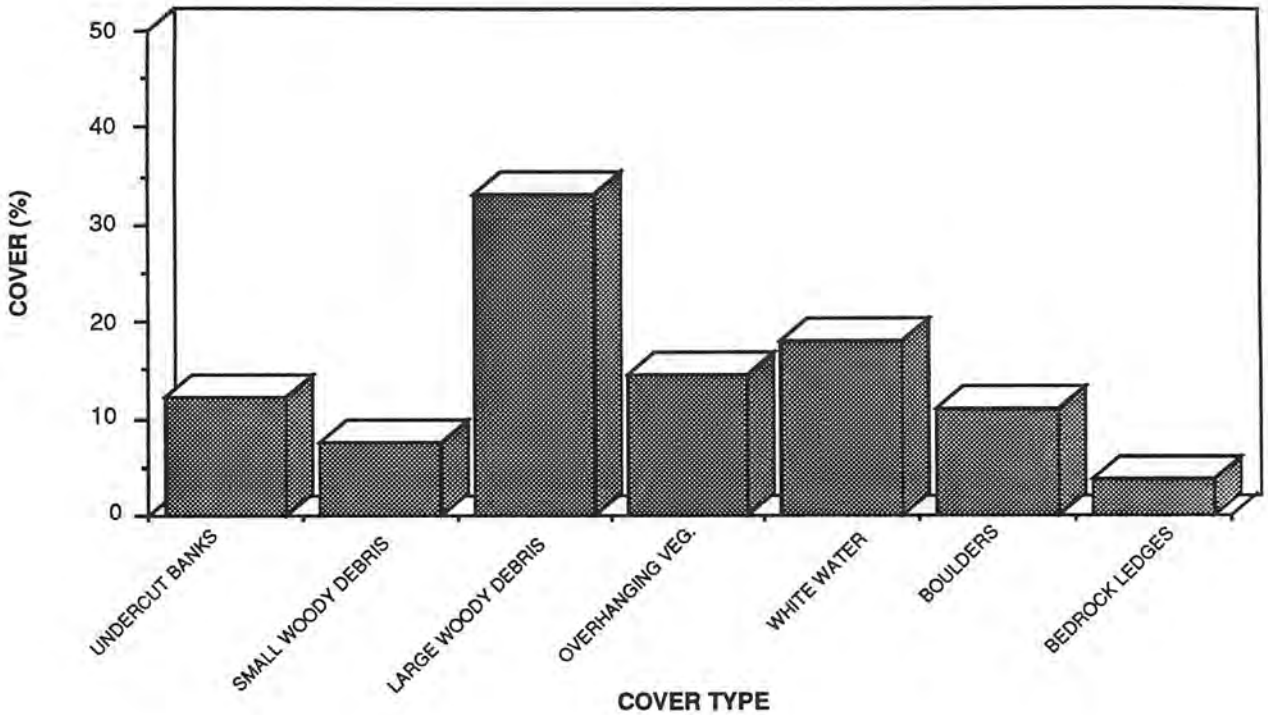


Figure C3.1-4. West Weaver Creek pool cover types as percent of total cover.

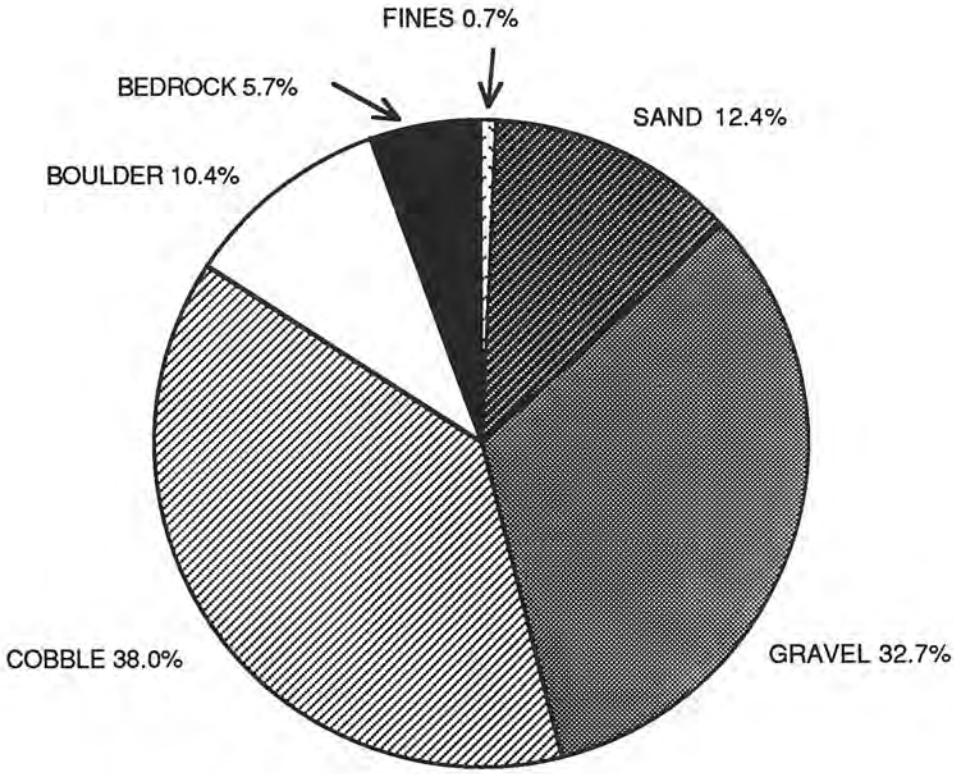


Figure C3.1-5. West Weaver Creek substrate composition as percent of total area for all habitat types.

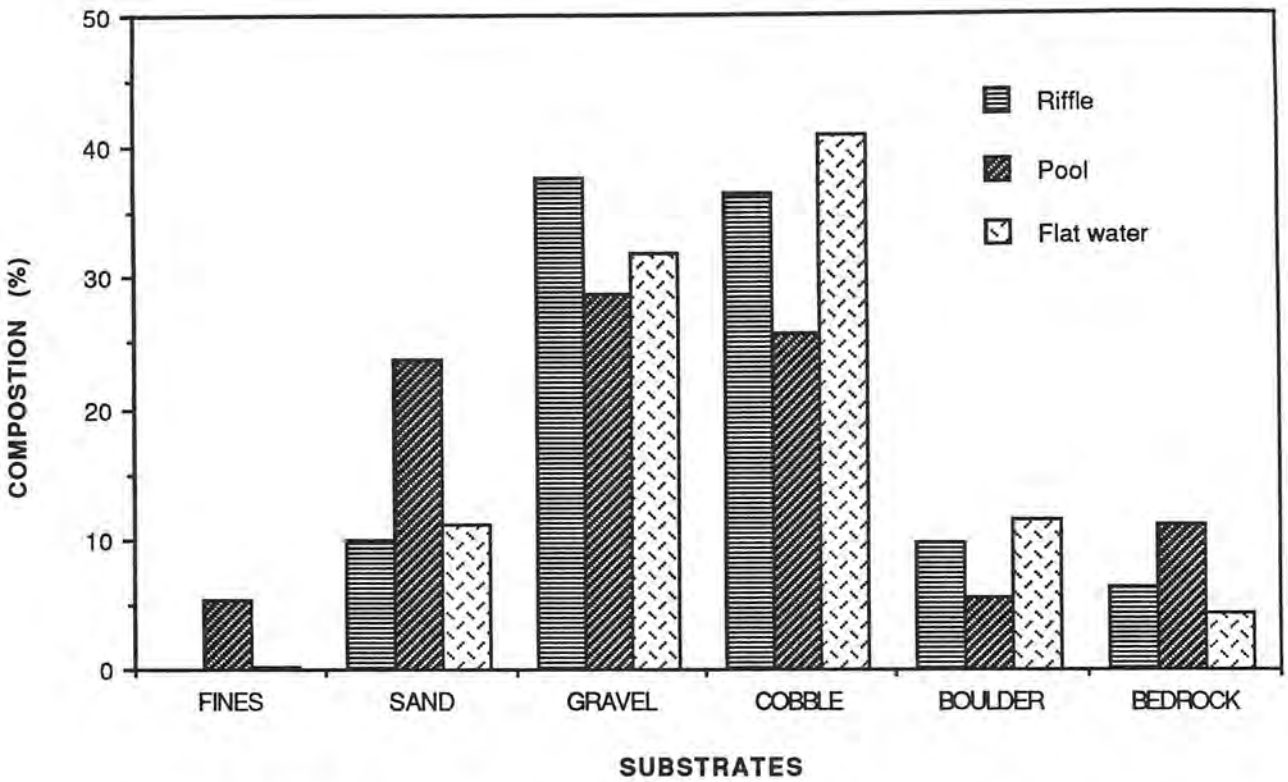


Figure C3.1-6. Percent compostion of West Weaver Creek substrates for riffle, pool and flat water habitats.

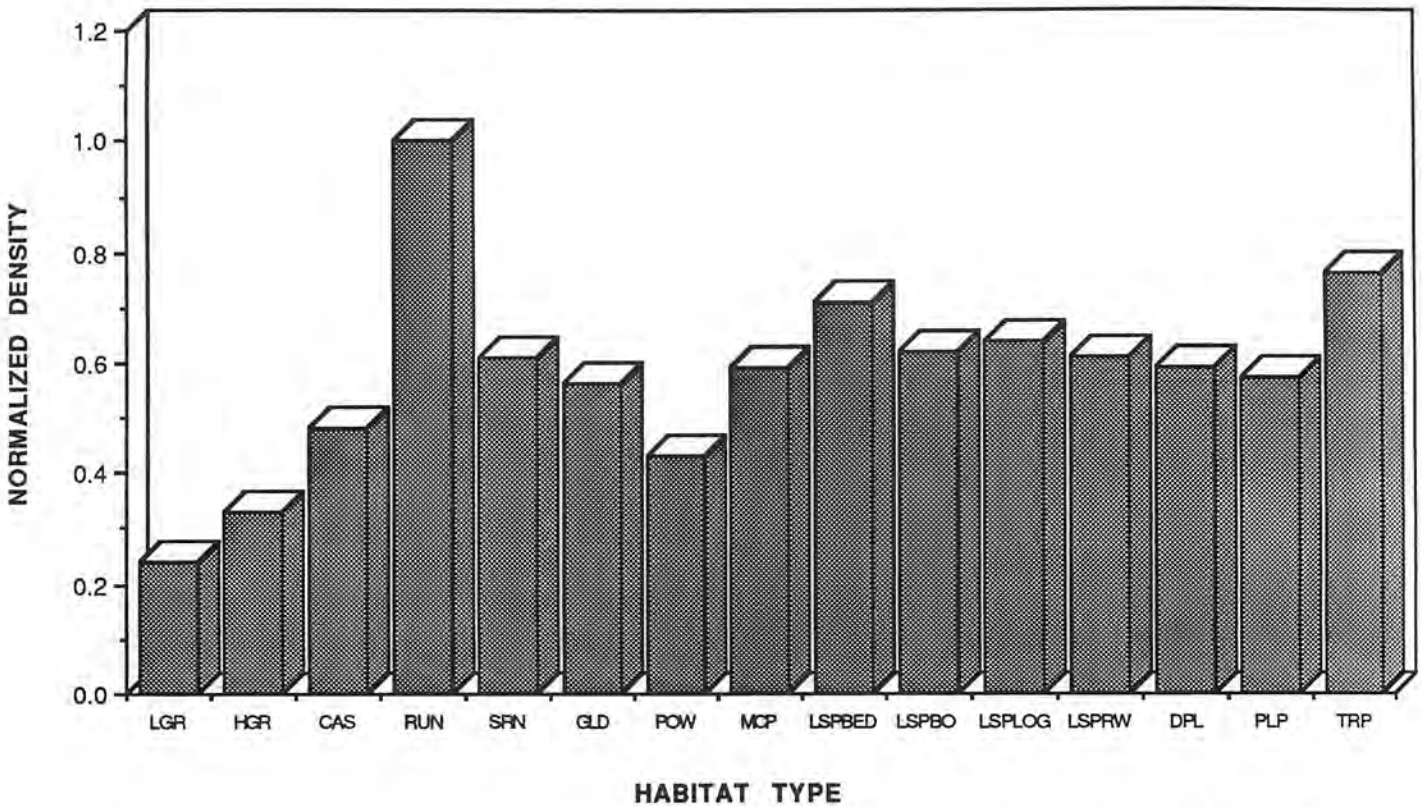


Figure C3.2-1. West Weaver Creek normalized 0+ steelhead densities. Densities were normalized by dividing the density for each habitat type by the highest density for any habitat type.

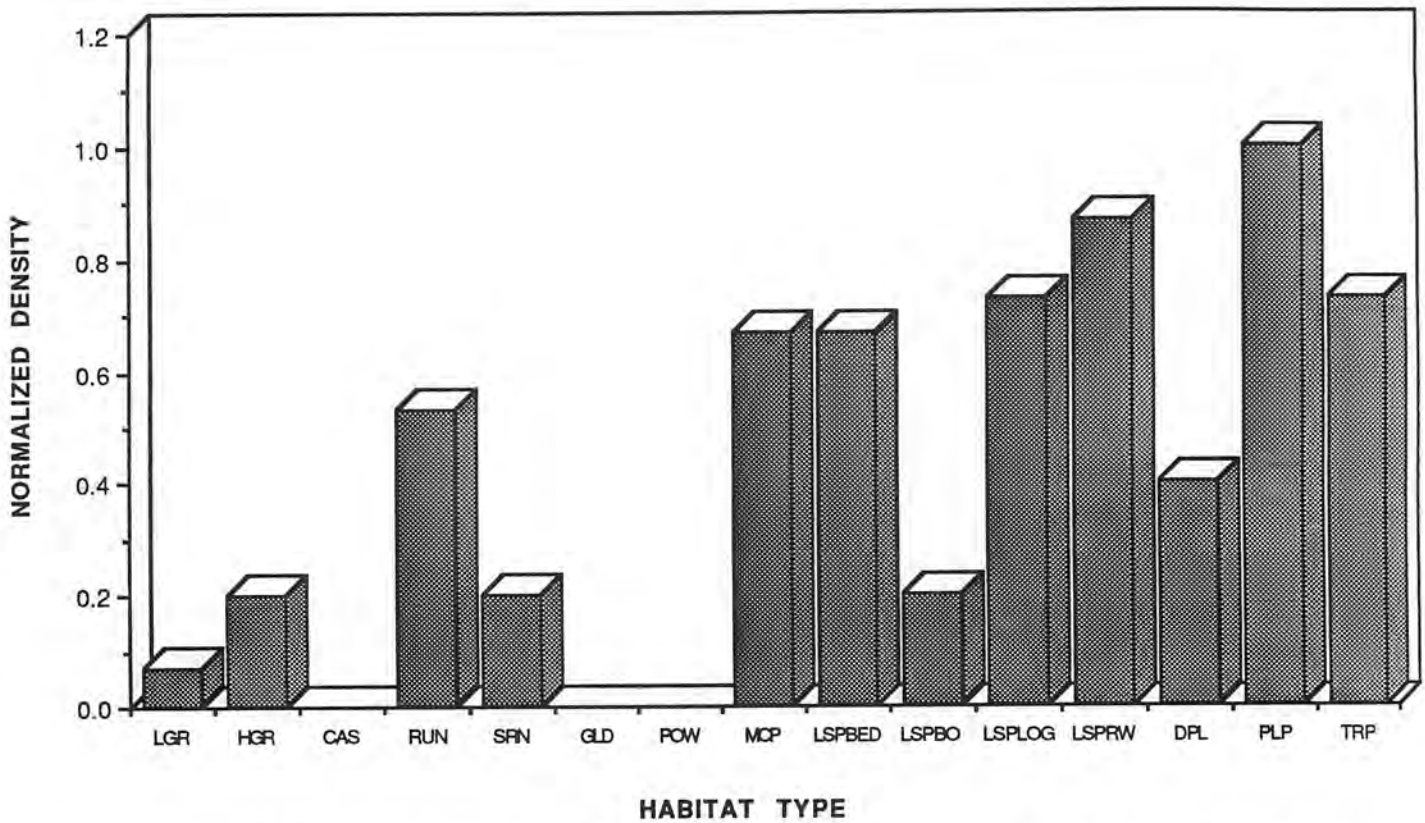


Figure C3.2-2. West Weaver Creek normalized 1+ steelhead densities. Densities were normalized by dividing the density for each habitat type by the highest density for any habitat type.

Table C3.2-1
West Weaver Creek Salmonid Standard and Normalized Densities by Habitat Type

Habitat Type	Sample Units	Age 0+ Steelhead			Age 1+ Steelhead			Total Density*	
		Density		Normalized Density	Density		Normalized Density		
		Fish/ 1000 Ft^2	Fish/ m^2		Fish/ 1000 Ft^2	Fish/ m^2		Fish/ 1000 Ft^2	Fish/ m^2
LGR	6	21	0.23	0.24	1	0.01	0.07	22	0.24
HGR	3	29	0.31	0.33	3	0.03	0.20	32	0.34
CAS	1	42	0.44	0.48	0	0	0	42	0.44
RUN	1	87	0.94	1.00	8	0.09	0.53	95	1.02
SRN	13	53	0.57	0.61	3	0.03	0.20	56	0.60
GLD	1	49	0.53	0.56	0	0	0	49	0.53
POW	8	37	0.40	0.43	0	0	0	37	0.40
MCP	3	51	0.55	0.59	10	0.11	0.67	64	0.69
LSPBED	2	62	0.67	0.71	10	0.11	0.67	75	0.81
LSPBO	1	54	0.58	0.62	3	0.03	0.20	57	0.61
LSPLOG	2	56	0.60	0.64	11	0.12	0.73	67	0.72
LSPRW	3	53	0.57	0.61	13	0.14	0.87	72	0.78
DPL	2	51	0.55	0.59	6	0.06	0.40	64	0.69
PLP	3	50	0.54	0.57	15	0.16	1.00	69	0.74
TRP	1	66	0.71	0.76	11	0.12	0.73	82	0.88
AVERAGE**	--	44.5	0.48	--	3.0	0.03	--	48.2	0.52

* Includes age 2+ steelhead and age 0+ coho.

** (Number of salmonids in all habitat types/Total biological survey area) x 1000

(Habitat type codes: LGR= Low gradient riffle; HGR= High gradient riffle; CAS = Cascade; RUN= Run; SRN= Step run; GLD= Glide; POW= Pocket water; MCP=Main channel pool; LSPBED= Lateral scour pool bedrock formed; LSPBO= Lateral scour pool boulder formed; LSPLOG = Lateral scour pool log formed; LSPRW= Lateral scour pool root wad formed; DPL= Dammed pool; PLP = Plunge pool; TRP= Trench pool.)

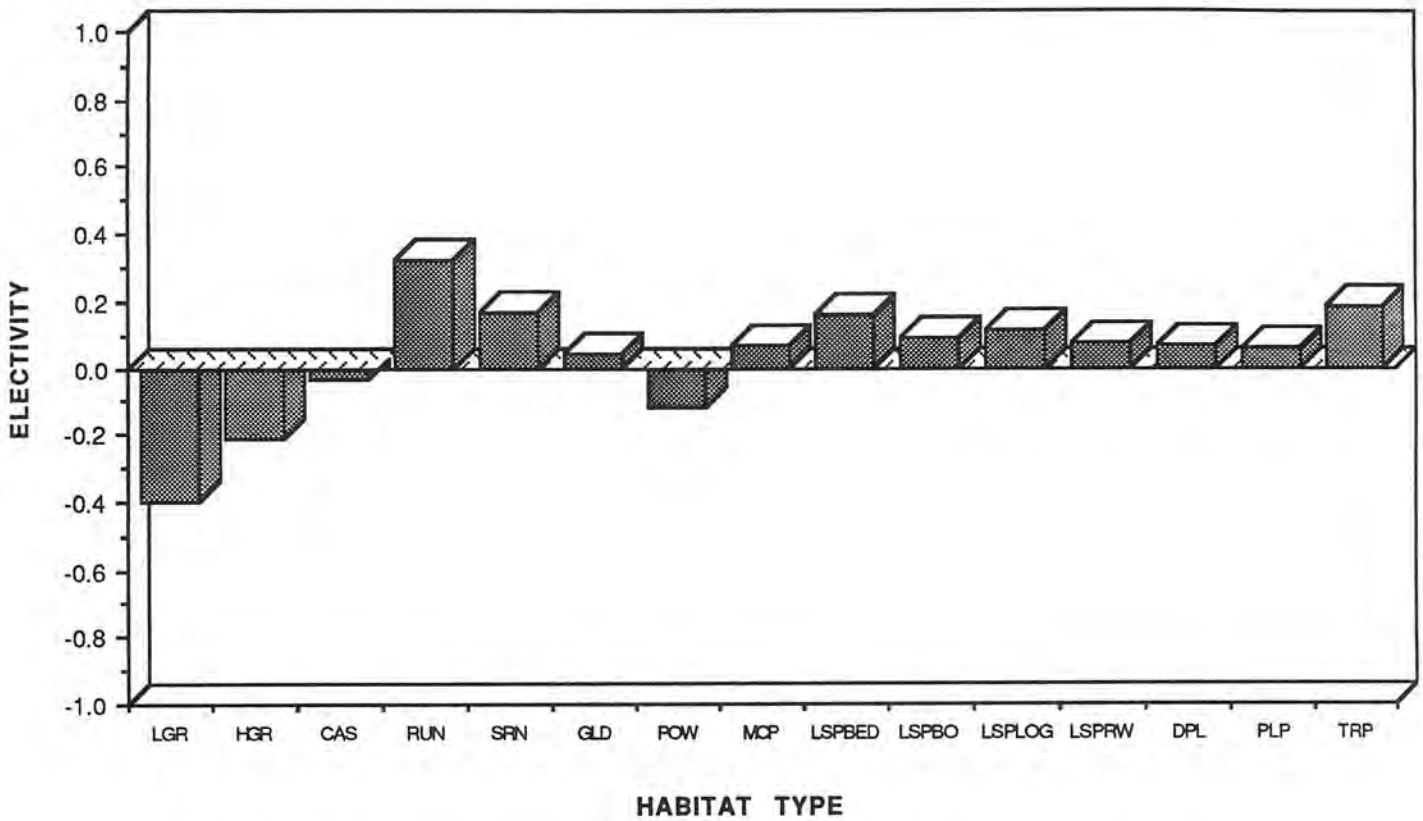


Figure C3.3-1. West Weaver Creek habitat electivities for age 0+ steelhead.

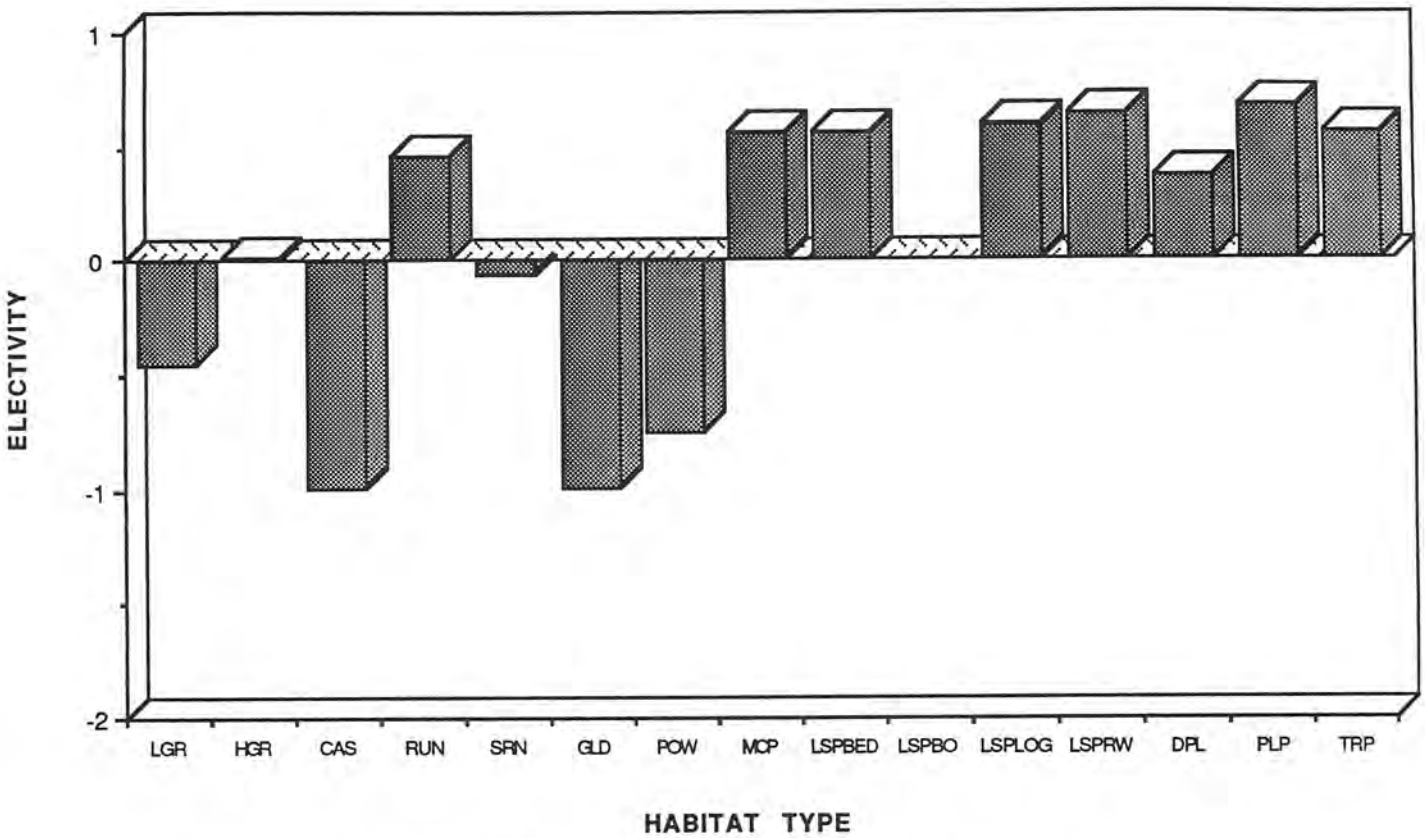
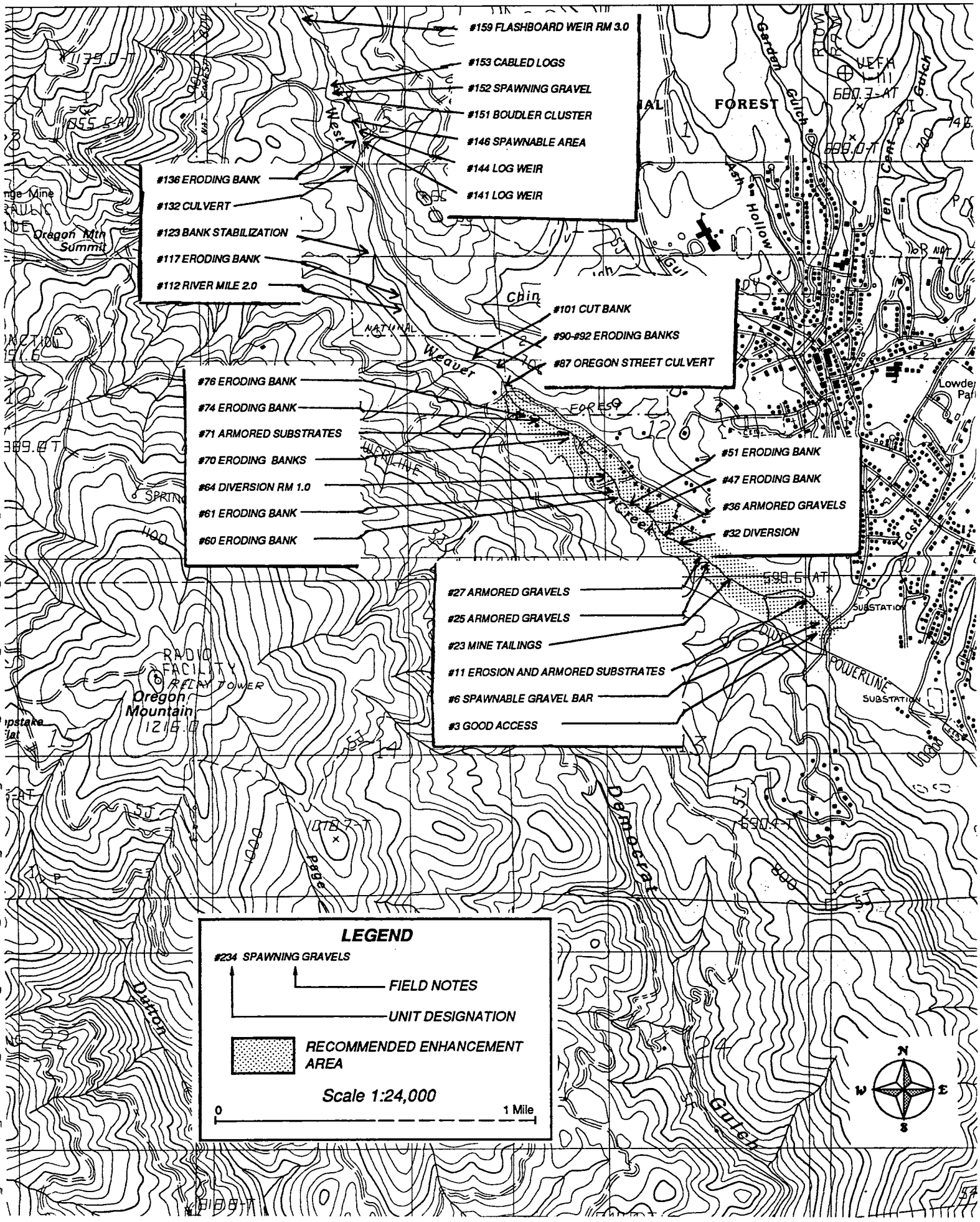
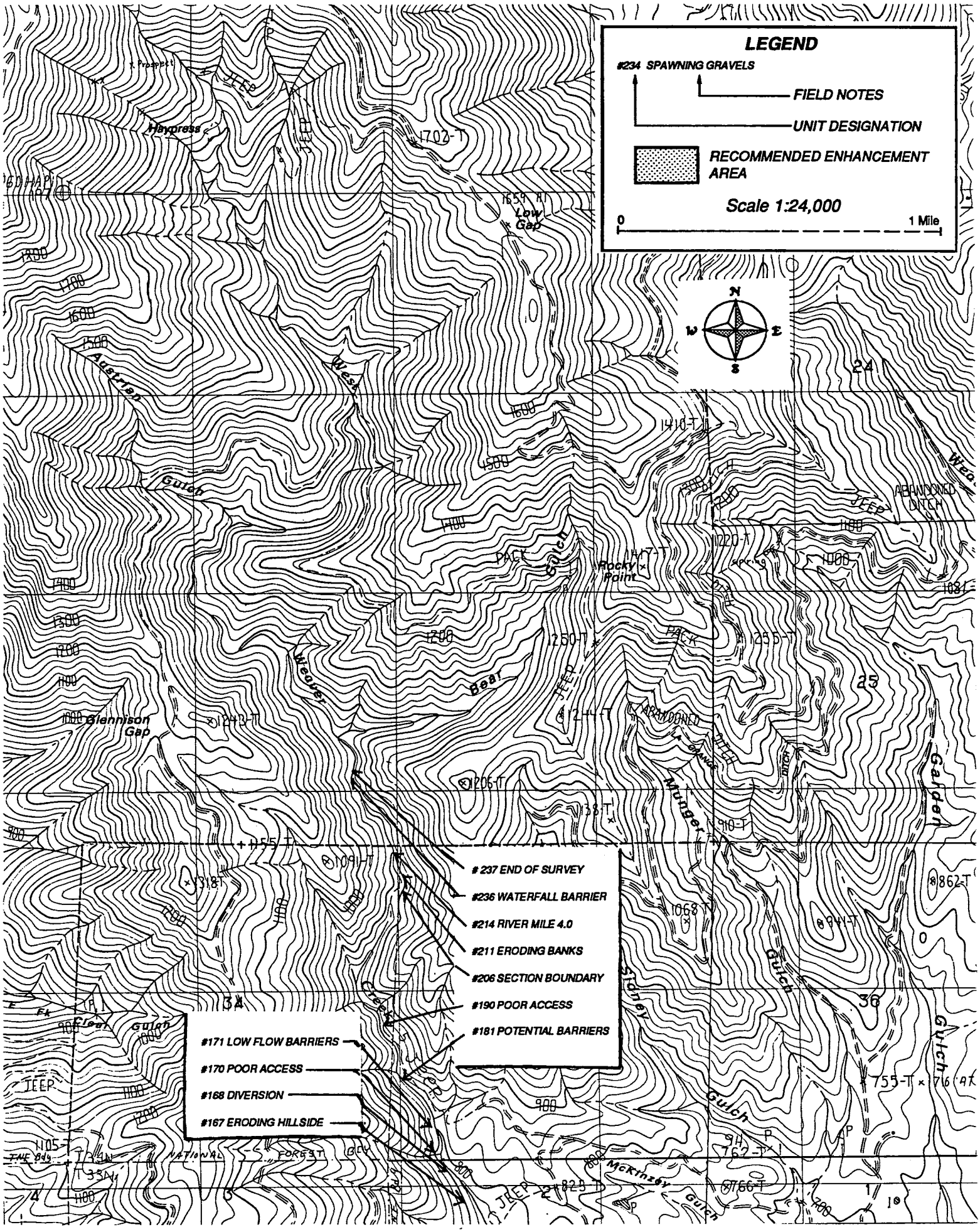


Figure C3.3-2. West Weaver Creek habitat electivities for age 1+ steelhead.

APPENDIX D

TOPOGRAPHIC MAPS


#159 FLASHBOARD WEIR RM 3.0
#153 CABLED LOGS
#152 SPAWNING GRAVEL
#151 BOULDER CLUSTER
#146 SPAWNABLE AREA
#144 LOG WEIR
#141 LOG WEIR
#136 ERODING BANK
#132 CULVERT
#123 BANK STABILIZATION
#117 ERODING BANK
#112 RIVER MILE 2.0
#101 CUT BANK
#90-#92 ERODING BANKS
#87 OREGON STREET CULVERT
#76 ERODING BANK
#74 ERODING BANK
#71 ARMORED SUBSTRATES
#70 ERODING BANKS
#64 DIVERSION RM 1.0
#61 ERODING BANK
#60 ERODING BANK
#51 ERODING BANK
#47 ERODING BANK
#36 ARMORED GRAVELS
#32 DIVERSION
#27 ARMORED GRAVELS
#25 ARMORED GRAVELS
#23 MINE TAILINGS
#11 EROSION AND ARMORED SUBSTRATES
#6 SPAWNABLE GRAVEL BAR
#3 GOOD ACCESS
LEGEND
#234 SPAWNING GRAVELS
FIELD NOTES
UNIT DESIGNATION
RECOMMENDED ENHANCEMENT AREA
Scale 1:24,000
0
1 Mile
FOREST
Garden Gulch
Ash Hollow
Ten Cent Gulch
West Weaver
Oregon Mtn Summit
Oregon Mountain
RADIO FACILITY
RELAY TOWER
Democrat Gulch
Page
Dutton
POWERLINE
SUBSTATION
Lowder Park
N
S
E
W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#234 SPAWNING GRAVELS
FIELD NOTES
UNIT DESIGNATION
RECOMMENDED ENHANCEMENT AREA
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Austrian
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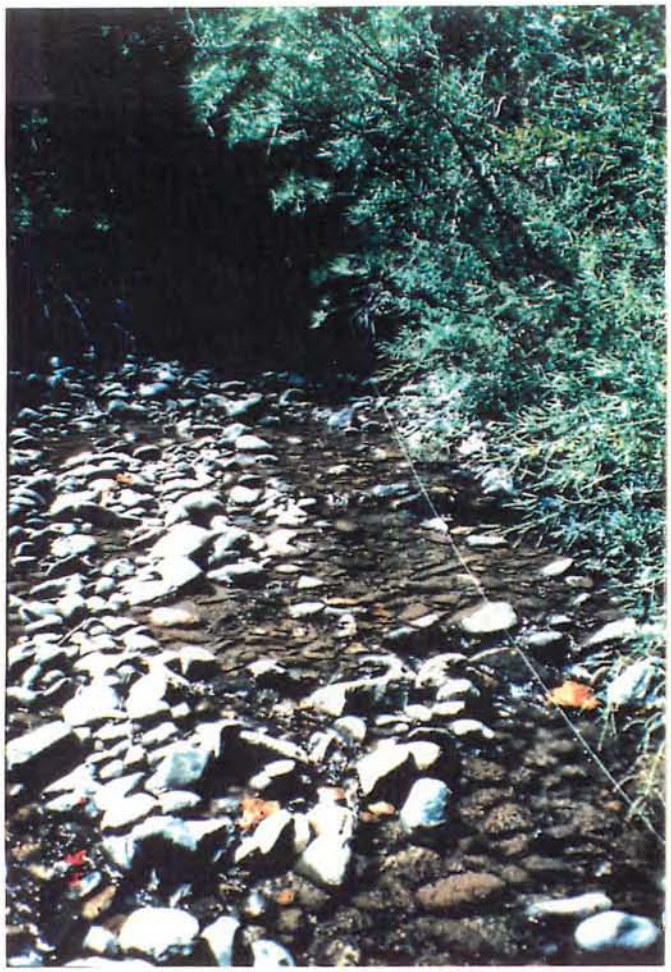
Beal
Glennison Gap
Rocky Point
PACK
JEEP
ABANDONED DITCH
Munger
Garden
Sidney
Gulch
McKinsey
Gulch
Great
Gulch
JEEP
24
25
34
36
#237 END OF SURVEY
#236 WATERFALL BARRIER
#214 RIVER MILE 4.0
#211 ERODING BANKS
#206 SECTION BOUNDARY
#190 POOR ACCESS
#181 POTENTIAL BARRIERS
#171 LOW FLOW BARRIERS
#170 POOR ACCESS
#168 DIVERSION
#167 ERODING HILLSIDE

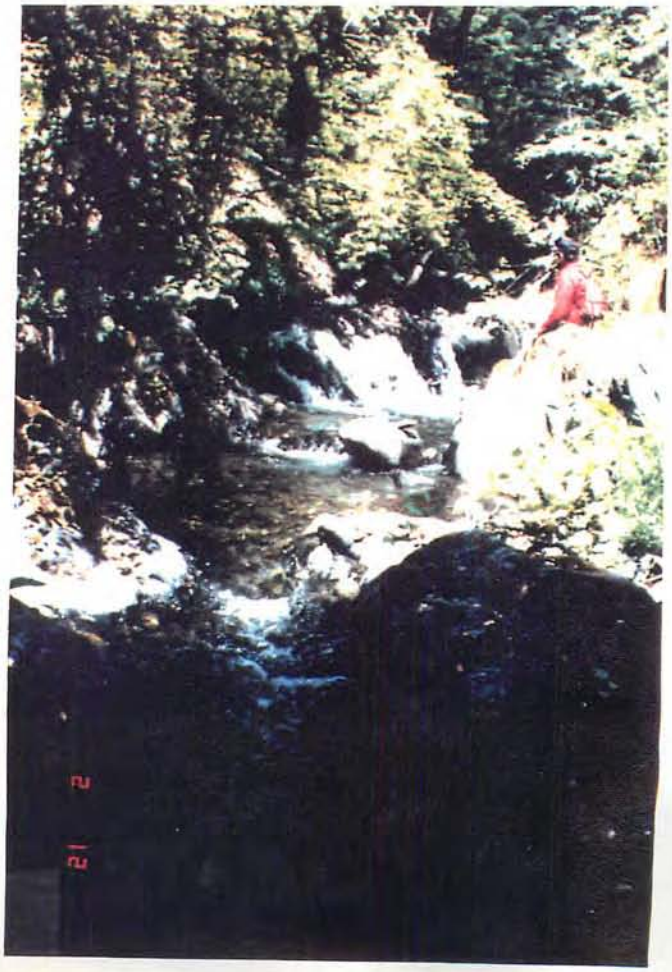
APPENDIX E

PHOTOS

Photograph	Unit number	Habitat type
1	28	Pocket water
2	189	Step run



Photograph #1



Photograph #2

U.S. Environmental Protection Agency
Region IX

Trinity River
Total Maximum Daily Load
for Sediment

Approved by:

/s/	20 December 2001
_____	_____
Alexis Strauss Director, Water Division	Date

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Trinity River TMDL Summary

Watershed Setting: Trinity River Basin area covered by TMDL is approximately 2,000 square miles. Major tributary to the Klamath River. Terrain is predominantly mountainous and forested. Elevations from 9,000 to 300 feet. Hydrologic Code: 18010211.

Major Features: Trinity and Lewiston Reservoirs. Significant water exports from the Trinity to the Sacramento River since early 1960's.
Wild and Scenic River Designation

Ownership: US Forest Service (67% of which 32% is Wilderness)
Private Industrial Forest (15%), Small Private (8%)
Tribal (6%), Not included in TMDL.
Bureau of Land Management (4%)

Water Quality Standard of Concern: Sediment, turbidity, suspended material, settleable material
Added to the Clean Water Act Section 303(d) list in 1992.

Beneficial Use Affected: Primarily cold water fish habitat for spawning, rearing and migration

Environmental Indicators: Spawning gravel quality and permeability, turbidity, pool depth and several geomorphic indicators of a healthy alluvial river.
Watershed indicators include: road location, stream crossings with diversion potential, road drainage, road maintenance, activities in unstable areas.

Major Source(s) of impairment: Roads, timber harvesting, mining and natural sources.

Loading Capacity: Based on sediment delivery rates in reference subwatersheds, EPA determined the total percentage of background sediment delivery that could occur and still meet water quality objectives. This percent (125% of background) was applied to subareas throughout the basin to determine the loading capacity or TMDL.

Wasteload Allocation (WLA): WLAs for point sources are identical to LAs for nonpoint sources according to subarea.

Load Allocation (LA): LAs for nonpoint sources apportioned between background and management-related sources on a subarea basis. Percent reduction needed in management sources also identified (Tables 5-2,3,4 and 5)

Margin of Safety: Incorporated into TMDL through conservative assumptions

Implementation Recommendations: 1. Reduce sediment production from roads and timber harvest in sediment-impaired subwatersheds at levels identified on a subarea basis; 2. Continued sediment prevention for reference ("properly functioning") watersheds through timely implementation of existing programs; 3. Implement the flow schedule, restoration measures and adaptive management program called for in Trinity River Mainstem Fishery Restoration Record of Decision (ROD) to the extent permitted by court order.

CHAPTER 1

INTRODUCTION

The Trinity River Total Maximum Daily Load (TMDL) for Sediment is being established in accordance with Section 303(d) of the Clean Water Act, because the State of California has determined that the water quality standards for the Trinity River are exceeded due to excessive sediment. In accordance with Section 303(d), the State of California periodically identifies "those waters within its boundaries for which the effluent limitations . . . are not stringent enough to implement any water quality standard applicable to such waters." In 1992, EPA added the Trinity River to California's 303(d) impaired water list due to elevated sedimentation. The North Coast Regional Water Quality Control Board (Regional Water Board) has continued to identify the Trinity River as impaired in subsequent listing cycles, the latest in 1998.

In accordance with a consent decree (*Pacific Coast Federation of Fishermen's Associations, et al. v. Marcus*, No. 95-4474 MHP, 11 March 1997), December 2001 is the deadline for establishment of this TMDL. Because the State of California will not complete adoption of a TMDL for the Trinity River by this deadline, EPA is establishing this TMDL, with assistance from Regional Water Board staff.

The primary adverse impacts associated with excessive sediment in the Trinity River pertain to anadromous salmonid fish habitat. The populations of several anadromous salmonid species present in the Trinity River and its tributaries are in severe decline. The population of coho salmon (*Oncorhynchus kisutch*) is listed as threatened under the federal Endangered Species Act.

The purpose of the Trinity River TMDL is to identify the total load of sediment that can be delivered to the Trinity River and its tributaries without causing exceedence of water quality standards, and to allocate the total load among the sources of sediment in the watershed. Although factors other than excessive sediment in the watershed may be affecting salmonid populations (e.g., ocean rearing conditions), this TMDL focuses on sediment, the pollutant for which the Trinity River is listed under Section 303(d). EPA expects the Regional Water Board to develop implementation measures which will result in implementation of the TMDL in accordance with the requirements of 40 CFR 130.6. The allocations, when implemented, are expected to result in the attainment of the applicable water quality standards for sediment for the Trinity River and its tributaries.

This TMDL applies to the portions of the Trinity River watershed governed by California water quality standards. It does not apply to lands under tribal jurisdiction. Nor does this TMDL apply to the South Fork Trinity River where EPA adopted a sediment TMDL in 1998 (US EPA 1998).

1.1. Watershed Characteristics

The Trinity River is the largest tributary to the Klamath River, draining an area of approximately 3,000 square miles, about 2000 of which are covered by this TMDL. The Trinity River has historically been recognized as a major producer of chinook and coho salmon and steelhead trout. The terrain is predominately mountainous and forested, with elevations ranging from 9,000 feet above sea level in the headwater areas, to less than 300 feet at the confluence with the Klamath River. The majority of the basin (approximately 70%) is under public ownership, including the Trinity Alps Wilderness areas, the Shasta-Trinity National Forest, Six Rivers National Forest, Bureau of Land Management, Bureau of Reclamation, and various state and county entities. The Hoopa Valley Tribe occupies 144 square miles of the lower basin, while industrial timber companies and other private landowners make up the remaining portions of the basin.

Several geologic strata transect the basin including the Eastern Klamath Subprovince, Central Metamorphic Subprovince, Hayfork Terrain, Galice Formation, and others. Land use activities in the Trinity include mining, timber harvesting, road construction, recreation and a limited degree of residential development in certain locations. The construction of Trinity and Lewiston dams in the early 1960's had and continues to have a major impact on the flow, function and use of the Trinity River.

Based on distinct physical and biological characteristics with the Trinity River Basin, EPA stratified the Basin into three scales (from large to small): Assessment Areas, Subareas and Subwatersheds. The TMDL assessment and companion sediment source analysis by GMA (2001b) are generally organized according this stratification. Table 1-1 identifies name and size of each area. Figure 1-1 on the following page is a map of the whole basin with assessment areas identified. More detailed maps of each assessment area including subwatersheds are included in Figures 1-2, 3, 4, 5.

Table 1-1. List of Assessment Areas, Subareas and Subwatersheds in the Trinity River Basin.

Subareas	Subwatersheds	Approximate Size (mi^2)
Upper Assessment Area		692
Reference	Stuarts Fork, Swift Creek, Coffee Creek	235
Westside Tributaries	Stuart Arm Area, Stoney Creek, Mule Creek, East Fork Stuarts Fork, West Side Trinity Lake, Hatchet Creek, Buckeye Creek	93
Upper Trinity	Upper Mainstem, Tangle Blue, Sunflower Creek, Graves Creek, Bear Creek, Upper Mainstem Area, Ramshorn Creek, Ripple Creek, Eagle Creek, Minnehaha Creek, Snowslide Gulch Area, Scorpion Creek	161
East Fork Tributaries	East Fork Trinity, Cedar Creek, Squirrel Gulch Area	115
East Side Tributaries	East Side Tributaries, Trinity Lake	89
Upper Middle Assessment Area		321
Weaver and Rush Creeks	Weaver and Rush Creek	72

Deadwood Creek, Hoadley Gulch and Poker Bar Area	Deadwood Creek, Hoadley Gulch and Poker Bar Area	47
Lewiston Lake Area	Lewiston Lake Area	25
Grass Valley Creek	Grass Valley Creek	37
Indian Creek	Indian Creek	34
Reading and Browns Creek	Reading and Browns Creek	104
Lower Middle Assessment Area		720
Reference	New River, Big French, Manzanita, North Fork, East Fork North Fork	434
Canyon Creek	Canyon Creek	64
Upper Tributaries	Dutch Creek, Soldier Creek, Oregon Gulch, Conner Creek Area	72
Middle Tributaries	Big Bar Area, Prairie Creek, Little French Creek	54
Lower Tributaries	Swede Creek, Italian Creek, Canadian Creek, Cedar Flat Creek, Mill Creek, McDonald Creek, Hennessy Creek, Quinby Creek Area, Hawkins Creek, Sharber Creek	96
Lower Assessment Area *(Hoopa Valley Tribe not included)*		189
Reference Subwatershed	Horse Linto Creek	64
Mill Creek and Tish Tang	Mill Creek and Tish Tang Creek	39
Willow Creek	Willow Creek	43
Campbell Creek	Campbell Creek	11
Lower Mainstem Area	Lower Mainstem Area and Coon Creek	32

1.2. Information Sources

The Trinity River TMDL is based on the best available information and data from several existing studies and reports including but not limited to:

* Trinity River Mainstem Fishery Restoration Environmental Impact Statement (US FWS 1999)
* Gravel Quality Monitoring in the Mainstem Trinity River (GMA 2001a)
* Trinity River Sediment Source Analysis (GMA 2001b);
* Trinity River Flow Evaluation Final Report (US FWS and HVT 1999);
* Trinity River Maintenance Flow Study Final Report (McBain and Trush 1997);
* Watershed Condition Assessment, Beta-test Results of Northern Province (De la Fuente et al 2000)
* Several habitat assessment reports and environmental assessment by the US Forest Service;
* Additional information sources as cited.

These information sources range from highly quantitative studies to general qualitative descriptions of

aquatic habitat or watershed condition. The Klamath River Information System (KRIS) is a database program containing fisheries, water quality and watershed information. EPA utilized the KRIS CD to access some of the Trinity River information. In addition, the EPA wishes to acknowledge the contribution of local expertise and knowledge supplied by numerous individuals from the following organizations: Trinity County Resource Conservation District, US Forest Service, California Department of Fish and Game (CDFG) Members of the Trinity River Task Force and associated subcommittees, Natural Resource Advisory Committee of Trinity County, Hoopa Valley Tribe, landowners, Humboldt State University, and many others.

EPA has initiated informal consultation with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (US FWS) on this action, under Section 7(a)(2) of the Endangered Species Act. Section 7(a)(2) states that each federal agency shall ensure that its actions are not likely to jeopardize the continued existence of any federally-listed endangered or threatened species.

EPA's consultation with the Services has not yet been completed. EPA believes that it is unlikely that the Services will conclude that the Total Maximum Daily Load (TMDL) that EPA is establishing violates Section 7(a)(2) since the TMDL and allocations are calculated in order to meet water quality standards, and water quality standards are expressly designed to "protect the public health or welfare, enhance the quality of water and serve the purposes" of the Clean Water Act, which are to "restore and maintain the chemical, physical, and biological integrity of the Nation's water." Additionally, this action will improve existing conditions. However, EPA retains the discretion to revise this action if the consultation identifies deficiencies in the TMDL or allocations.

1.4. Organization

This report is divided into chapters. Chapter 2 (Problem Statement) describes the nature of the environmental problem addressed by the TMDL. Chapter 3 (Stream Habitat Indicators) identifies specific stream and watershed characteristics to be used to evaluate whether the Trinity River is attaining water quality standards. Chapter 4 (Source Analysis) describes what is currently understood about the sources of sediment in the watershed. Chapter 5 (TMDL and Allocations) identifies the total load of sediment that can be delivered to the Trinity River and its tributaries without causing exceedence of water quality standards, and describes how EPA is apportioning the total load among the sediment sources. Chapter 6 (Implementation and Monitoring Recommendations) contains recommendations to the State regarding implementation and monitoring of the TMDL. Chapter 7 (Public Participation) describes public participation in the development of the TMDL.

Figure 1-1. Map of the Trinity River Basin

Figure 1-2. Map of Subareas of Upper Assessment Area

Figure 1-3. Map of Upper Middle Assessment Area

Figure 1-4. Map of Lower Middle Assessment Area

Figure 1-5. Map of Lower Assessment Area

CHAPTER 2

PROBLEM STATEMENT

The beneficial uses associated with cold water fish habitat are currently impaired in the Trinity River Basin. Conditions in portions of the Trinity River and its tributaries have degraded and are not adequate to support the beneficial uses. Disturbance is a natural part of stream ecosystems, and salmonid populations naturally fluctuate in response to disturbances, but human activities can result in increased severity and frequency of disturbances. Habitat degradation, exacerbated by human activites, has contributed to a dramatic decline in the populations of coho, chinook, and steelhead from historical levels.

This chapter summarizes how and where sediment is affecting the beneficial uses of the Trinity River and its tributaries associated with the decline of cold water fish habitat. The water quality standards section (2.1) describes the beneficial uses and sediment-related water quality objectives (i.e., suspended material, settleable material, turbidity, etc.) that apply to the Trinity River Basin. Section 2.2 summarizes the distribution and abundance of fish populations based on various estimates by state, federal and tribal entities. The salmonid life cycle and habitat requirements are described in Section 2.3. Finally, Section 2.4 provides a qualitative assessment of existing instream and watershed conditions in the Trinity River basin, including both healthy and degraded areas of the Trinity River Basin.

2.1. Water Quality Standards

In accordance with the Clean Water Act, TMDLs are set at levels necessary to implement the applicable water quality standards. Under the Clean Water Act, water quality standards consist of designated uses, water quality criteria to protect the uses, and an antidegradation policy. The State of California uses slightly different language (i.e., beneficial uses, water quality objectives, and a non-degradation policy). This section describes the State water quality standards applicable to the Trinity River TMDL using the State's terminology. The remainder of the document simply refers to water quality standards.

The beneficial uses and water quality objectives for the Trinity River are contained in the *Water Quality Control Plan for the North Coast Region* (Basin Plan) as amended in 1996 (Regional Water Board 1996). The beneficial uses pertinent to the Trinity River are listed in Table 2-1.

Table 2-1. Trinity River Beneficial Uses by Hydrologic Area (Regional Water Board 1996)

Beneficial Water Use	Upper Trinity Hydrologic Area		Lower Trinity Hydrologic Area (Trinity River below Lewiston Reservoir)
	Trinity Lake and Lewiston Reservoir	Trinity River above Trinity Lake	
Municipal and Domestic Supply (MUN*)	E	E	E
Agricultural Supply (AGR*)	E	E	E
Industrial Service Supply (IND*)	E	E	P
Industrial Process Supply (PROC*)	E	P	P
Groundwater Recharge (GWR)	E	E	E
Freshwater Replenishment (FRSH)	E	E	E
Hydropower Generation (POW)	E		
Water Contact Recreation (REC-1)	E	E	E
Non-contact Water Recreation (REC-2)	E	E	E
Commercial and Sport Fishing (COMM)	E	E	E
Warm Freshwater Habitat (WARM)	E		
Cold Freshwater Habitat (COLD)	E	E	E
Wildlife Habitat (WILD)	E	E	E
Migration of Aquatic Organisms (MIGR)		E	E
Spawning, Reproduction and/or Early Development of fish (SPWN)	E	E	E
Aquaculture (AQUA)	E	E	P

* Groundwater or surface water
E = Existing
P = Potential

As defined in the Basin Plan (Regional Water Board 1996), the beneficial uses impaired by excessive sediment in the Trinity River are primarily those associated with supporting high quality habitat for fish, specifically: Commercial or Sport Fishing (COMM), Cold Freshwater Habitat (COLD), Migration of Aquatic Organisms (MIGR), and Spawning, Reproduction, and/or Early Development (SPWN). In addition, the Regional Water Board is in the process of updating the Beneficial Uses chapter of the Basin Plan and will likely include Rare, Threatened, or Endangered Species (RARE) beneficial use for the Trinity River basin as a result of the listing of coho salmon as threatened under the Federal ESA. (pers. comm David Leland). See Section 2.2 for further discussion of salmonid fish populations and habitat needs.

Recreation is another important beneficial use potentially impacted by sedimentation. The two existing recreational beneficial uses described in the Basin Plan (Regional Water Board 1996) that apply to the Trinity River Basin are water contact recreation (REC-1) and non-contact water recreation (REC-2). The

Trinity River Basin, including designated wilderness areas (Trinity Wilderness Area, the Chanchelulla Wilderness Area, and the Trinity Alps Wilderness), the river itself and the two reservoirs (Lewiston and Trinity) support an abundance of recreational opportunities including: boating, fishing, camping, swimming, sight-seeing, hiking, etc. The USFS quantifies the amount of recreational activity in a particular area in terms of "recreational visitor days." In 1995, an estimated 214,000 recreational visitor days were spent on the Trinity River (US FWS 1999, p.3-263). The net economic value to persons who recreated along the Trinity River in 1995 is estimated to be $9.9 million.

The entire mainstem of the Trinity River was designated a National Wild and Scenic River by the Secretary of the Interior in 1981. Approximately 97.5 miles of the river are classified as recreational under the National Wild and Scenic River Act. The mainstem Trinity River is also classified as recreational and scenic under the California Wild and Scenic Rivers Act.

The USFS manages the Shasta-Trinity National Recreation Area which includes Trinity and Lewiston Reservoirs. Trinity Reservoir features 4 marinas, 10 boat launches, 20 campgrounds, and 2 swimming areas. Recreation opportunities in the vicinity of Trinity reservoir include powerboating, sailing, houseboating, swimming, water-skiing, camping, hunting, fishing, hiking and sight-seeing. Recreational facilities at Lewiston Reservoir, include campgrounds, a picnic area, boat ramp, and marina. Low water temperatures generally make this reservoir unsuitable for water-contact activities (e.g., swimming) (US FWS, p. 3-279.)

The Basin Plan (Regional Water Board 1996) identifies both numeric and narrative water quality objectives for the Trinity River. Those pertinent to the Trinity River TMDL are listed in Table 2-2.

Table 2-2. Water Quality Objectives Addressed in the Trinity River TMDL

Parameter	**Water Quality Objective**
Suspended Material	Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.
Settleable Material	Waters shall not contain substances in concentrations that result in deposition of material that causes nuisance or adversely affect beneficial uses.
Sediment	The suspended sediment load and suspended sediment discharge rate of surface water shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.
Turbidity	Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution with which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof.

In addition to water quality objectives, the Basin Plan (Regional Water Board 1996) includes two prohibitions specifically applicable to logging, construction, and other associated nonpoint source activities:

- the discharge of soil, silt, bark, sawdust, or other organic and earthen material from any logging, construction, or associated activity of whatever nature into any stream or watercourse in the basin in quantities deleterious to fish, wildlife, or other beneficial uses is prohibited; and

- the placing or disposal of soil, silt, bark, slash, sawdust, or other organic and earthen material from any logging, construction, or associated activity of whatever nature at locations where such material could pass into any stream or watercourse in the basin in quantities which could be deleterious to fish, wildlife, or other beneficial uses is prohibited.

2.2. Decline of Fish Populations

This section describes how the populations of anadromous salmonids have declined in the Trinity River. It also briefly discusses other fish species of interest in the watershed. Anadromous salmonids have declined throughout their range in California over the last several decades. For example, CDFG (1994a) reported that "coho salmon in California, including hatchery stocks, could be less than 6 percent of their abundance during the 1940's, and have experienced at least a 70 percent decline in numbers since the 1960's." NMFS (1995) concluded that natural coho populations within the Southern Oregon/northern California coasts evolutionary significant unit (ESU) are not self-sustaining and are presently threatened, i.e., are likely to become in danger of extinction in the foreseeable future if present trends continue.

Abundance of native anadromous fish populations in the Trinity River Basin has changed dramatically from historic levels and is presently well below the goals set by the Trinity River Restoration Program (TRRP). For example, estimates of fall chinook salmon escapement (i.e., return from the ocean to spawn) prior to dam construction in the early 1960's averaged 45,600 compared with an average of 11,932 from 1982-2000 (US FWS 1999). Distribution of salmonid populations within the basin also changed significantly due, primarily, to the construction of the Trinity River Division (TRD) dams which blocked access to approximately 109 miles of steelhead habitat and 59 miles (50%) of chinook habitat (US FWS 1999). The Trinity River fishery has been a cultural and subsistence mainstay of the Hoopa people for several thousand years (HVT 2000).

Following the dramatic decline in fish populations after dam construction, the 1983 Environmental Impact Statement (EIS) on the Trinity River Basin Fish and Wildlife Management Program (US FWS 1983) established inriver spawner escapement goals that could be met once restoration was complete. "Inriver spawner escapement" refers to the number of returning fish that physically spawn in the river. Based on adult escapement estimates since the early 1980's, the US FWS (1999) have found that naturally produced anadromous salmonid populations are, on average, well-below the restoration goals. However, certain tributaries (e.g., North Fork, New River, Horse Linto) appear to be supporting stable or recovering populations of salmonids. The relatively low returns of naturally produced fish in the mainstem, compared to hatchery produced, are likely indicative of low survival rates of young freshwater life stages (eggs, fry and/or juvenile fish).

Table 2-3 provides a comparison between the TRRP inriver spawner escapement goals with the average inriver escapement of naturally produced fish. The TRRP makes a clear distinction between "naturally produced" spawners and "hatchery produced" spawners. Naturally produced fish refers to the progeny of fish that physically spawned in the river or its tributaries, without human intervention (i.e., hatchery raised). Hatchery produced fish refers to the progeny of fish that were spawned and raised at the hatchery. (US FWS 1999, p. B-3) Achievement of the TRRP natural escapement goals would indicate that fish populations are self-sustaining rather than dependent on artificial hatchery production. (US FWS 1999, B-3) The data indicate that current/recent levels of naturally produced fish are far below the goals.

Table 2-3. Comparison of TRRP Inriver Spawner Escapement Goals to Average Numbers of Naturally Produced Fish (Updated from US FWS 1999, Table 3-13)

Species	TRRP Inriver Spawner Escapement Goals	Average Inriver Escapement of Naturally Produced Fish	Years of Available Data	Percent of TRRP Goal Met
Fall chinook salmon	62,000	11,932	1982-2000	19
Spring chinook salmon	6,000	2,370	1982-1999	40
Coho salmon	1,400	390	1991-1995, 1998,1999	28
Steelhead	40,000	1870	1992-1996	5

The in river spawning escapement estimates of all the anadromous species have varied tremendously each year. Figures 2-1 and 2-2 illustrate the high variability in escapement estimates year-to-year as well as the relatively low percentage of naturally produced fish that return to spawn for Fall Chinook and Coho salmon, respectively. During the period of the 1990's, each of the species experienced at least two or more extremely low escapement years.

Figure 2-1. Fall Chinook Spawner Escapement in the Trinity River above Willow Creek, 1982-1999. (Source: CDFG 2001a, US FWS 1999)

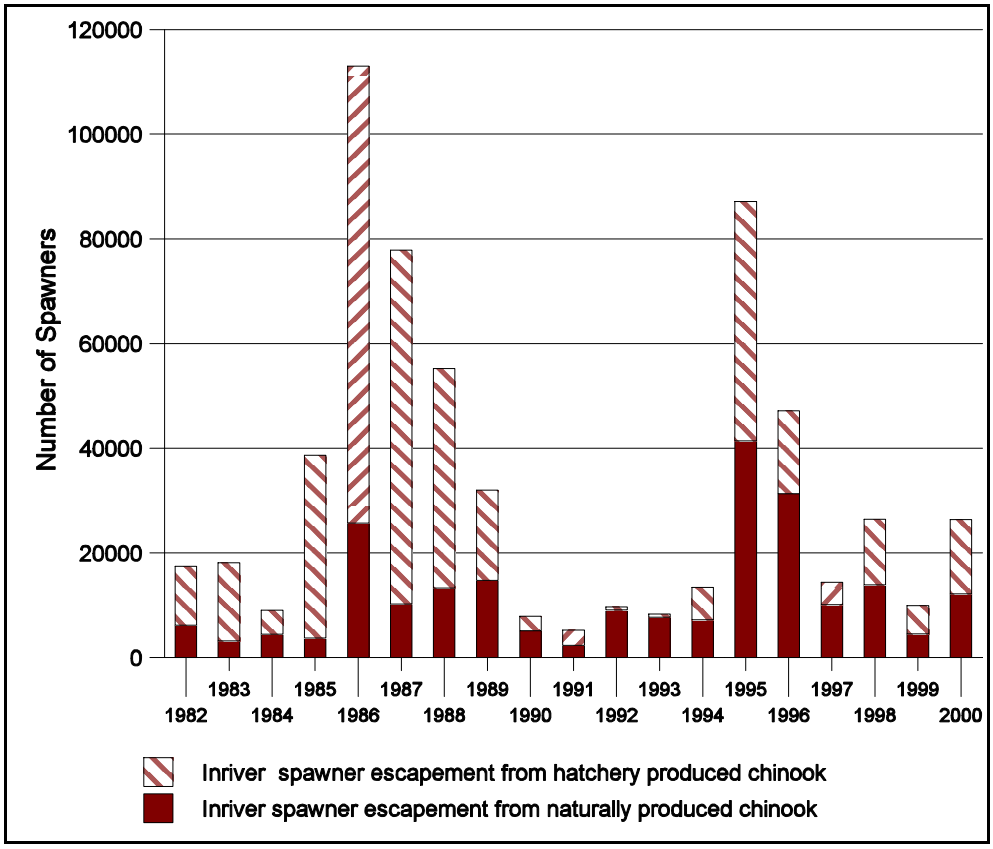
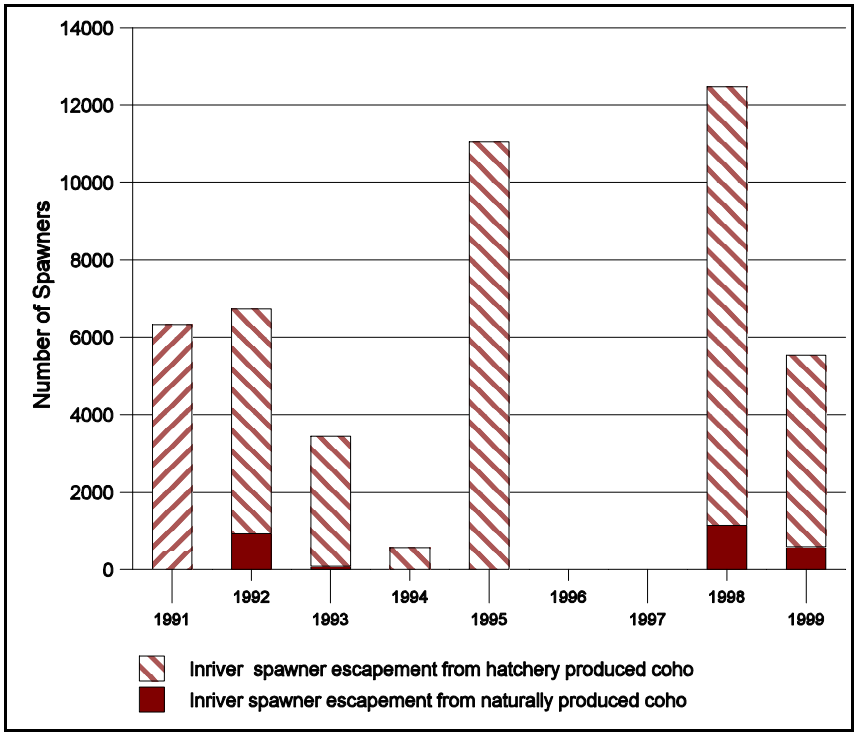


Figure 2-2. Coho spawner escapement in the Trinity river above Willow Creek, 1991-1999, data not available '96, '97. (Source: CDFG 2001, US FWS 1999)



Coho

USFWS and CDFG (1956) estimated that 5,000 coho salmon were spawning above Lewiston prior to dam construction. Accurate estimates of coho populations below Lewiston prior to dam construction were not available. Coho inriver escapement estimates for the decade of the 1990's (excluding 1996, 1997 when data were not available) averaged 390 naturally produced fish above Willow Creek compared with the TRRP goal of 1,400. Data for the proportion of hatchery-produced coho salmon during this period indicate that the coho population is predominantly of hatchery origin. Captures of [yearling] coho salmon in recent years during USFWS outmigrant trapping efforts have been consistent, but numbers have been very low (Glase 1994).

With regard to coho usage of the tributaries within the Upper Middle Assessment Area, the USBLM (1995) reported that: "...it is likely that coho utilized accessible tributaries in years when returning adult numbers were high. Salmon carcass surveys in 1995 (unpub. data. USFWS 1995) indicate substantial usage in many of the tributaries from the North Fork upstream to Deadwood Creek. Surveys in the 1980's (Ebasco Environmental 1989, 1990; USFS 1988) revealed coho in some tributaries." The USBLM (1995) also identified migration barriers and potential habitat limiting factors for coho and other anadromous salmonids. The USFS (2000a) reported that coho salmon are "rarely found" in the New River.

In the Lower Assessment Area, the USFS (2001a) identified Sharber/Peckham Creek, compared with other lower basin tributaries, as supporting the highest number of spawning coho salmon based on redd and carcasses surveys conducted from 1996 to 2000. The USFS estimated that 110 coho salmon spawned in Sharber/Peckham Creek in 1998, however only one coho carcass and two live coho were

observed in the 2000 survey. Coho salmon also inhabit the lower portions of Mill Creek (within the Hoopa Valley Tribal lands) and Horse Linto Creek. However, the Six Rivers National Forest indicated that populations in these areas are extremely low, particularly in Horse Linto Creek since 1995 (USFS 2001b, p. G-21) . Based on fish population studies conducted by the Hoopa Valley Tribal Fisheries Department, coho salmon is the least abundant of the three anadromous salmonid species in Mill Creek.

The Six Rivers National Forest and Hoopa Tribal Fisheries Department have operated downstream migrant traps in Horse Linto Creek, Supply Creek, Tish Tang Creeks and Mill Creeks in the Lower Basin to estimate juvenile anadromous fish populations. Very few juvenile coho have been trapped in these tributaries, compared with chinook and steelhead, during the years in which data were collected throughout the 1990's (see KRIS for reporting of data).

Fall and Spring Chinook

The annual pre-dam estimates of fall chinook escapement averaged 45,600 based on a few studies conducted between 1944 and 1963. Based on yearly estimates from 1982 through 2000, the CDFG estimated that the river below Lewiston produced an average of 11,932 fall chinook salmon which is 19 percent of the TRRP goal of 62,000 naturally produced fall chinook salmon (US FWS 1999, p. 3-159) and much less than historic estimates for this reach of the river (22,600 adults and jacks). The CDFG estimated that naturally produced spring chinook averaged 2,370 or 40 percent of the TRRP goal of 6,000, between 1982 and 1999 (excluding 1983 and 1995 when surveys were not conducted).

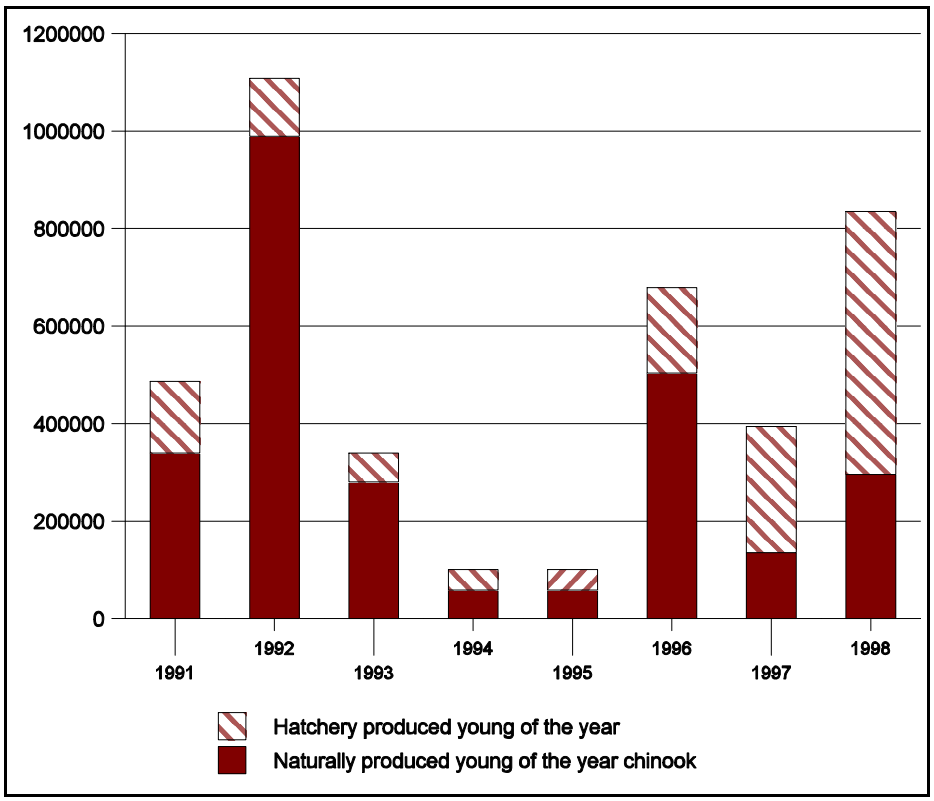
Adult spawning chinook make limited use of the tributaries compared to the mainstem above the Junction City Weir, based on CDFG surveys of carcass and redd counts. (CDFG 1996, Table 6, Appendix 5, CDFG 1994a). For example, CDFG found only 29 carcasses in the tributaries out of a total of 690 (including mainstem) during spawner surveys in 1991. Between the North Fork confluence to Cedar Flat (39 Km), the US FWS (1999) surveyed chinook salmon redd distribution and abundance from 1996 to 1998. They found: 602 redds in 1996, 928 redds in 1997 and 187 redds in 1998. Redd numbers were highest between Big Bar Creek and Big French Creek. Interestingly, they also found 72 redds (4%) on or near the tailings from suction dredge mining operations. Due to the instability of tailings during high flows, however, redds constructed therein face a high risk of scouring (Harvey and Lisle 1998).

In the Lower Trinity tributaries, adult spawner populations have varied widely from year to year during the 1990's, however they appear to be strongest in Horse Linto Creek. The USFS in cooperation with several other agencies, organizations, the Hoopa Valley tribe and Humboldt State University, developed a small chinook production facility in 1981, designed to increase returning chinook spawners to a level that would no longer require augmentation (USFS 2000b, p. 3-170). The USFS has continued to monitor redds, carcasses and juvenile production since 1994 to evaluate the viability of the population. The USFS (2001b) observed close to 400 redds in 1997 and less than 100 redds in 1998 and considers the “hatchbox” project a success due to the comparatively strong population estimates. Old Campbell Creek and Willow Creek, other tributaries in the lower Trinity, have continued to support chinook, however the USFS (2001a) has counted precariously low numbers of redds and carcasses in some years during the 1990s.

Juvenile chinook abundance above the Willow Creek weir has varied from 77,230 in 1991 to almost 2,000,000 in 1998 based on US Fish and Wildlife Service estimates (reported in KRIS database). More than 50% of the 1998 estimate were hatchery fish. The US Forest Service (1988) estimated that juvenile chinook salmon density in Canyon Creek was lower than densities obtained from other researchers working in Idaho, Oregon and Northern California. Whereas in the North Fork Trinity, they found juvenile chinook salmon density higher than in other Northern California streams. Juvenile chinook

estimates from outmigrant traps in tributaries to the Lower Trinity have ranged widely during several years the traps were operation during the 1990' s (see KRIS for data results).

Figure 2-3. Juvenile Chinook Estimates in the Trinity River at Willow Creek Weir, 1991-1998. (Source: US FWS)



Winter and Summer Steelhead:

Prior to the construction of the dam, CDFG and US FWS (1956) estimated winter steelhead spawner escapements above Lewiston ranged from 6,900 to 24,000 while summer steelhead averaged 8,000. From 1980 through 1999 (excluding a few years when no estimates were made) CDFG estimated an average of 4,400 naturally produced steelhead spawning escapement which represents approximately 11 percent of the TRRP goal of 40,000. Of all the anadromous species, steelhead extend the furthest up tributary streams. Summer steelhead hold over during the summer months then spawn in the following late winter or early spring. Agencies have focused population surveys of summer steelhead in the following tributaries: North Fork, South Fork, Canyon Creek, and the New River. The USFS (2000a) reported that the summer steelhead counts in the New River over the last decade range from 307 to 804 making it one of the larger populations in California. Populations of summer steelhead on tributaries other than the New River and North Fork Trinity are significantly low (USFS 2000a).

Juvenile steelhead production in most of the lower tributaries has varied widely during the 1990's based on outmigrant trapping data collected by the USFS (reported in KRIS). However, the USFS (2001b, p. g-22) reports that Steelhead populations in Horse Linto Creek appear to be stable including well balanced year-class distributions for juvenile steelhead.

For a more complete discussion of anadromous fish population estimates see the Trinity River Mainstem Fishery Restoration EIS/R, particularly Appendix B, and CDFG Reports, generally available via KRIS database.

Other Fish Species

The Trinity and Klamath River Basins contain the largest spawning population of green sturgeon in California. Green sturgeon was recently petitioned for listing on the federal endangered species list due to declining populations (reported in Times-Standard 2001). Green sturgeon generally begin migrating into the Klamath Basin in late February and spawn in spring and early summer. Sturgeon require deep pool habitat and suitable substrate quality for spawning. Excessive fine sediment can limit sturgeon production by decreasing the adhesiveness of eggs to channel substrate following spawning.

Population estimates of Pacific lamprey are limited, however, anecdotal evidence suggests the population has dramatically declined over the last few decades (Bias 2001).

Although anadromous fish no longer exist above Lewiston dam, the reservoir and associated tributaries support a broad range of fish species and other beneficial uses which can be affected by sediment. Trinity Reservoir supports a trophy smallmouth bass fishery and provides sport fishing for largemouth bass, trout, kokanee salmon, landlocked chinook salmon, and other gamefish. Cool water and the high percentage of gravel-rubble bottom in Trinity Reservoir create ideal forage and habitat conditions for smallmouth bass. The species requires clean sand, gravel, or debris-littered bottoms to spawn, at depths of 103 feet up to 23 feet. Spawning begins in April.

Kokanee salmon are a “land-locked” form of sockeye salmon. They were introduced and have become well established in both Trinity and Lewiston Reservoirs. The species makes its spawning migration into streams between early August and February (US FWS 1999, p. 3-185). The CDFG has determined that the size of kokanee salmon are stunted (7"-8") due to overproduction and are consequently not a highly sought after sport fishery (B. Aguilar personal communication). CDFG has begun planting chinook salmon to control the kokanee population and potentially produce additional sport fishing opportunities.

Rainbow trout are the most abundant salmonid found in the Trinity and Lewiston reservoirs. They spawn in the spring in streams flowing into the reservoirs. Juvenile trout enter the reservoir to forage and mature where the cold, deep water provides suitable habitat. (US FWS 1999, p. 3-185). The CDFG (letter dated June 7) identifed Stuart Fork, Coffee Creek, Upper Trinity River, Mule Creek and Swift Creek as key trout streams providing refugia and major recreational opportunities.

In summary, naturally produced anadromous salmonid populations are clearly below historic levels and the goals set by the TRRP. Certain subwatersheds (i.e. North Fork, New River, Horse Linto) appear to be supporting stable or recovering populations of salmonids. Population estimates for adult salmonid escapement and juvenile outmigration have varied widely over the past 20 years. The relatively low returns of naturally produced fish, compared to hatchery produced, are likely indicative of low survival rates of young freshwater life stages (eggs, fry and/or juvenile fish).

2.3. Salmonid Life Cycle and Water Quality Requirements

This section describes the life cycle of anadromous salmonids and the habitat conditions that are crucial for the survival of each life stage. Salmonid populations are affected by a number of factors including: operation of the Trinity River Salmon and Steelhead Hatchery with regard to species competition, predation, dilution of native genetic stock and transmission of disease organisms; commercial and sport harvest; operation of TRD; food production; and factors which occur outside of the watershed (e.g., ocean rearing conditions). This TMDL focuses on achievement of water quality standards related to sediment, which will facilitate, but not guarantee, population recovery.

Salmonids have a five-stage life cycle. First, adult salmonids lay their eggs in clean stream or lake gravels to incubate. Second, the eggs hatch and young fish seek shelter in the pools and adjacent wetlands. Third, juvenile fish leave the stream or lake, migrate downriver, and reside in the estuary to feed and adjust to saltwater for up to a year before continuing onto the ocean. Fourth, juvenile fish mature in the ocean. And fifth, adult fish return to their home stream or lake to spawn. This cycle from spawning area to the ocean and back defines Pacific salmonids as "anadromous." Most Pacific salmonids die after spawning: their total energies are devoted to producing the next generation, and their bodies help enrich the stream for that generation.

Salmonids have a variety of requirements related to sediment. Salmonids have different water quality and habitat requirements at different life stages. Sediment of appropriate quality and quantity is needed for redd (i.e., salmon nest) construction, spawning, and embryo development. However, excessive amounts of sediment or changes in size distribution (e.g., increased fine sediment) can adversely affect salmonid development and habitat.

Excessive fine sediment can reduce egg and embryo survival and juvenile salmonid development. Tappel and Bjornn (1983) found that embryo survival decreases as the amount of fine sediment increases. Excess fine sediment can prevent adequate water flow through salmon redds, which is critical for maintaining adequate oxygen levels and removing metabolic wastes. Deposits of these finer sediments can also prevent the hatching fry from emerging from the redds, resulting in smothering. Excess fine sediment can also cause gravels in the waterbody to become embedded (i.e., the fine sediment surrounds and packs-in against the gravels), which effectively cements them into the channel bottom. Embeddedness can prevent the spawning salmon from building their redds.

An imbalance of fine or coarse sediment supply or transport rate can also adversely affect the quality and availability of salmonid habitat by changing the morphology of the stream. It can reduce overall stream depth and the availability of shelter, and it can reduce the frequency, volume, and depth of pools. CDFG

habitat data indicate that coho in Northern California tend to be found in streams that have as much as 40% of their total habitat in primary pools (Flosi et al. 1998). Pools in first and second order streams are considered primary pools when they are at least as long as the low-flow channel width, occupy at least half the width of the low-flow channel, and are two feet or more in depth. Primary pools in third order and larger channels are defined similarly, except that pool depth must be three feet or more. Pools provide salmon with protection from predators, a food source, and resting location.

Excessive sediment can affect other factors important to salmonids. Stream temperatures can increase as a result of stream widening and pool filling. The abundance of invertebrates, a primary food source for juvenile salmonids, can be reduced by excessive fine sediment. Large woody debris, which provides shelter, can be buried. Increased sediment delivery can also result in elevated turbidity, which is highly correlated with increased suspended sediment concentrations. Increases in turbidity or suspended sediment can impair growth by reducing availability or visibility of food sources, and the suspended sediment can cause direct damage to the fish by clogging gills.

2.4. Habitat Conditions in the Trinity River Watershed

This section describes the existing habitat conditions in the Trinity River basin. First, an approach is described for assessing qualitatively the health of watersheds, then habitat conditions are described for subwatersheds in each of the four main assessment areas of the Trinity River addressed in this TMDL. In each of the four main assessment areas, some subwatersheds appear healthy and properly functioning with regard to physical watershed processes affecting beneficial uses and some are impaired and not supporting beneficial uses. Habitat conditions in the impaired subwatersheds are described in this chapter because they demonstrate the nature of the sediment problems in the Trinity River watershed. Habitat conditions in the healthy subwatersheds are described because this information was used to help select reference streams (reference streams are used in Chapter 5 as the basis for determining the appropriate loading capacity or TMDL for all the subareas).

Subwatershed Assessment Approach

EPA has utilized all available, relevant instream habitat and watershed condition information to determine whether subwatersheds within the Trinity basin are presently healthy or impaired. Much of the information available has been developed by the USFS.

Using the approach in Rating Watershed Condition: Reconnaissance Level Assessment for the National Forests of the Pacific Southwest Region ("Watershed Condition Assessment") (USFS 2000c), De la Fuente et al. (2000) assessed the condition of watersheds on USFS land in Northern California including the Trinity River basin. Each watershed received a rating of its ***hazard*** of impairment to watershed resources (i.e., disturbance prone to accelerate future sediment delivery to streams) and its ***expression*** of watershed condition (i.e., water quality). The ratings were based on several quantitative and qualitative indicators. For example, the USFS assigned a value (1=properly functioning; 2=functioning, at-risk; 3=impaired) based on best professional judgment to the following indicators that reflect the expression of watershed condition: floodplain connectivety, water quality, water quantity, riparian vegetation, channel stability and aquatic integrity. The resulting values were added together for an overall expression rating. The hazard and expression ratings were then used to classify the overall condition of the watershed into one of three categories.

Healthy (Reference) watersheds (Category I): ***Watersheds that are currently exhibiting high geomorphic, hydrologic, and biotic integrity relative to their natural potential condition and exhibit a stable drainage network. Physical and biological conditions suggest that aquatic and riparian systems***

are predominantly functional in terms of supporting dependent species and beneficial uses of water. The risks of management induced disturbance have not been expressed or resulted in significant alteration of geomorphic, hydrologic, and biotic processes.

Moderate watersheds (Category II): ***Watersheds that are currently exhibiting moderate geomorphic, hydrologic, and biotic integrity relative to their natural potential condition and portions of these watersheds exhibit an unstable drainage network. Physical and biological conditions suggest that aquatic and riparian systems are at risk in being able to support dependent species and retain beneficial uses of water. The risks of management induced disturbance are variable and effects have partially been expressed or have resulted in localized alteration of geomorphic, hydrologic, and biotic processes***.

Impaired watersheds (Category III): ***Watersheds that are currently exhibiting low geomorphic hydrologic, and biotic integrity relative to their natural potential condition and a majority of the drainage network is unstable. Physical and biological conditions suggest that riparian and aquatic systems do not support dependent species nor beneficial uses of water. The risks of management induced disturbance are high; they have been fully expressed and/or have resulted in deterioration of geomorphic, hdyrologic, and/or biotic processes.***

Another assessment by the USFS (1997) identified specific watersheds as "Focal" watersheds which they define as: "...critical areas supporting a mosaic of high-quality habitats that sustain a diverse or unusually productive complement of native species. Most typically, they are relatively undisturbed headwater watersheds that foster spawning and rearing habitat for remnant populations of sensitive fishes and other organisms." EPA considered the focal watershed designation when assessing watershed conditions.

The Aquatic Conservation Strategy (ACS) of the Northwest Forest Plan (USDA and USDI 1994) identified "Key Watersheds" throughout the range of the Northern Spotted Owl. Tier 1 Key Watersheds are intended to provide refugia that are crucial to at-risk fish species and stocks and provide high quality water. The Trinity River basin contains the following Tier 1 Key Watersheds: Horse Linto Creek, New River, North Fork Trinity and Canyon Creek.

EPA combined the USFS information for the Trinity with other available information regarding stream and watershed condition. This remainder of this section describes both the healthy and degraded subwatershed areas existing in each of the four assessment areas. EPA is using the healthy streams as "reference" streams for comparing the degree of sediment impairment in the other streams in the area. Figures 1-2,3,4, and 5 identify the reference subwatersheds throughout the basin.

Habitat Conditions in Upper Trinity Assessment Area

Healthy subwatersheds:
Based on the results of a regional watershed condition assessment, De la Fuente et al. (2000) classified Coffee Creek and Stuart Fork watersheds, including Swift Creek, as Category I watersheds. Also, USFS (1997) has identified Middle Fork Coffee Creek, North Fork Swift Creek and Stuart Fork as "Focal" watersheds. CDFG (2001b) confirms that several of these west-side tributaries are important for spawning of kokanee salmon and resident trout. Although recent stream condition data is limited for most upper basin tributaries, CDFG surveys from the 1970's document the relatively good habitat conditions in portions of Coffee Creek despite the impact of historic hydraulic mining that occurred until 1939. These streams have long been tourist destinations for recreation, sport fishing and scenic attributes, particularly in the Trinity Alps Wilderness.

Impaired Areas:
Several tributaries to Trinity and Lewiston Reservoirs are currently exhibiting low (watershed condition Category II or III) geomorphic and biotic integrity relative to their natural potential condition; specifically, portions of the upper Trinity River mainstem, East Fork and Eastside tributaries to the Trinity reservoir (De la Fuente et al. 2000). The Upper Trinity mainstem and the East Fork each received values indicating an "at risk" condition.

A USFS channel survey of the upper mainstem of the Trinity River from 1991 reveals moderate to fair habitat conditions and a high degree of disturbance in the form of historic or active mine tailings, mass wasting features, and bank erosion (USFS 1991). Certain tributaries are discharging excessive levels of suspended sediment, affecting the beneficial uses in the tributaries themselves and in the reservoir and posing a risk to beneficial uses downstream of the dams. Discharge from the reservoirs has had high levels of turbidity and suspended sediment for extended periods during and following high flow years (e.g., 1974, 1983, 1997) (GMA 1997).

Habitat Conditions in Upper Middle Assessment Area

The condition of aquatic habitat in the Upper Middle Assessment Area is of particular importance for two reasons: (1) biologically, it is utilized more extensively for anadromous fish spawning and rearing than other basins, and (2) the tributaries and mainstem of the Middle Basin have been subjected to a high level of habitat modification, due to the TRD and land management in the tributaries, including mining, timber extraction and road building. Due to the magnitude of impairment in the mainstem and level of disturbance throughout the tributaries, EPA was unable to identify completely healthy subwatersheds in the Upper Middle Assessment Area. The sediment related problems are described below.

Mainstem impairment:
The reduction in quantity and variability of mainstem flows following dam construction, coupled with an accellerated rate of sediment delivery due to intensive management practices in the tributaries, resulted in an inbalance in the sediment budget and a reshaped channel (McBain and Trush 1997). The once diverse channel was converted into a structurally uniform channel, in some places choked with sediment and a few places deprived of sediment, thereby eliminating or modifying critical habitat elements for anadromous salmonids. Each sediment-related change and relation to biological values is briefly characterized below.

1) Loss of coarse sediment supply from the upper basin (due to blockage by the dams) resulted in a reduction of spawning gravels and cobble channel margins in the mainstem below Lewiston Dam to the confluence with Rush Creek.

> High-quality spawning habitat for anadromous salmonids requires frequent mobilization and replenishment of gravel. Gravel deposits in the tails of pools and runs, often preferred spawning habitat, are subject to frequent scour during high flow events. Lewiston and Trinity Dams completely cut-off the upstream source of coarse bed material to replace bed material transported downstream. The mainstem immediately below Lewiston Dam (to confluence with Rush Creek approximately) has responded with slight down-cutting and significant channel bed coarsening (US FWS and HVT 1999). Despite supplementation of spawning gravels immediately below the Dam in 1998, the U.S. FWS and HVT (1999) determined that the channel had degraded a depth of 2 feet. They recommended supplementing 10,000 yds^3 of properly graded gravel material on the short term to the reach immediately below the Dam to offset gravel export and presumably enhance spawning capacity.

2) The mainstem channelbed has not been adequately mobilized resulting in sediment accumulation at the deltas of tributaries and loss of habitat characteristics associated with alternate bar sequence.

Healthy alluvial river systems require frequent (1-3 years) mobilization of the channelbed for several reasons: 1) facilitate the transport of bedload; 2) discourage riparian vegetation from colonizing and fossilizing alluvial features; 3) clean spawning gravel deposits; and 4) facilitate the formation of alternate bars (McBain and Trush 1997). The gravels delivered by the mainstem tributaries below the dam have not been effectively mobilized and dispersed due to inadequate flood flows. Below the confluence with Rush Creek the annual coarse sediment supply from downstream tributaries has continued at rates equal to or slightly higher than before TRD but lower instream flows reduce mainstem transport capacity (US FWS and HVT 1999). Using tracer rock movement studies among diverse alluvial features (i.e. pool tail deposits edges of point bars, long riffles, etc.), McBain and Trush (1997) document the inability of the regulated flows to adequately mobilize the coarse bedload. Inadequate bedload mobility results in a decrease in substrate complexity thereby reducing macroinvertebrate production and reducing pool depths needed for adult fish cover and holding. GMA (2001b) identified a 12 foot increase in channel bed elevation at a cross-section just below the confluence of Indian Creek.

3) Sediment has filled in mainstem pools thereby eliminating deep pool habitat important for adult salmonids holding over the summer.

After access to the upper basin was eliminated due to dam construction, spring chinook had to "summer-over" in any available deep pools below the dam until spawning began in Fall. Since many of these pools were historically occupied by summer-run steelhead, chinook and steelhead were forced to compete for pool habitat below the dam. Deep pools provide thermal refuge during warm summer months as well as potential refuge from predators. However, flows below Lewiston dam have not been sufficient to move sediment, delivered from tributaries, out of mainstem pools. Thus, pools have filled, and the lack of deep pools now restricts adult salmonid holding habitat.

4) Excessive levels of fine sediment in the stream channel have limited anadromous salmonid habitat by: 1) infiltrating spawning gravel which can increase egg and alevin mortality; 2) depositing on exposed cobble bars which can impact salmonid fry and over-wintering rearing habitat; and 3) filling pools, in some cases, and limiting adult holding habitat.

GMA (2001a) determined that spawning gravel quality generally declines in a downstream direction from the spawning area just below Lewiston dam (river mile 111.5) through the study sites below each of the major tributaries (to river mile 80.3). The Poker Bar site (river mile 102.7), just below the confluence of Grass Valley Creek, contained the poorest gravel quality of all the study sites as indicated by increased percentages of fines, decreased D_{84} to D_{16} values (the sizes at which 84% and 16% of the sample, respectively, are finer) and decreased geometric mean diameter. Mean site permeability shows the same general trend of decreasing in a downstream direction. Sand size particles (<2mm) appear to be limiting emergence of alevins from redds by blocking interstitial space in spawning size gravel, particularly below Grass Valley Creek.

5) Sediment has deposited and accumulated around riparian vegetation contributing to the creation of "fossilized" berms along the channel resulting in the loss of open, shallow, low-velocity gravel bar habitats for rearing salmonid fry.

Riparian vegetation along the low-water channel margin has grown and matured at unnaturally high densities due to consistent year-round low flow releases (150-300 cfs), in the absence of high

scouring flows. These riparian berms trap sediment which further contributes to the size of the berm. The berms and associated dense vegetation serve to restrict access of emerging fry into important shallow, low velocity stream margin habitat. In addition, much of the sediment deposited in the berm no longer has access to the floodplain where, under less disturbed conditions, the sediment deposit and contribute to certain ecological functions on the floodplain.

6) Geomorphology: The pre-dam riffle-pool sequences associated with point bars were replaced with monotypic runs, which reduced the quantity, quality, and diversity of aquatic habitats (US FWS and HVT 1999, p. 3-25, Figure 3-6).

> Changes in sediment transport and storage, in combination with the reduction in mainstem flow following construction of the TRD, altered the channel geomorphology thereby reducing the number and quality of alternate bar sequences. Important fish habitat characteristics impacted by the loss of alternate bar sequences includes: pools that provide cover from predators and cool resting places for juveniles and adults; gravelly riffles where adults typically spawn; open gravel/cobble bars that create shallow, low-velocity zones important for emerging fry; and slack water habitats for rearing juveniles.((US FWS and HVT 1999, App. B-12) The Trinity River does not approach a pre-dam channel geomorphology until the confluence with the North Fork

Although this TMDL does not directly address temperature, there is a direct link between sediment storage in the pools and thermal impacts on anadromous fish. Moffett and Smith (1950) documented that the deepest levels of pools, prior to the TRD, were as much as 7 degrees Fahrenheit cooler than the shallow levels. The cooler temperatures at the bottom of pools provided thermal refugia for migrating adult and rearing juvenile salmonids. The change in channel geomorphology due to the altered flow regime decreased or eliminated the temperature stratification in pools, particularly in the summer and early fall months.

In addition, changes in channel structure and substrate quality have reduced total habitat areas suitable for the production of food organisms, primarily benthic macroinvertebrates (insects). Production of benthic macroinvertebrates takes place on the submerged portions of a streambed (Frederiksen, Kamine, and Associates 1980). Substrate quality and particle size within the streambed can greatly influence the production of benthic macroinvertebrates. Boles (1980) documented an increase in productivity, biomass, and diversity of benthic organisms following the “flushing” of granitic sand from a riffle in the Junction City reach of the Trinity River. However, the EIS noted that based on investigations of macroinvertebrate production in the Trinity compared with other basins, benthic food production does not appear to be a major factor in limiting fish production in the mainstem Trinity at the current time (US FWS and HVT 1999, App. B-13)

<u>Tributary impairment:</u>
Many of the middle basin tributaries presently or historically contain salmonid habitat, particularly in the lower gradient reaches. As discussed in the fisheries section (2.2), steelhead are the most abundant of the salmonids in the tributaries followed by chinook then coho. LaFaunce (1965) reported spawning chinook salmon in Rush, Reading, Brown’s and Canyon Creeks in the Middle Basin. Most of these tributaries have been subjected to some form of habitat modification, including historic hydraulic mining, water diversion, road construction and timber harvesting continuing through the present. Unfortunately, aquatic habitat conditions and potential limiting factors in the tributaries are not nearly as well studied as in the mainstem.

De la Fuente et al. (2000) determined that Weaver and Rush Creeks are impaired (Category III) based on an analysis of the stream and watershed condition indicators. The water quality and channel conditions

in Weaver and Rush Creeks were rated as functioning at risk and the watershed hazard condition was high. The same assessment determined that Brown's Creek was in a moderate (Category II) condition. In other words, physical and biological conditions suggest that aquatic and riparian systems are at risk in being able to support dependent species and retain beneficial uses of water.

Numerous studies have identified and evaluated sediment sources and delivery from Grass Valley Creek (GVC) which is considered to be the primary producer of sand-size sediment to the mainstem. As a result, the TRRP supported the development of an extensive erosion control program including: 1) Construction of the Buckhorn Debris Dam in 1990 to trap sediment; 2) Construction of Hamilton Ponds in 1984, 1988-89 to trap sediment close to the mouth of the GVC before entering the mainstem; 3) Bureau of Land Management aquired 17,000 acres of highly eroded private timberland for restoration purposes; and 4) extensive erosion control program largely implemented by the Trinity County Resource Conservation District and the Natural Resource Conservation Service that continues today.

Based on a survey initiated by Pacific Watershed Associates (2000) in 1992, stream channel conditions in GVC appeared to be improving (pools were more common, larger and deeper; substrate was more coarse; and channel complexity increased). Since GVC is a transport dominated system (PWA 2000), most of the sediment produced from GVC is transported to the mainstem, aside from what is trapped in the sediment retention basins. Even though sediment production has decreased (perhaps by as much as one fifth of estimates made prior to Buckhorn dam construction (PWA 2000)), GVC appears to continue discharging sand-size sediment in quantities that are impacting the mainstem. GMA (2001a) found that substrate samples taken at Poker Bar, below the confluence of GVC with the mainstem, contained excessive levels of sand-size particles (64% <5.6mm) compared to other mainstem sampling sites.

GMA (2001a) found that permeability levels in several of the Tributaries were quite low (98cm/hr in Reading Creek; 258 cm/hr in Indian Creek; 363 cm/hr in Rush Creek; 521 cm/hr in Canyon Creek) indicative of low survival rates of salmonids.

Habitat Conditions in Lower Middle Assessment Area

The lower middle assessment area generally consists of relatively steep gradient (i.e. sediment transport) stream reaches and rugged terrain, much of which lies within the Trinity Wilderness area. Although land management disturbance is minimized in much of the area due to the Wilderness designation, a large wildfire, termed the Big Bar Complex, burned close to 80,000 acres (53%) of the New River watershed in August, 1999. Thus far, the fire has not resulted in a significant impact to the aquatic ecosystem, in part due to mild winters since the fire. Fortunately, the majority of the acres burned (72%) were categorized in the low to moderate range of intensity whereby perennial plants with thicker bark generally survive. However, the burned area does create significant future risk to the existing good health of the New River should a major storm event occur while the landscape is not fully revegetated and is susceptible to erosion.

<u>Healthy Subwatersheds</u>:
The New River, North Fork Trinity, East Fork North Fork, Big French Creek and Manzanita Creek, all major tributaries to the lower-middle mainstem, are presently considered "properly functioning" with regard to aquatic habitat and watershed conditions (De la Fuente 2000). The North Fork and New River are identified as tier one "Key Watersheds" according to the Aquatic Conservation Plan contained in the Northwest Forest Plan (USDA and USDI 1994). Key watersheds are intended to provide refugia that are crusial to at-risk fish species and stocks and provide high quality water. One key indicator of healthy aquatic conditions in these tributaries is the relatively strong trend in summer steelhead populations in the New River and North Fork Trinity since the 1970's. As discussed in the fisheries section above,

summer steelhead populations ranging between 300 and 800 in the New River make it one of the larger populations in California (USFS 2000a, p.4-11). The USFS estimates similar population sizes for the North Fork Trinity through the decade of the 1990s.

Aquatic habitat surveys conducted sporadically since the 1970's and 1980's generally characterize instream and riparian habitat in the New River as good to excellent, despite the high level of historic mining activity (USFS 2000a, p.4-12). Following the 1999 Big Bar fire, the USFS (2000d) found that stream conditions in reaches influenced by the fire are not significantly different than reference streams with regard to pebble counts, large woody debris, width to depth ratios, entrenchment ratios, pools and shade, based on surveys conducting using the Stream Condition Inventory protocol (USFS 1998). In addition, De la Fuente et al. (2000) classified both the New River and North Fork as properly functioning with regard to the "expression" indicators as part of the watershed condition assessment.

Big French Creek and Manzanita Creek are also considered to be in a properly functioning condition (De la Fuente 2000). As a relatively undisturbed, wilderness watershed, the USFS (1989) recommended that Big French Creek serve as an index steelhead stream and not be subject to any habitat modification projects for comparison purposes with more intensively managed streams.

Impaired areas:
Canyon Creek: According to De la Fuente et al. (2000), Canyon Creek is at risk with regard to several aquatic habitat indicators including water quality, stream vegetation, channel stability and aquatic integrity. The present unstable channel conditions in Canyon Creek are largely due to intensive historic mining activity and other land use activities for several miles along the lower mainstem which is easily accessible via a primary road (pers. comm. Loren Everest). Conversely, other tributaries in the lower-middle area are relatively difficult to access and have not experienced the same level of disturbance as in Canyon Creek. In a habitat typing report, the USFS (1989) identified spawning gravel degradation due to fine sediments, particularly within the lower two reaches, and specific incidents of suspended sediments resulting from dredging activities.

Lower-Middle mainstem area: Quihillalt (1999) indicated that suction dredge mining pressure in high-density redd habitats could impact the survival of incubating chinook salmon eggs particularly between Big Bar Creek and Little Swede Creek. Suction dredging activity may affect the viability of spawning redds on the Trinity river by altering the stability of spawning gravels. Although dredge tailings may be attractive sites for redd construction because they provide loose, appropriately sized gravel near riffle crests where fish frequently spawn, embryos in tailings may suffer high mortality due to scouring during high flows (Harvey et al. 1998).

Habitat condition data in many of the smaller tributaries in the Lower Middle Area were not available. However, the sediment source analysis (chapter 4) indicates that some of these tributaries have high percentages of legacy or management-related sediment delivery, compared to background, and consequently may be exhibiting a high risk of watershed disturbance.

Habitat Conditions in Lower Assessment Area:

The lowest area includes the tributary watersheds and mainstem Trinity outside of the Hoopa Valley Tribal reservation.

Healthy Subwatersheds:
Horse Linto Creek is a designated Tier-1 Key watershed, according to the Northwest Forest Plan, which is intended to serve as refugia for maintaining and recovering habitat for at-risk stocks of anadromous

salmonids (USDA and USDI 1994). The USFS (2000b, p.3-175) characterized the health of the Horse Linto watershed as properly functioning, according to the methodology to determine environmental baseline conditions (NMFS 1996). This methodology considers several variables including: water quality, habitat access, habitat elements, channel condition and dynamics, flow/hydrology and watershed conditions. Horse Linto Creek has been in a gradual state of recovery since the 1964 flood severely impacted channel conditions. The USFS has contributed to the recovery effort by establishing instream habitat structures, operating a chinook rearing "hatchbox" facility, and decommissioning high impact roads (USFS 2000b). Recent sediment and habitat monitoring (e.g., V*, turbidity) data from the USFS indicate relatively healthy habitat conditions that can serve as a "reference" watershed for the Trinity Basin.

It is not clear to what degree the Meagram fire that occurred in 1999 will affect anadromous fish and associated aquatic habitat. Two mild winters since the fire has had a minimal effect on aquatic habitat condition. However, one can expect increased erosion and change in the hydrology of the watershed due to the changes in vegetation caused by the fire. The full effect of the impact to environmental baseline conditions may not be evident for several years depending on the severity of storm events and natural recovery processes in the future.

Impaired areas:
Both Campbell Creek and Willow Creek have experienced more intensive land management than Horse Linto Creek in recent decades which has impacted aquatic habitat conditions. The USFS has designated Campbell Creek as "not properly functioning" with regard to sediment/turbidity, disturbance history and riparian reserves, according to an assessment of environmental baseline conditions required under Endangered Species Act consultations (matrix from USFS, no date). Similarly, the USFS determined that Willow Creek is at risk for several indicators including sediment/turbidity, substrate and watershed conditions.

Mill Creek and Tish Tang Creek, lower basin tributaries that flow for the most part through the Hoopa Valley tribal reservation, are also considered more heavily impacted by sediment than Horse Linto Creek. Although all three of the tributaries were heavily impacted by the 1964 flood, Mill Creek and Tish Tang Creek have not recovered as rapidly as Horse Linto due, in part, to subsequent road building and timber harvesting (USFS 2000b).

CHAPTER 3

STREAM HABITAT INDICATORS

This chapter identifies freshwater habitat indicators that are more specific to the Trinity River and generally more quantifiable than the water quality standards for sediment contained in the Basin Plan (see section 2.1). They are interpretations of the water quality standards expressed in terms of instream and watershed conditions. For each indicator, a numeric or qualitative target value is identified to define the desired condition for that indicator. EPA expects that these indicators, and their associated target values, will provide a useful reference in determining the effectiveness of the TMDL in attaining water quality standards, although they are not directly enforceable by EPA.

No single indicator adequately describes water quality related to sediment, so a suite of instream and watershed indicators is identified. Because of the inherent variability associated with stream channel conditions, and because no single indicator applies in all situations, attainment of the targets is intended to be evaluated using a weight-of-evidence approach. When considered together, the indicators are expected to provide good evidence of the condition of the stream and attainment of water quality standards.

In addition to instream indicators, we are including watershed indicators in this TMDL because watershed indicators focus on imminent threats to water quality that can be detected and located before the sediment is actually delivered to the stream, and because watershed indicators are often easier to measure than instream indicators. These watershed indicators are established to identify conditions in the watershed needed to protect water quality. They are set at levels associated with well-functioning watersheds.

Watershed indicators assist with the identification of threats to water quality for both temporal and spatial reasons. Watershed indicators reflect conditions in the watershed at the time of measurement, whereas instream indicators can take years or decades to respond to changes in the watershed, because linkages between hillslope sediment production and instream sediment delivery are complicated by time lags from production to delivery, instream storage, and transport through the system. Also, watershed indicators tend to reflect local conditions, whereas instream indicators often reflect upstream watershed

conditions as well as local conditions. Thus, watershed indicators help to identify more prospectively conditions in the watershed needed to protect water quality.

The indicators and associated targets for the Trinity River TMDL are divided between geomorphology-related targets that apply to the upper middle mainstem reach, based largely on the TRFE, and other sediment-related targets that apply throughout the Trinity River network, including tributaries.

3.1. Upper Middle Mainstem Geomorphic Indicators and Targets:

EPA is establishing distinct indicators and targets for the upper middle mainstem for several reasons: (1) the geomorphology of the middle mainstem functions as an alluvial floodplain as opposed to steeper gradient, transport reaches in many of the tributaries; (2) the middle mainstem channel is highly altered due to the operation of the TRD; (3) the middle mainstem is more extensively studied than other areas of the basin; and (4) the Trinity Management Council (TMC) is developing a unique suite of hypotheses for the middle mainstem as part of the Adaptive Management Program component of the ROD for the TRRP. These hypotheses for sediment-related features such as geomorphology, substrate quality and mobility, can serve as TMDL indicators and targets for middle mainstem.

The establishment of TMDL target conditions for the mainstem alluvial reach below Lewiston is based largely on the attributes of a healthy alluvial river developed by McBain and Trush (1997) and later incorporated into the Trinity River Mainstem Fishery Restoration EIS/EIR (US FWS and HVT 1999). The ten attributes, which were developed specifically for the Trinity River, describe the geomorphic environment and processes of a healthy alluvial river. The attributes were developed based on a comparison of pre- and post-dam conditions using aerial photographs and examining sediment budgets, riparian community, and channel characteristics in the basin. Table 3-1 on the following page identifies the sediment related indicators, target condition, and relationship to beneficial use for the middle mainstem.

The Trinity Management Council (TMC) and associated subcommittees are in the process of developing specific hypotheses and thresholds for each indicator through the Trinity River Adaptive Environmental Assessment and Management (AEAM) program. The AEAM program consists of the following components: "(1) defines goals and objectives in measurable terms; (2) develops hypotheses, builds models, compares alternatives, and designs system manipulations and monitoring programs for promising alternatives; (3) proposes modifications to operations that protect, conserve and enhance the resources; and (4) implements monitoring and research programs to examine how selected management actions meet resource management objectives. The intention of the AEAM program is to provide a process for cooperative integration of water-control operations, resource protection, monitoring, management, and research." (US FWS and HVT 1999,N-2).

Because the hypotheses and thresholds are still under development, EPA is identifying the broader characteristics of alluvial rivers in Table 3-1 as the indicators and targets for the TMDL. However, a workgroup of the TMC has drafted a list of potential hypotheses some of which correspond very well with sediment-related numeric targets within the TMDL context for the middle mainstem. EPA endorses testing of specific hypotheses through the AEAM process, the results of which can serve to refine the indicators and targets for the middle mainstem reach of the Trinity River.

The existing condition of the middle mainstem relative to these targets is summarized in 2.4. Habitat Conditions in the Trinity River Watershed. For more quantitative analysis of the conditions, refer to McBain and Trush (1997), US FWS and HVT (1999), and/or US FWS (1999) .

Table 3-1. Geomorphic Indicators, Targets and Beneficial Use Relationship for the Upper Middle Mainstem (adapted from TRMFR EIS table 3-1, US FWS (1999)

Indicator	Target Condition	Beneficial use relationship
Spatially complex channel geomorphology (Attribute #1): The sum of channel segments provides high-quality habitat for all life stages of native species.	- Restore alluvial channel (self-forming bed particle and bank dimensions). - Create and/or maintain structural complexity of alternate bar sequences. - Create and maintain functional floodplains - Increase diversity of channelbed particle size. - Greater topographic complexity in side channels.	Diverse salmonid habitat available for all life stages over a wide range of flows.
Frequently mobilized channelbed surface (Attribute #3): Channelbed framework particles of coarse alluvial surfaces are mobilized by the bankfull discharge, which on average occurs every 1-2 years.	- Achieve incipient motion for most of channelbed surface (riffles, face of point bars). Flow: >6,000 cfs every 2 or 3 years; - Exceed incipient motion for mobile active channel alluvial features (median bars, pool tails, spawning gravel deposits). Flow: > 3,000 cfs every 2 or 3 years. - Exceed threshold for transporting sand through most pools. Flow: > 3,000 cfs every 2 or 3 years.	Higher egg and alevin survival due to reduced fine sediment in redds. Greater substrate complexity, increasing macroinvertebrate production, and creating deeper pool depths for adult fish cover and holding.
Periodic channelbed scour and fill (Attribute #4): Alternate bars are scoured deeper than the coarse surface layer by floods exceeding 3-5 year annual maximum flood recurrences.	- Scour/redeposit faces of alternate bars (at least to D_{84}). Flow: > 8,500 cfs every 3-5 years. - Maintain scour channels on alternate bar surfaces. Flow: > 8,500 cfs every 3-5 years. - Scour/redeposit spawning gravel deposits (at least to D_{84}). Flow: >6,000 cfs every 2-3 years. - Deposit fine sediment onto upper alternate bar and floodplain surfaces. Flow: > 6,000 cfs.	Anadromous spawning and rearing habitat. Channel-wide habitat complexity. Lower rates of riparian encroachment on alternate bars.
Balanced fine and coarse sediment budgets (attribute#5): River reaches export fine and coarse sediment at rates approximately equal to sediment inputs.	- Reduce fine sediment storage in mainstem, particularly sand size particles (<2mm) which may prevent emergence of alevins. Flow: Qualitative based on fine sediment budget. - Maintain coarse sediment budget in the mainstem. Flow: Qualitative based on coarse sediment budget. - Route mobilized D_{84} through alternate bar sequence. Flow: 6,000 cfs every 2-3 years. - Prevent excessive aggradation of tributary-derived material in mainstem. Flow: 6,000-14,000 cfs every 2-3 years.	Improved spawning, rearing and overwintering habitat. Reduced riparian fossilization. Maintenance of habitat complexity
Periodic channel migration (Attribute #6): The channel migrates at variable rates and establishes wavelengths consistent with regional rives with similar conditions.	- Create channel avulsions every 10 years. Flow: 30,000 cfs every 10 years. - Channel migrates in alluvial reaches. Flow: 6,000cfs - Maintain channel geometry as channel migrates. Flow: 6,000cfs.	Improved habitat for developing salmon. Refugia from high-flow and high-temperature conditions.

3.2. Basin-wide Sediment Indicators and Targets

This section describes several additional sediment indicators for the Trinity River TMDL, including target values, relationship to beneficial uses, scientific references and a summary of existing conditions where available. In several cases, targets are expressed as improving trends, since thresholds specific to the Trinity River have not been developed. Table 3.3 on the following page summarizes the indicators, targets, description and purpose.

Spawning Gravel Quality

Streambed gravels naturally consist of a range of particle sizes from finer clay and sand to coarser cobbles and boulders. Kondolf (2000) described how various gravel sizes and mixtures can influence different salmonid life stages including redd construction, egg incubation and alevin emergence. In addition, interstitial spaces in clean cobble provide important cover for salmonid and other fry at a critical and vulnerable time in their life history. A variety of indicators are necessary to express the overall substrate quality relative to salmonid life stage requirements. Each indicator, target threshold and available Trinity River data are described below.

<u>Target: Improving trend (increase) in particle size distribution as measured by median particle diameter (D_{50}) and geometric mean (Dg).</u>
Median particle diameter (D_{50}) and geometric mean (Dg) are measures of the central tendency of the substrate sample and relate to the ability of salmonids to move the gravel and construct a redd. A precise target threshold is difficult to express at this point due to lack of long-term data set from the Trinity River and lack of literature relating specific thresholds to survival estimates for salmonids. However, EPA expects to D_{50} and Dg values to increase (improve) over time from baseline levels as fine sediment input is reduced, coarse gravel inputs increase, and flows increase in the Upper Middle Mainstem.

Trinity River Data: GMA (2001a) collected bulk samples of gravel substrate on several mainstem and tributary sites in the Upper Middle Assessment Area (where spawning was likely but had not yet occurred) using a 2' diameter sampler in 2000. Results of this study indicate that spawning gravel quality generally declines in a downstream direction from the mainstem spawning area just below Lewiston dam (river mile 111.5) through the study sites below each of the major tributaries (to river mile 80.3). The median particle diameter (D_{50}) and geometric mean (Dg) were lowest (3.24mm and 4.33 respectively) at the Poker Bar site followed by the Evans bar site (12.66 and 10.23 respectively). These samples contained relatively high proportion of finer grain material, likely delivered from upstream tributaries (Grass Valley Creek and Reading Creek), which is indicative of poor spawning gravel quality. The highest, better quality D_{50} and Dg values are observed at the Lewiston site where essentially all fine sediment inputs are eliminated due to the dam located immediately upstream of the sampling site and due to the mechanical introduction of spawning size gravel as part of mainstem restoration efforts.

GMA (2001a) also documented a decline in spawning gravel quality by comparing year 2000 D_{50} data with year 1992 D_{50} values from samples taken by Wilcock et al. (1995). The study indicated that D_{50} values degraded from 35 mm in 1992 to 19.9 mm in 2000 at one sample site (Table 3-2). At another sample site, the D_{50} values declined from 33 mm to 22.6 mm during the same time period. This suggests that fine sediment has increased during this period and/or flows have not been adequate to “flush” the existing sediment load, at least at the Steelbridge site, and spawning gravel quality has correspondingly declined.

Table 3-2. Comparison of D_{50} values from 1992 to 2000 indicating declining quality (GMA 2001a)

	D_{50} Values 1992 (Wilcock et al 1995)	D_{50} Values 2000 (Matthews 2001a)
Steelbridge Sample #1	35 mm	19.9 mm
Steelbridge Sample #2	33 mm	22.6 mm

Table 3-3. Sediment Indicators and Targets

INDICATOR	TARGET	DESCRIPTION	PURPOSE
Instream			
Spawning Gravel Quality	Improving Trend: $D_{50,}$ Dg ≤10% < 0.85 mm ≤15% < 2.0 mm ≤30% < 6.4 mm;	Bulk sample dry weight) during low-flow period, at riffles heads in potential spawning reaches. Methods on the mainstem should be consistent with Matthews (2001a). Discussion of indicators and targets by Kondolf (2000), Chapman (1988).	Indirect measure of fine sediment content relative to incubation and fry emergence from the redd. Indirect measure of ability of salmonids to construct redds
Permeability of spawning gravel	Improving trends (increase cm/hr)	Permeability standpipe driven into potential spawning gravel to a depth of approximately 35 cm below the bed surface (Matthews 2001a)	Measure of oxygenated water supply directly affecting salmon egg survival
Turbidity and Suspended Sediment	Turbidity ≤ 20% above naturally occurring background (Basin Plan)	Measured upstream and downstream of sediment discharging activity or between "paired" watersheds.	Indirect measure of fish feeding/growth ability related to sediment, and impacts from management activities
	Decreasing trend in days of turbidity threshold exceedance	Develop turbidity rating curve and relate to biological effects (Newcombe and Jenson 1996)	Indirect measure of chronic suspended sediment affects on fish feeding, growth, etc.
Riffle Embeddedness	≤25% or improving (decreasing) trend	Estimated visually at riffle heads where spawning is likely, during low-flow period (Flosi et al 1998)	Indirect measure of spawning support; improved quality & size distribution of spawning gravel
V*	≤0.21 (Franciscan) or <0.10 (other)	Residual pool volume. Measure during low-flow period. (Lisle and Hilton 1992)	Estimate of sediment filling of pools from disturbance
Aquatic Insect Production	Improving trends	EPT, Richness & % Dominant Taxa indices. Methods should follow CDFG-WPCL (1996).	Estimate of salmonid food availability, indirect estimate of sediment quality.
Thalweg profile	Increasing variation from the mean	Measured in deposition reaches during low-flow period.	Estimate of improving habitat complexity & availability
pool/riffle distribution & depth of pools	increasing trend toward >40% in primary pools	Trend or greater than % (by length) of primary pools, measured low-flow period.	Estimates improving habitat availability
Large Woody Debris (LWD)	increasing distribution, volume & of key pieces	Increasing number & volume of key pieces or increasing distribution of LWD-formed habitat.	Estimates improving habitat availability
Watershed Indicators			
Diversion potential & stream crossing failure potential	≤1% crossings in 100 yr storm	Conduct road inventory to identify and fix stream crossing problems (Weaver and Hagans 1994). See USDA (1999) Roads Analysis for assessing road network.	Estimates potential for reduced risk of sediment delivery from hillslope sources to the watercourse
Hydrologic connectivity of roads	Decreasing length of road	Conduct road inventory to identify and fix road drainage problems (Weaver and Hagans 1994).	Estimates potential for reduced risk of sediment delivery from hillslope sources to the watercourse
Annual road inspection & correction	Increased mileage inspected and corrected	Roads inspected and maintained, or decommissioned or hydrologically closed prior to winter- No migration barriers.	Estimates potential for reduced risk of sediment delivery from hillslope sources to the watercourse
Road location, surfacing, sidecast	Reduce density next to stream, increased % outsloped and hard surfaced roads	see text	minimized sediment delivery
Activities in unstable areas	avoid and/or /eliminate	Subject to geological/geotechnical assessment to minimize delivery and/or show that no increased delivery would result	minimized sediment delivery from management activities
Disturbed Area	Decrease in impaired subareas	Disturbed area is area covered by roads, landings, skid trails, agriculture, etc.	Correlated with suspended sediment (Lewis 1998)

Percent Fines < 0.85 mm: <10%
The percent fines <0.85 mm is defined as the percentage of subsurface fine material in pool tail-outs < 0.85 mm in diameter. This indicator and target represent adequate spawning, incubation, and emergence conditions relative to substrate composition. Excess fine sediment can decrease water flow through salmon redds. Sufficient water flow is critical for maintaining adequate oxygen levels and removing metabolic wastes. Deposits of these finer sediments can also prevent the recently hatched fry from emerging from the redds, resulting in entrapment. Monitoring should be conducted by bulk sampling during low-flow periods at the heads of riffles, in potential spawning reaches. The numeric target for this parameter is 10% based on the following: (1) 10% is generally within the range that supports high levels of survival to emergence of salmonids (Chapman 1988); (2) 10% is achievable based on recent data collected by GMA (2001a) indicating the geologic and hydrologic conditions in the Trinity are generally capable of producing relatively small percentages of finer grain material than other Northcoastal rivers.

Trinity data: Most of the samples taken by GMA (2001a) in both the mainstem and tributaries, demonstrate that percent fines <0.85 are below threshold levels indicating that this size class may not presently be a limiting factor for salmonid production in the Upper Middle Area. Data not available for other areas of the basin.

Percent Fines 15% <2.0 mm; 30%<6.4 mm :
After hatching, alevins live within the intragravel pore space in the redd then migrate upward toward the surface. The presence of excessive sand size particles can result in the "capping" of the redd and prevent emergence of alevins (Phillips et al. 1975). EPA has selected sand sized particles (approximately 2.0mm), which is particularly representative of the decomposed granitic terrain in the Upper Middle Assessment Area, and fine sediment (6.4 mm) as additional surrogate measurements of spawning gravel quality. The target thresholds of 15% for particles less than 2.0mm and 30% for particles less than 6.4mm sizes are based on literature relating size classes survival to emergence (summarized in Chapman 1988, and Kondolf 2000) and were shown to be achievable at many of the GMA (2001a) sampling sites.

Trinity Data: The Poker Bar site (river mile 102.7), just below the confluence of Grass Valley Creek, contained high levels (30%) of sand size particles (<2.0 mm) and approximately 65% of size class 5.6 mm (GMA 2001a). These values indicate a relatively low chance of survival to emergence under these excessive fine sediment conditions in this reach. In addition, this suggests that erosion control efforts are still necessary in Grass Valley Creek to reduce the supply of sand-sized sediment. Most of the other mainstem sampling sites (besides Lewiston which was significantly below) were very close to the 30% threshold, indicating that this size class is potentially a limiting factor salmonid production throughout the middle mainstem.

Riffle Embeddedness

Target: <25% or improving (decreasing) trend
Embeddedness is a measure of fine sediment that surrounds and packs-in gravels. A heavily embedded riffle section may limit the ability of an adult female to construct a redd. When constructing its redd, generally at a pool tail-out (or the head of the riffle), the spawning fish essentially slaps its tail against the channel bottom, which lifts unembedded gravels and removes some of the fine sediment. This process results in a pile of cleaner and more permeable gravel, which is more suited to nurturing of the eggs. Embedded gravels do not generally lift easily, which prevents spawning fish from building their redds. Flosi et al. (1998) suggest that gravels that are less than 25% embedded are preferred for spawning. This target should be estimated during the low-flow period, generally at riffle heads, in potential spawning reaches.

Trinity Data: The USFS has collected embeddedness data in various tributaries throughout the Trinity Basin following the Stream Condition Inventory methodology (USFS 1998) which is different than the

methodology used by the CDFG. The USFS conducts a modified Wolman pebble count to determine a percentage of the gravel and cobble that are considered embedded (defined as >50% covered in fine material)(USFS 2000d). Alternatively, the CDFG (1998) samples five small cobbles at pool tail-outs and estimates the amount (percent) of the stone buried in the sediment to determine an average cobble embeddednes rating. Due to these differences, data are not comparable. Since the USFS manages the majority of land in the Trinity Basin, it may be advisable to determine an embeddedness threshold based on the USFS monitoring protocol, which presently is not available.

The Forest Service found a range of 5 to 44 percent of the gravel or cobble in the New River, including tributaries, were embedded more than 50%. Recent samples from Manzanita Creek, North Fork Trinity, Canyon Creek, Eagle Creek and Halls Creek all show seemingly low percentages of embeddedness (USFS data sheets 2001).

V*

Target: <0.21 (Franciscan geology) or <0.10 (stable geology)
V* is a measure of the fraction of a pool's volume that is filled by fine sediment, and represents the in-channel supply of mobile bedload sediment (Lisle and Hilton 1992). It reflects the quality of pool habitat, since a lower filled pool volume reflects deeper, cooler pools offering protection from predators, a food source, and resting location. Lisle and Hilton (1992) also describe methods for monitoring, which should be conducted in low-flow periods. V* is not appropriate for large rivers, but in large river systems it is appropriate for tributaries. The target of V* values less than .21 (Franciscan geology) is based on Knopp (1993).

Trinity Data: Lisle and Hilton (1992) measured residual pool volumes in the Big French, Horse Linto, Three Creeks and Grass Valley Creek watersheds. The study reach in each creek consisted of between 13 and 21 pools. Big French Creek and Horse Linto Creek, both reference streams, had a average V* value of 0.04 and 0.12 respectively, indicative of very low sediment yields. Grass Valley Creek had an average V* of 0.50, indicative of high yields.

Aquatic Insect Production

Target: improving trends in EPT, % dominant taxa and species richness indices
Benthic macroinvertebrate populations are greatly influenced by water quality and are often adversely affected by excess fine sediment. This TMDL recommends several indices be calculated, following the CDFG Water Pollution Control Laboratory Stream Bioassessment Procedures (1996).

1) EPT Index. The EPT Index is the number of species within the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT), more commonly known as mayflies, stoneflies and caddisflies. These organisms require higher levels of water quality and respond rapidly to improving or degrading conditions.
2) Percent Dominant Taxa. This index is calculated by dividing the number of organisms in the most abundant taxa by the total number of organisms in the sample. Collections dominated by one taxa generally represent a disturbed ecosystem.
3) Richness Index. This is the total number of taxa represented in the sample. Higher diversity can indicate better water quality.

Trinity Data: Boles (1980) documented an increase in productivity, biomass, and diversity of benthic organisms following the "flushing" of granitic sand from a riffle in the Junction City reach of the Trinity River. However, the TRMFR EIS noted that based on investigations of macroinvertebrate production in the Trinity compared with other basins, benthic food production does not appear to be a major factor in limiting fish production in the mainstem Trinity at the current time (US FWS 1999, App B-13).

Turbidity and Suspended Sediment

Target: <20% above naturally occurring background levels; and Decreasing trend in number of days in which a turbidity threshold is exceeded

Turbidity is a measure of the ability of light to shine through water (with greater turbidity indicating more material in the water blocking the light). Although turbidity levels can be elevated by both sediment and organic material, in California's North Coast stream turbidity levels tend to be highly correlated with suspended sediment. High turbidity in the stream affects fish by reducing visibility, which may result in reduced feeding and growth. Elevated suspended sediment, particularly over a long period, may also result in direct physical harm, for example, by clogging gills. The deleterious effects on salmonids were found not only to be a function of concentration of fine particles but also a function of duration of exposure. Chronic turbidity can also reduce productivity by impeding photosynthesis.

Sigler et al (1984) found that as little as 25 NTUs of turbidity caused a reduction in fish growth. The North Coast Basin Plan presently stipulates that turbidity shall not be increased more than 20 percent above naturally occurring background levels by an individual activity. This indicator should be measured during and following winter storm flows, and upstream and downstream of a management activity to compare changes in the turbidity levels that are likely attributable to that activity. Information should include both magnitude and duration of elevated turbidity levels.

The number of days per year in which a turbidity threshold is exceeded is another important expression of the effects of turbidity on salmonids. For a stream where suspended sediment or turbidity monitoring has taken place, a rating curve that relates suspended sediment or turbidity to an exceedance probability can be developed based on the relationship developed between suspended sediment or turbidity to stream flowrate. This rating curve shows the likelihood of the exceedance of a given suspended sediment concentration or turbidity for a given site specific data set. Turbidity and/or suspended sediment rating curves should be developed and maintained to establish temporal trends for suspended sediment and/or turbidity concentrations. Present turbidity levels and exceedance durations should be established for the Trinity River before an exceedance threshold is defined.

Trinity Data: GMA (2001b) collected turbidity and suspended sediment data from various tributaries (with a focus on the Upper Middle Area) during WY2000 and 2001. This data was used to determine calculate the amount of total suspended sediment transported from certain tributaries as part of the sediment budget development (Section 4.3). GMA (2001b) reported maximum turbidity values (NTU) by sampling stations according to various ranges of turbidities (e.g., <10, 10-50,...,>500). According to GMA (2001b), no sites that are considered to have little disturbance upstream were found to have NTU values exceeding 100, and most were lower than 50 during the storms in WY2000 and 2001 when data were collected. In contrast, in watersheds with high disturbance, values were typically in excess of 100 NTU, and sometimes higher. Values in excess of 500 NTU were found at Indian, Reading and Browns Creeks as well as a small creek draining the Diener Mine, southwest of Trinity Center.

The USFS (2000b, 3-149,) reports that turbidity measurements in Horse Linto Creek since the Meagram fire are mostly in the 5 to 10 NTUs with occasional spikes of 40 to 80 NTUs during high flows (and one peak of 200-300 NTUs in January, 2000). These low values provide support the consideration of Horse Linto Creek as a reference watershed.

Permeability:

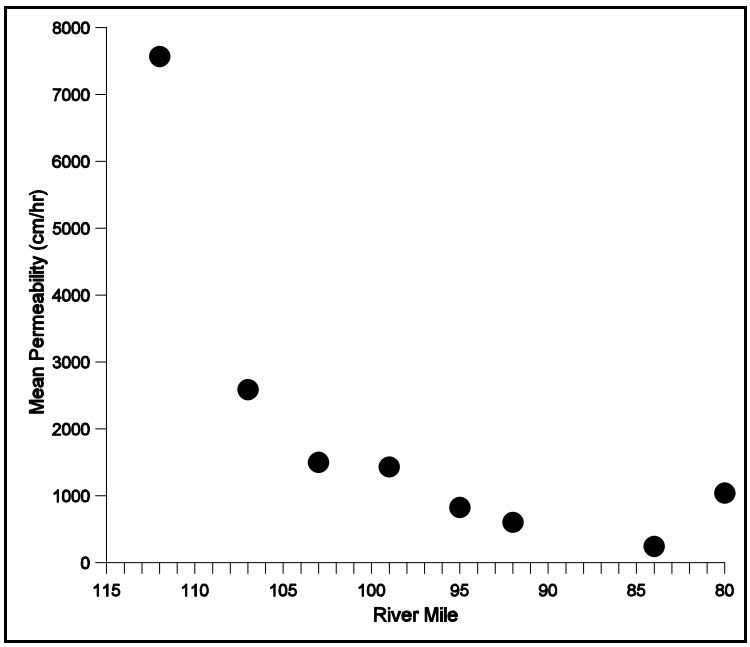
Improving trend (increasing cm/hr):

Permeability is a measure of the ease with which water can pass through gravel, thereby supplying dissolved oxygen directly to salmon eggs and facilitating the removal of metabolic waste from the egg pocket. The higher the permeability, the greater the supply of oxygenated water that can reach the salmon eggs (Terhune 1958, in McBain and Trush 2000). Fine sediment intrusion into gravel reduces permeability. Permeability is potentially an important indicator for TMDL purposes because: 1) it

measures factors that directly affect salmonid egg incubations, and 2) new techniques to measure permeability are more cost- and time-effective than other measures of spawning gravel quality (e.g., bulk samples). Since few studies have related permeability to egg survival-to-emergence (even though it is possible to design research around this question), the TMDL target for permeability at this point is an improving trend over time.

Trinity data: Similar to substrate quality, GMA (2001a) found that permeability values generally declined in a downstream direction from the Lewiston monitoring site to Junction City on the mainstem in the UMT (Figure 3-1). GMA (2001a) utilized equations presented by McBain and Trush (2000) and McCuddin (1977) to estimate chinook survival to emergence using mean site permeability. This suggests a much lower suvival percentage than suggested by the gravel distribution indexes. GMA (2001a) reports that, "permeability index drops in steps below Rush Creek, Grass Valley Creek, and to 0% survival at the Evans Bar site, suggesting deteriorating conditions due to increased fines contributed by tributaries."

Figure 3-1. Mean permeability vs. River Mile (source: GMA 2001a)



Thalweg Profile

Target: Increasing variation of elevation around the mean slope
Variety and complexity in habitat is needed to support fish at different times in the year or in their life cycle. Both pools and riffles are used through spawning, incubation of eggs, and emergence of the fry. Once fry emerge, they rest in pools and other slower-moving water, darting into faster riffle sections to feed where insects are abundant. Deeper pools, overhanging banks, or logs provide cover from predators. Measuring the thalweg profile is an indicator of habitat complexity.

The thalweg is the deepest part of the stream channel at a given cross section. The thalweg profile is a plot of the elevation of the thalweg as surveyed in a series of cross sections. Harrelson et al. (1994) provide a practical guide for performing thalweg profiles and cross sections. The profile appears as a jagged but descending line, relatively flat at pool areas, and descending sharply at cascades. The comparison between the mean slope (i.e., the overall trend of the descending stream) and the details of the slope is a measure of the complexity of stream habitats. More variability in the profile indicates more complexity in stream

habitat. Inadequate availability of pool-forming features, such as bedrock or large wood debris, can be revealed by this indicator of channel structure. Because the change in the profile will occur relatively slowly, and because not enough is yet known about channel structure to establish a specific number that reflects a satisfactory degree of variation, the target is simply an increasing trend in variation from the mean thalweg profile slope. This indicator should be measured during the low-flow period every 5-10 years, after large storm seasons.

Trinity Data: The US FWS and HVT (1999) thoroughly describes the change in middle mainstem from an alternatve bar morphology which provided velocity, substrate and topographical diversity to monotypic channel lacking such diversity. EPA refers the reader to the Trinity River Flow Study (McBain and Trush 1997) and the Trinity River Flow Evaluation Final Report (US FWS and HVT 1999) for more detail.

Pool Distribution and Depth

Target: increasing inventory of reaches which are >40% pools
Pools generally account for more than 40% of stream length in streams with good salmonid habitat (Flosi et al. 1998). Frequent pools are important for providing feeding stations and shelter, and may also serve locally as refugia. This indicator should be measured during the low-flow period every 5-10 years, after large storm seasons. Information should include length and depth of pools, and should report the number of primary pools, usually defined as pools greater than two feet in depth in 1st and 2nd order streams, and greater than three feet in depth in 3rd and 4th order streams. Backwater pools are used by salmonids as overwintering habitats (Flosi et al. 1998). In particular, they provide shelter from high storm flows. Lateral scour pools (i.e., pools formed near either bank) tend to be heavily used by fish for cover and refugia.

Trinity Data: McBain and Trush (1997) documented the change in fine sediment storage in five mainstem Trinity River pools between 1993 and 1997. Four of the five pools increased in fill material ranging from 670yds^3 to 4,050 yds^3 during this time period (p.164). The TRFE thoroughly describes the change in middle mainstem from an alternative bar morphology which provided velocity, substrate and topographical diversity to monotypic channel lacking such diversity (US FWS and HVT 1999). EPA refers the reader to the TRFE and TRMFR EIS for more detail than was provided in the description of habitat conditions (Section 2.4).

With regard to tributary pool conditions, the Shasta/Trinity National Forest has recently initiated stream condition inventories in several tributaries throughout the basin from which to establish baseline conditions for determining future trends. In addition, the USFS conducted habitat surveys in the late 1980's in some tributaries. However, EPA determined that this data was not recent enough to indicate current conditions relative to beneficial uses support.

Large Woody Debris (LWD)

Target: increasing distribution, volume and number of key pieces
California coastal streams are especially dependent on the presence of large woody debris to provide ecological functions, such as sediment metering, sediment grading, pool formation, and shelter. Large pieces of woody debris in streams influence the physical form of the channel, the movement of sediment, the retention of organic matter and the composition of the biological community (Bilby and Ward 1989). Debris can be instrumental in forming and stabilizing gravel bars (Bilby and Ward 1989, Lisle 1986, in US EPA 1999), or in accumulating fine sediment (and thereby keep it from clogging spawning areas) (Zimmerman et al. 1967, Megahan 1982, in Bilby and Ward 1989). LWD can also form pools by directing or concentrating flow in the stream in such a way that the bank or bed is scoured, or by impounding water upstream from the obstruction (Lisle and Kelsey 1982, in US EPA 1999). LWD and key pieces are found by lineal stream reach and are related to the piece diameter and length, channel gradient, and channel

width (Montgomery and Buffington 1993). LWD plays a more significant role in routing sediment in small streams than in large ones (Bilby and Ward 1989). However, it also plays a role on floodplains and in off channel wetted areas of larger streams. This indicator should be measured during the low-flow period, and should report the number and volume of key pieces or the distribution of LWD-formed habitat.

Trinity Data: The US Forest Service has begun gathering LWD data (number of pieces, size classes, lengths) following the SCI protocol (USFS 1998) in survey reaches of the North Fork and New River to determine trends following the Big Bar Fire Complex. Trends can only be determined after several more years of data collection are complete.

3.3. Watershed Indicators

Stream Crossings with Diversion Potential or Significant Failure Potential

Target: <1% of all stream crossings divert or fail as a result of a 100-year or smaller flood
Most roads, including skid roads and railroads, cross ephemeral or perennial streams. Crossings are built to capture the stream flow and safely convey it through, under, or around the roadbed. However, stream crossings can fail, adding sediment from the crossing structure (i.e., fill) or from the road bed directly into the stream. Stream crossings with diversion potential or significant failure potential are high risks for sediment delivery to streams. Stream crossing failures are generally related to undersized, poorly placed, plugged, or partially plugged culverts. When a crossing fails, the total sediment volume delivered to the stream usually includes both the volume of road fill associated with the crossing and sediment from collateral failures such as debris torrents that scour the channel and stream banks. Diversion potential is the potential for a road to divert water from its intended drainage system across or through the road fill, thereby delivering road-related sediment to a watercourse. The potential to deliver sediment to the stream can be eliminated from almost all stream crossings by eliminating inboard ditches, outsloping roads, or installing rolling dips (US EPA 1998). Less than 1% of stream crossings have conditions where modification is inappropriate because it would endanger travelers or where modification is impractical because of physical constraints.

Trinity data: A recent road inventory conducted as part of the Five County Salmon Conservation Program ("Five County Program") identified 787 stream crossings, out of a total of 1195 sites, as potential sediment delivery sites from county roads throughout Trinity County (PWA 2001). Several of the stream crossing sites are located on key tributary streams including Canyon Creek Road (49 sites), Coffee Creek Road (42 sites), Indian Creek Road (52 sites), Deadwood Creek Road (34 sites), Rush Creek Road (40 sites). The total potential sediment yield from the Trinity County road sites is approximately 650,963 (PWA 2001).

As part of the USFS watershed condition assessment, De la Fuente et al. (2000) calculated several road related values which illustrate which subwatershed areas represent higher road hazard potential with regard to sediment delivery. Table 3-4 contains the several road-related indicators and associated values including the composite rating of road hazard potential. Although the data do not reflect the quality of stream crossings (i.e., number of diversion potentials), it does illustrate that certain watershed areas consist of relatively high numbers and densities of stream crossings which generally correlates with a higher sediment delivery risk. The subwatersheds in Table 3-4 are listed from lowest to highest based on their composite rating of road hazard potential.

Table 3-4. Summary of Selected Road Hazard Indicators from Lowest Composite Rating Hazard Potential to Highest (Adapted from De la Fuente 2000)

Subwatershed Area	Road miles on steep slopes (slopes >45%)	Stream Buffer Road Density (mi/mi^2)	Density of road/stream intersects (# per mi^2)	Composite rating of road hazard potential
North Fork	16	0.15	0.38	12
Coffee Creek	6	0.26	0.62	19
New River	36	0.26	0.76	20
Lower Trinity	42	0.55	1.39	39
Trinity - SF to Tish Tang	78	0.48	1.00	41
Brown's Creek	16	0.83	1.61	56
Stuart Fork	8	0.88	2.00	57
Canyon Creek	33	0.82	2.22	59
Trinity - New River to South Fork	22	0.77	1.66	63
Mainstem Trinity	39	0.84	1.61	65
East Fork	30	0.96	1.95	75
Trinity Reservoir	33	1.34	3.78	91
Weaver-Rush	13	1.65	3.61	104

Hydrologic Connectivity

Target: decreasing length

A road is hydrologically connected to a stream when the road drains water directly to the stream. A hydrologically connected road increases the intensity, frequency, and magnitude of flood flows and suspended sediment loads in the adjacent stream, which can result in destabilization of the stream channel. This can have a devastating effect on salmonid redds and growing embryos (Lisle 1989). The connectivity can be reduced by outsloping roads, creating road drainage that mimics natural drainage as much as possible, and other factors (USDA 1999, Weaver and Hagans 1994).

The reduction of road densities and the reconstruction of roads to reduce the use of inboard ditches, for example, can reduce the amount of water that is directly delivered to watercourses, including any associated sediment load. Current research appears insufficient to identify a specific target, so this TMDL calls for a reduction in the hydrologic connectivity of roads to watercourses.

Trinity Data: The USFS has assessed the potential for an altered hydrologic regime (changes in timing, magnitude, duration and spatial distribution of runoff flows) and stream diversion associated with roads as part of the Road Hazard Potential indicator in their Watershed Condition Assessment. Specifically, they examined the road network in relation to slope position, slope gradient, proximity to stream channels, number of stream crossings and density within watershed assessment areas. The composite rating of road hazard potential for each watershed is displayed in Table 3-4 above. The higher rating represents a higher potential hazard for hydrologic change associated with roads.

As part of the Five County Program, PWA (2001) estimated that approximately 95,087 yds^3 of sediment represent "persistent surface erosion" from all the county road sites identified.

Annual Road Inspection and Correction

Target: decreasing road length next to streams, increasing proportion outsloped or hard surfaced roads
EPA's analysis indicates that in watersheds with road networks that have not experienced excessive road-related sedimentation, roads are either (1) regularly inspected and maintained; (2) hydrologically maintenance free (i.e., they do not alter the natural hydrology of the stream); or (3) decommissioned or hydrologically closed (i.e., fills and culverts have been removed and the natural hydrology of the hillslope has largely been restored). If not, they are potentially large sources of sediment (D. Hagans, pers. comm., 1998, in EPA 1998). In general, road inspection should be undertaken annually, and could in most cases be accomplished with a windshield survey. The areas with the greatest potential for sediment delivery should be corrected prior to the onset of winter conditions. This target calls for an increase in the proportion of roads that are either (1) inspected annually and maintained prior to winter, (2) hydrologically maintenance free, or (3) decommissioned or hydrologically closed, until all roads in the Trinity River watershed fall into one of these categories.

Trinity Data: The US Forest Service has acknowledged that funding for road inspection and maintenance is well below the demand on the expansive federal forest road network nationwide. The Six Rivers National Forest has conducted extensive road inventories throughout the Lower Assessment Area. A transportation strategy was developed for Horse Linto Creek, Mill Creek and Tish Tang Creek in 1997. 23 miles (19%) of the road network in Horse Linto Creek has been decommissioned or placed in a hydrologically maintenance free condition (USFS 2000b). EPA was not able to ascertain the degree to which other federal and non-federal roads throughout the Trinity Basin are inspected and maintained. However, based on the road-related sediment problems identified by GMA (2001b) and the Five County Program (PWA 2001), it appears that annual road inspections on both federal and non-federal land are lacking in many areas.

Road Location, Surfacing, Sidecast

Target: prevent sediment delivery
This indicator is intended to address the highest risk sediment delivery from roads not covered in other indicators. Roads located in inner gorges and headwall areas are more likely to fail than roads located in other topographic locations. Other than ephemeral watercourses, roads should be removed from inner gorge and potentially unstable headwall areas, except where alternative road locations are unavailable and the road is clearly needed. Road surfacing and use intensity directly influences sediment delivery from roads. Rock surfacing or paving is appropriate for frequently used roads. Sidecast on steep slopes can trigger earth movements, potentially resulting in sediment delivery to watercourses. These factors reflect the highest risk of sediment delivery from roads, and should be the highest priorities for correction (C. Cook, M. Furniss, M. Madej, R. Klein, G. Bundros, pers. comm., 1998, in EPA 1998).

This target calls for several things: (1) all roads alongside inner gorge areas or in potentially unstable headwall areas are removed unless alternative road locations are unavailable and the need for the road is clearly justified; (2) road surfacing, drainage methods, and maintenance are appropriate to their use patterns and intensities; and (3) sidecast or fill on steep (i.e., greater than 50%) or potentially unstable slopes, that could delivery sediment to a watercourse, are pulled back or stabilized.

Trinity Data: De la Fuente (2000) evaluated the number of miles of roads located on steep slopes (>45%) within each sub-basin as part of the watershed condition assessment (Table 3-4). Roads located in these sensitive areas should be prioritized for further evaluation to determine degree of sediment delivery risk.

Activity in Unstable Areas

Target: avoid or eliminate, unless detailed geologic assessment by a certified engineering geologist concludes there is no additional potential for increased sediment loading

Unstable areas are those areas that have a high risk of landsliding, including steep slopes, inner gorges, headwall swales, stream banks, existing landslides, and other locations identified in the field. Any activity that might trigger a landslide in these areas (e.g., road building, harvesting, yarding, terracing for vineyards) should be avoided, unless a detailed geologic assessment by a certified engineering geologist concludes there is no additional potential for increased sediment loading. An analysis of chronic landsliding in the Noyo River basin indicated that landslides observed on aerial photographs largely coincide with predicted chronic risk areas, including steep slopes, inner gorges and headwall swales (Dietrich et al. 1998). Several other studies have shown that landslides are larger or more common in some harvest areas, particularly in inner gorges (US EPA 2000). Weaver and Hagans (1994) also suggest methods for eliminating or decreasing the potential for road-related sediment delivery.

Disturbed Area

Target: decrease

Studies in Caspar Creek indicate that more disturbed areas have higher suspended sediment discharge rates (Lewis 1998). In addition, studies in Caspar Creek indicate that clearcutting causes greater increases in peak flows (and, by extension, increased suspended sediment loads) than does selective harvest (Ziemer 1998). As with the "hydrologic connectivity" target, increases in peak flows, annual flows, and suspended sediment discharge rates negatively affect the potential survivability of ova in redds (Lisle 1989).

Available information is insufficient to identify a threshold below which effects on the Trinity River watershed would be insignificant. Accordingly, the target calls for a reduction in the amount of disturbed area. In this context, "disturbed area" is defined as the area covered by management-related facilities of any sort, including: roads, landings, skid trails, firelines, harvest areas, animal holding pens, and agricultural fields (e.g., pastures, vineyards, orchards, row crops, etc.). The definition of disturbed area is intentionally broad to include managed agricultural areas, such as pastures and harvest areas, where the management activity (e.g., logging or grazing) results in removal of vegetation sufficient to reduce significantly important rainfall interception and soil protection functions. Agricultural fields or harvest areas in which adequate vegetation is retained to perform these ecological functions can be excluded from consideration as disturbed areas. Dramatic reductions in the amount of disturbed area, then, can be made by reducing road densities, skid trail densities, clearcut areas, and other management-induced bare areas.

Trinity Data:

GMA (2001b) determined the amount of timber harvest area by decade by each assessment area which is an indicator of the level of disturbance that has occurred between these area (summarized in Table 3-5). Of course, timber harvest is just one indicator of disturbance in addition to road construction, mining, etc. The sediment source analysis (chapter 4) provides a quantitative evaluation of the sediment delivery rates associated with the various management-related and background sources.

Table 3-5. Timber Harvest Area (acres) by Decade within each Assessment Area (source: GMA 2001b).

Harvest Area by Decade	Upper Trinity		Upper Middle Trinity		Lower Middle Trinity		Lower Trinity	
	acres	percent	acres	percent	acres	percent	acres	percent
1940	9,331	6%	351	0.2%	103	0.2%	1,035	30%
1950	24,019	15%	39,302	29%	6,069	10%	16,269	30%
1960	34,626	22%	15,094	11%	13,905	24%	23,407	43%
1970	56,917	36%	18,673	14%	29,643	50%	11,433	21%
1980	13,885	9%	25,693	19%	4,086	7%	0	0
1990	17,816	11%	34,465	26%	5,157	9%	1,875	4%
Total	**156,595**	**35%**	**133,577**	**65%**	**58,963**	**13%**	**54,020**	**28%**

CHAPTER 4

SEDIMENT SOURCE ANALYSIS and BUDGET

The purpose of the sediment source analysis is to identify the various sediment delivery processes and sources in the watershed and to estimate the sediment yield from those sources. A sediment budget is an accounting of the sources as well as the storage and transport of sediment out of a drainage basin. This chapter summarizes the methodology (section 4.1) and results (section 4.2) of the sediment source analysis and sediment budget calculations (section 4.3), based largely data compiled by GMA (2001b). The results of the sediment source analysis (expressed in tons per square mile per year (t/mi2/yr)), including the amount of sediment delivered from each management-related source category (e.g., roads, timber harvest, legacy mining) and background source categories are summarized in Tables 4-2, 4-3, 4-4, 4-5 according to subareas within each assessment area.

4.1 Sediment Source Analysis Methods

The sediment source analysis consisted of the following components to quantify the rates of sediment yield from management and background source categories that have occurred in the recent past: landslide mapping, field plot inventory, surface and gully erosion estimates, legacy (i.e., abandoned roads and historic mining activity) erosion estimates, and bank erosion estimates.

Landslide Mapping

The relative importance and contribution of landslide-generated sediment was estimated based on air photo and field estimates of volumes of sediment introduced into streams by landslides over the duration of the air photo record (1944 to 2000). Measurements made during the landslide inventory were used to estimate the sediment contribution of both management (primarily timber harvesting and road building) and non-management or natural sources that appear to be associated with landslide activity. The landslide inventory documents the location, timing, classification (e.g., rotational, earthflow, debris torrent, etc.) and relative size of landslides in the watershed.

GMA (2001b) field verified about 15% of the landslides mapped, which was considered a representative sample of landslides in the watershed, to evaluate air photo interpretation limitations and help resolve

major uncertainties. The sample size was primarily a function of access (i.e. permission, distance from road access, etc.), with most emphasis on verification in the Upper Middle Assessment Area. The factors assessed during the field inventory included the following: landslide area/volume, land use association, initiation factors, delivery to streams, etc.

The landslide database and landslide inventory maps were linked through the project GIS. Each slide mapped onto the overlays was digitized as a polygon and linked to the database. Slides judged questionable and/or non-delivering were discarded from further analysis. The remaining dataset was queried by landslide type, year, number of slides and area, geology, and the locations were separated into sub-watershed areas for evaluation at that level. Summary tables for the assessment areas and each sub-watershed were prepared for use in interpreting the data and performing volume calculations. The volume of delivering landslides in each accounting unit (watershed and/or sub-watershed) was computed based on delivery percentage multiplied by slide area times slide thickness. Selection of an average slide thickness by type was based on literature review and field verification. Slide volumes were converted from cubic yards to tons based on soil bulk density data. This allows comparison of sediment inputs to sediment transport values, which are usually computed in term of tons.

Field Plot Inventory

In order to assess the relative contribution of smaller slide features, GMA (2001b) conducted detailed mapping in the watershed study. Within the Upper Middle Assessment Area sites were randomly selected. Depending on access limitations, certain selected sites had to be rejected and another site randomly chosen. The size of each site was approximately 40 acres, which provided a manageable size and often has easily determined boundaries due to the subdivision of sections (40 acres being 1/16th of a square mile (640 acres per section)). A total of 40 detailed sample plots were mapped, with almost all of these sites in the Upper Middle. All of these sites were located on public land (due to access permission), thus the effects of management activities on private lands could not be ascertained by this method.

Once a sample plot was selected, field personnel mapped all erosional features within the boundaries of the plot by walking its entire area. Each feature had the following data recorded: (1) type of sediment source, (2) any apparent land use or management associations, (3) area, thickness and volume of erosion, (4) estimate of the percentage of sediment delivered to the stream, (5) estimate of the feature's age, and (6) specific location characteristics such as geomorphic form, hillslope steepness, dominant vegetation, and canopy cover. All data was entered on a data form that was then input into the project database.

Data analysis included evaluation of sediment delivery by process (slides, gullies, rill erosion, bank erosion) and by land use association (non-management, harvest-related, road related). Data collected allowed differentiation between system roads (currently in use) and abandoned or legacy roads. Volumes were computed and rates computed after selecting a typical time period for which the observed features were determined to be representative.

Surface and Gully Erosion

<u>Road Surface Erosion</u>
Unlike surface erosion from exposed hillslopes where revegetation usually occurs within a few years, road surfaces can continue to erode as long as the road is used. The road cut slopes and fill slopes tend to revegetate, reducing erosion from those sources over time. However, road-running surfaces continue to provide fine-grained sediments over the life of the road. The purpose of this part of the sediment source analysis was to identify portions of the road network that deliver sediment to streams and therefore affect aquatic habitat or water quality. This analysis develops an understanding of the overall effects of the road system on sediment yield by roughly quantifying the amount of sediment delivered to streams from roads in a sub-basin for use in comparing that amount to the estimated sediment input rates for background and

other land management activities.

The approach for estimating sediment production was to examine road segments for characteristics of the road prism, drainage system, and traffic as they influence the delivery of sediment to the stream system, and calculate sediment yield based on them. Factors were applied for differing conditions of the road tread, cut- and fill-slopes, and traffic use that increase or decrease the estimated sediment yield of that segment. The result is an estimate of sediment yield for each road segment. The estimate was further modified according to the estimated delivery of sediment to streams along that segment.

Road segment groups were analyzed to produce estimates of sediment delivery for each road segment type. That rate was applied to all of the segments of that type in each sub-basin, resulting in an estimate of sediment delivery from roads for each sub-basin. The amount of sediment delivered to the stream from each road segment type was estimated by apportioning the inherent erosion rate among the road prism components. Each component rate was modified by factors based on road prism characteristics and the percentage of the road delivering sediment into the stream system. The final product is the rate of sediment delivered to streams from road segment types. The rate multiplied by the length of each segment type in each sub-basin provides the total sediment from roads for each sub-basin.

Field Inventory was used to verify traffic and surfacing information, to verify segment types and grouping, to check average road attributes (tread, ditch, cut slope, fill slope) and prism dimensions, to collect information on cover percentage on cut- and fill-slopes, to review localized problem areas, and to determine potential delivery to streams. Prior to field inventory, GMA (2001b) performed GIS analyses to identify those portions of the road network within the standard 200 foot buffer from a Class I, II, or III watercourse (i.e. riparian roads). Because of the much greater delivery from riparian roads, these areas were prioritized. During field surveys, information on road sediment delivery was also collected for each segment. At each drainage site, the potential for sediment delivery to the stream was determined.

Gully Erosion On Roads

Gully erosion on roads can occur when surface runoff is concentrated along the tread or ditch for long distances. The most common causes of gully erosion are plugged culverts, undersized culverts, or steep un-surfaced roads (over 10% grade). Gully erosion is not included in estimates of surface erosion using the Washington Department of Natural Resources (1997) method, and so must be analyzed separately. Because gully erosion is often episodic (e.g., in response to a blocked culvert that causes a stream to flow down or across the road tread) it is difficult to obtain a good quantitative estimate of gully erosion. Instead, a qualitative estimate of how severe the problem is in different areas of the basin or on different road slopes was made during road field-verification. When gullying was seen in the field, data were recorded including the location, cause, and approximate dimensions of the gully to help determine the relative amount of sediment produced by this mechanism. Separate rates for gullies were developed by road surface, hillslope position, and geology.

Road Surface Erosion Calculations by Sub-Watershed

A formula was developed in order to estimate total sediment delivered for the entire Trinity River basin. The formula used was similar to the formula used in SEDMODL, which was used in the Sediment Source Analysis for thee South Fork Trinity River (Raines 1998, in US EPA 1998). The formula developed does not, however, account for road use factors, precipitation factors, or road slope factors.

The total amount of erosion from each drainage segment was calculated as the sum of tread erosion, cutbank erosion, and other sources of erosion. Total erosion was then divided by the length of the segment and by the age of the road. The ratio of segment length to total length surveyed was then used to derive an adjusted total erosion amount recorded in tons per mile per year. Total erosion from each site was summed for each of the geology types and then sorted by both surfacing type and hillslope location. These values were then used to develop surface erosion rates (tons/mi/year) which could then be applied to data

extracted from the project GIS.

Surface erosion from roads within each sub-watershed and planning watershed was computed for existing conditions by stratifying by geology, stratifying by location (riparian, mid-slope, and ridge categories), and stratifying by road surface (paved, rocked, and native categories) and then applying the appropriate rate developed from the field inventories. Slope positions were assigned using the following methodology. To determine the location of Riparian roads, all Class I and Class II streams were buffered by 200 feet on either side. All roads segments within this buffer were considered Riparian. To determine the location of Ridge roads, ridgelines were identified by creating watershed boundaries from the 10-meter DEM with a minimum area of approximately 75 acres. Next all Class I streams were buffered by 500 feet to clip the watershed boundaries away from the riparian zone. The resulting ridgeline coverage was then buffered by 100 feet on either side. All roads segments within this buffer were considered Ridge roads. All the roads segments that didn't fall into the 200 foot riparian buffer or the 100 foot ridge buffer were considered to be Mid-Slope.

Surface Erosion from Harvest Areas:
Surface erosion from harvested areas is most often related to various surface disturbance activities, primarily skid trails. Without access to verify rates for harvested areas (almost all recently harvested land in the watershed is privately owned), we were limited to application of a single sediment delivery rate which was obtained from the literature. 4 tons/ac/year was selected from a review of the literature and values used in the South Fork Trinity River Sediment Source Analysis (Raines 1998) for the post-1974 period after development of Forest Practice Rules regulating harvesting methods. For pre-1974 harvesting, the rate was assumed to be 12 tons/ac/year or three times as great prior to regulation. These values were applied to all harvested areas, regardless of silviculture method, by the appropriate period. Areas of harvest were determined in several ways, including: (1) Maps of timber harvesting prepared by Department of Water Resources (CDWR 1981) were digitized and input into the project GIS thus providing information from 1940 to 1978, (2) maps contained in California Department of Forestry (CDF) THP's for the period 1979-2001 were digitized and combined with USFS compartment data to arrive at harvest acreage by sub-watershed for the current period.

The only modification to the calculation of surface erosion as described above occurred in those portions of the Upper Middle Trinity underlain by the extremely erodible Shasta Bally Formation, primarily in the Grass Valley Creek sub-watershed. This area has long been known to have produced enormous sediment yields following disturbance in the 1960s and 1970s. For those portions of the basin underlain by this geologic formation, a rate of 40tons/ac/year was used.

From 1988 to present, road and harvest history was obtained from CDF's GIS coverages which had been developed by directly inputting information provided as part of submitted Timber Harvest Plans (THPs). Data from the pre-1988 mapping efforts were shown on overlays and simply record road or harvest activity during the period between years of photographs reviewed. For roads, only main roads or haul roads were generally mapped. Because of revegetation over time, probably not all haul roads were mapped. Furthermore, their importance could be misinterpreted because of lack of use, being overgrown, or being incorporated into harvest units and lost in a maze of skid trails. In tractor-logged harvest units, road and skid trail density was characterized as low, moderate, or high. Data from the overlays was digitized into the GIS database for subsequent mapping and analysis.

Legacy Road and Mining Erosion

Data from the sample plots allowed a distinction to be made between active system roads and abandoned roads (termed legacy roads). Rates for sediment delivery from legacy roads were computed assuming that observed erosion occurred over a 30-year period. Sediment volumes from legacy roads for each sub-watershed were computed on a per square mile basis, since no data were available on the extent of these

abandoned roads.

The Trinity River Watershed has a long history of mining, starting with the Gold Rush in 1848. Hard rock, placer, and hydraulic mining were all extensive, with hundreds of mines operating at various times between 1948 and 1962 with an estimated production of $60,000,000-$70,000,000. One of the largest hydraulic mines in the world, the La Grange Mine near Junction City, operated for a number of years in the watershed. Although scars are still visible at a number of these historic mining sites, no acreage for these mines is available with which to compute a surface erosion rate. However, there is fairly detailed information on a mining-related feature, ditches, which have caused considerable erosion, and we developed data with which to estimate the magnitude of these impacts on sediment delivery. Ditches conveyed water from the point of diversion, often high up in a tributary watershed, to the hydraulic mine site, where with the considerable pressure obtained from the elevation difference, large hydraulic "giants" could be operated. These ditches were constructed over often steep and challenging terrain, and a number of large landslides have occurred in recent years caused by failure of some portion of the long-abandoned ditch system. GMA (2001b) walked several miles of the most well-known of the ditches (the La Grange Ditch) and mapped all landslides and gullies found along the ditch. The volume was converted into a rate per mile of ditch assuming that an 80-year period had occurred since the ditch was last maintained. The miles of ditches by Planning Watershed were obtained from California Division of Mines and Geology 1965 Trinity County Mineral Resources Report.

Bank Erosion

Most bank erosion, except large-scale changes in alluvial reaches, cannot be mapped from aerial photography. GMA (2001b) followed the following steps to estimate bank erosion. The channel network in each watershed was analyzed to compute stream order. The number of segments of each type was computed, and a stratified random sampling approach undertaken. The main channel of each significant tributary watershed was walked in its entirety, providing access was available. For smaller drainage channels, the total length of the segments in that stream order was obtained, and the random sampling scheme was applied in proportion to the percent of the total drainage network that the segments in that particular stream order represented. Approximately 10-20% of the stream network outside of the main channel was assessed.

In order to quantify the amount of sediment contributed to stream channels, selected reaches of channels were selected and inventoried for past erosion. All erosion from hillslopes and inner channel banks was summed and divided by total length of the stream reach. Stream length and site location were identified using a range finder and aerial photography mapping. Erosional features less than ten cubic yards were not recorded. Sources of erosion were from natural bank erosion from channel changes, road related feature, and hillslope debris slides. Features were given a volume, delivery percentage, and an age. The data set was limited by the amount of private land surrounding the stream channels in the Upper Middle Area, however, 27 miles of channel, all in the Upper Middle Assessment Area, were field inventoried.

Background Sediment Delivery Rates

Background sediment delivery is considered to be all sediment that is not associated with management-related causes (such as natural landslides in Wilderness areas). GMA (2001b) determined background for each subwatershed throughout the Trinity River basin by combining the non-management sediment delivery rates from the following four categories: landslides based on air photo inventory, various processes from inventoried field plots, bank erosion estimates and soil creep.

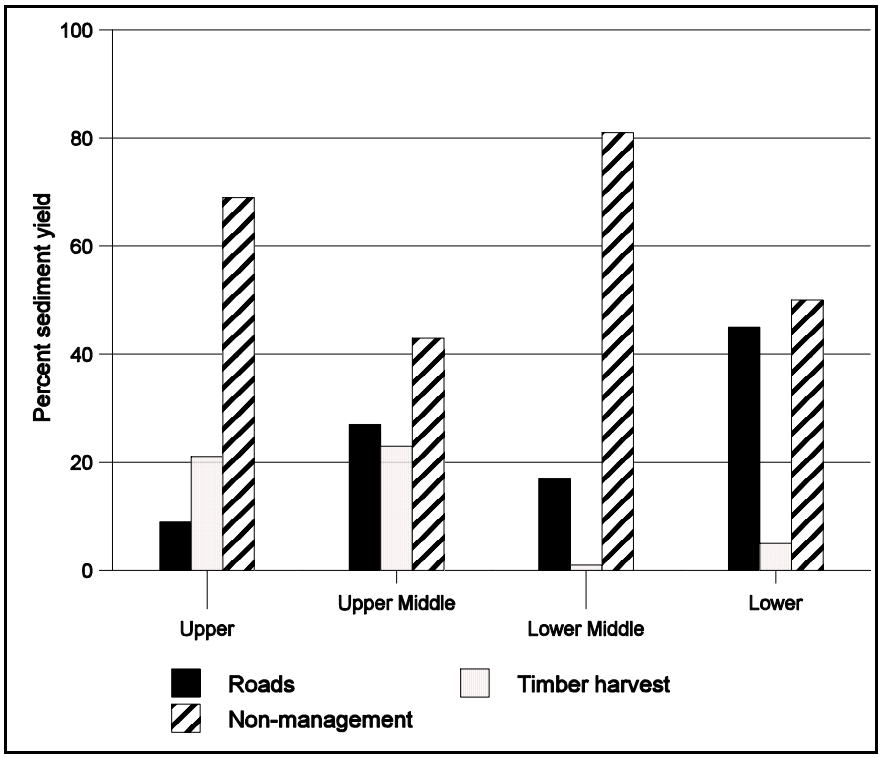
4.2. Summary of Sediment Source Inputs

The results of the sediment source analysis are summarized first by each source category and erosion process according to the four assessment areas (Table 4-1). The quantities of sediment are expressed in tons/mi2/year and the percentage by source category within each assessment area is indicated in Table 4-1. Figure 4-1 on the following page displays the percentage contribution between management, legacy and background within each assessment area.

Table 4-1. Sediment Source Summary by Category and Assessment Area

Source Category		Current Load Estimate by Assessment Area tons/mi^2/yr (%)			
		Upper	Upper Middle	Lower Middle	Lower
Management Associated Load					
Roads	Landslides	108	186	219	1307
	Cut-Bank	15	59	8	20
	Tread	17	82	9	13
	Other	14	33	6	11
	Total Roads	154 (9%)	360 (27%)	242 (17%)	1351 (45%)
Timber Harvest	Landslides	335	146		124
	Various processes (plot data)	10	18	7	15
	Surface	4	146	3	2
	Total Timber Harvest	349 (21%)	310 (23%)	10 (1%)	141 (5%)
Legacy	Roads	17	31	12	na
	Mining (slides/gullies)	1	57	6	na
Total Management-related		521 (31%)	758 (57%)	270 (19%)	1492 (50%)
Background (Non Management-associated) loads					
Landsliding		960	352	935	1280
Various Processes (plot data)		110	147	114	110
Bank Erosion		55	35	54	51
Soil Creep		30	40	30	30
Total Background		1155 (69%)	574 (43%)	1133 (81%)	1471 (50%)
Total Sediment Yield		1676	1332	1403	2963

Figure 4-1. Percent Sediment Input by Source Category within each Assessment Area.



Secondly, the results are summarized by grouping the erosional processes into four categories (background, roads, timber harvest, legacy) according to subareas within each of the assessment areas (Tables 4-2, 4-3, 4-4, 4-5). Subareas are an appropriate scale to display results because they provide a finer resolution to distinguish differences within each assessment area while at the same time combining small subwatersheds with similar characteristics. EPA uses the same subarea scale for calculating the TMDLs and allocations in the following chapter.

In addition to expressing the loading rates in terms of tons/mi^2/year, EPA has also expressed them as a percentage of the background sediment delivery rate. The percent of background indicates the magnitude of management-related sediment sources in relation to background rates for each subarea. For example, the percent of background in the East Fork Tributaries (252%, Table 4-2) indicates a higher proportion of management-related sediment delivery than the percent of background in the Westside Tributaries (137%, Table 4-2). GMA (2001b) provides more detailed results by subwatersheds and more specific sediment input categories.

Table 4-2. Sediment Source Summary by Category and Subareas within the Upper Assessment Area

Sediment Source Categories		Current sediment delivery rates (tons/mi^2/year) by subareas (GMA 2001b)				
		Reference Subwatersheds[1] (235 mi2)	Westside Tributaries[2] (93 mi2)	Upper Trinity[3] (161 mi2)	East Fork Tributaries[4] (115 mi2)	East Side Tributaries[5] (89 mi2)
Background (Non-management)		1125	421	2759	258	241
Management	Roads	129	101	162	319	48
	Timber Harvest	240	31	1084	46	22
	Legacy (Roads, Mining)	7	25	21	26	26
	Total Management	376	157	1267	391	96
Total Sediment Delivery		1501	578	4026	649	337
Total as percent of background		133%	137%	146%	252%	140%

1. Stuarts Fork, Swift Creek, Coffee Creek
2. Stuart Arm Area, Stoney Creek, Mule Creek, East Fork Stuart Fork, West Side Trinity Lake, Hatchet Creek, Buckeye Creek;
3. Upper Trinity River, Tangle Blue, Sunflower, Graves, Bear Upper Trinity Mainstem Area, Ramshorn Creek, Ripple Creek, Minnehaha Creek, Snowslide Gulch Area, Scorpion Creek
4. East Fork Trinity, Cedar Creek, Squirrel Gulch Area
5. East Side Tributaries, Trinity Lake

Table 4-3. Sediment source Summary by Category and Subareas within Upper Middle Assessment Area

Sediment Delivery Categories		Current sediment delivery rates (tons/mi^2/year) by subareas (GMA 2001b)					
		Weaver and Rush Creeks *(72 mi2)*	Deadwood Creek, Hoadley Gulch and Poker Bar Area *(47 mi2)*	Lewiston Lake Area (25mi2)	Grass Valley Creek[1] *(37 mi2)*	Indian Creek *(34 mi2)*	Reading and Browns Creek *(104 mi2)*
Background (non-management)		675	273	195	175	324	263
Management	Roads	144	220	83	287	1570	126
	Timber Harvest	61	280	37	1136	330	204
	Legacy (Roads, Mining)	81	62	69	65	68	42
	Total Management	286	562	189	1488	1968	372
Total Sediment Delivery		961	835	384	1663	2292	635
Total as percent of background		142%	305%	197%	950%	707%	241%

1. The rates in Grass Valley Creek do not account for the amount of sediment trapped by Buckhorn Dam and Hamilton Ponds.

Table 4-4. Sediment Source Summary by Category and Subareas within the Lower Middle Assessment Area

Sediment Input Categories		Current sediment delivery rates (tons/mi^2/year) by subareas (GMA 2001b)				
		Reference Subwatersheds[1] *(434 mi2)*	Canyon Creek *(64 mi2)*	Upper Tributaries[2] *(72 mi2)*	Middle Tributaries[3] *(54 mi2)*	Lower Tributaries[4] *(96mi2)*
Background (non-management)		1568	1302	268	210	221
Management	Roads	11	2482	60	37	41
	Timber Harvest	4	4	29	16	20
	Legacy (Roads ,Mining)	9	17	46	28	29
	Total Management	24	2503	135	81	90
Total Sediment Yield		1592	3805	403	291	311
Total as percent of background		102%	292%	150%	139%	141%

1. New River, Big French, Manzanita, North Fork, East Fork North Fork.
2. Dutch, Soldier, Oregon Gulch, Conner Creek Area
3. Big Bar Area, Prairie Creek, Little French Creek.
4. Swede, Italian, Canadian, Cedar Flat, Mill, McDonald, Hennessy, Quinby Creek Area, Hawkins, Sharber.

Table 4-5. Sediment Source Summary by Category and Subareas within the Lower Assessment Area

Sediment Source Categories		Current sediment delivery rates (tons/mi^2/year) by subareas, outside of the Hoopa Valley Tribe Reservation boundaries (GMA 2001b)				
		Reference Subwatershed (Horse Linto Creek: 64 mi2)	Mill Creek and Tish Tang (39 mi2)	Willow Creek (43 mi2)	Campbell Creek and Supply Creek (11 mi2)	Lower Mainstem Area and Coon Creek[1] (32mi2)
(Background (non-management)		2110	839	374	7845	252
Management	Roads	483	703	854	14349	76
	Timber Harvest	87	83	201	785	15
	Legacy (Roads ,Mining)	26	26	26	26	22
	Total Management	596	812	1081	15160	113
Total Sediment Yield		2706	1651	1455	23005	365
Total as percent of background		128%	197%	389%	293%	145%

1. Since background rates for Lower Mainstem Area and Coon Creek were not available from GMA (2001b), EPA used the same rate as was calculated for the Quinby Creek Area which is immediately upstream, because Quimby Creek Area is comparable in size and underlain by the same geology type (Galice Formation).

4.3. Development of the Sediment Budget

Reid and Dunne (1996) define a sediment budget as, "an accounting of the sources and disposition of sediment as it travels from its point of origin to its eventual exit from a drainage basin." In addition to the sediment source information above, GMA (2001b) was able to estimate output (transport) components of a complete sediment budget for portions of the basin, particularly the Upper Middle Assessment Area. Output values are based on measurements of sediment transport at the gaging stations near the confluence of some tributaries as well as the mainstem in the Upper Middle Assessment Area. Unfortunately, many areas of the basin do not have sufficient record of flow and sediment transport data to support complete sediment budget construction. Moreover, information on change in storage was not available for a sufficient portion of the watershed, which further limits the analysis. A summary of the methods and results of the sediment budget by GMA (2001b) is described in this section.

Hydrology

Existing precipitation data were collected from the USFS, DWR, and the National Weather Service. Streamflow records were obtained from the USGS, USBR, DWR, and the Trinity River Restoration Program. Streamflow records have been maintained in the Trinity River basin for various periods of record. The USGS, USBR, DWR, the Hoopa Valley Tribe, and private organizations have maintained gages on the Mainstem Trinity River, North Fork Trinity River, various tributaries, and Trinity Reservoir. The quality of streamflow records range from good to excellent. Most records are available from the various agencies and/or organizations in either digital or hardcopy formats.

Since 1996, the Hoopa Valley Tribe has been installing and operating a series of mainstem and tributary streamflow stations, mostly in the Upper Middle Trinity Planning Watershed. The purpose of these stations is to provide streamflow and sediment transport data with which to develop a sediment budget for the mainstem in this reach, as part of planning efforts for implementation of the Trinity River Restoration Program.

Turbidity and Suspended Sediment Data Collection

GMA (2001b) conducted a reconnaissance assessment of relative tributary sediment yields based on collection of turbidity and suspended sediment data during storm events in the water year (WY) 2000. Sample sites were established throughout the entire watershed on sub-watersheds of all sizes and with a variety of upstream land uses. In WY2000, samples were collected at over 150 sites, with a total of 650 samples collected. Preliminary streamflow rating curves were established at over 60 sites, with a total of 230 discharge measurements made. Sample sites were stratified by geology and comparisons of sediment transport rates between basins and differing geologies were made.

In WY 2001, dataloggers were installed at 11 sites throughout the watershed. These records, combined with existing streamflow and sediment transport stations operated and maintained by the USGS or the Hoopa Valley Tribe, were used to compute continuous records of streamflow and sediment transport. In addition, many of the manual gage sites, established in Phase 1 were also operated in WY2001. Most of these sites were upgraded to contain crest stage gages and indirect peak discharge (e.g. slope-area peak) computation sites. Unfortunately, WY2001 turned out to be a critically dry year, with only a few small storms. Approximately 400 samples were collected in WY2001 in the Trinity Watershed.

Since the detailed data collection effort spanned only one winter season, GMA (2001b) assessed the relative magnitude of the winter in comparison to long-term historical records of storm intensity, duration, and frequency in order to develop a mechanism for translating data from WY 2001 into average yields (for example a 10-20 year period). GMA (2001b) used two approaches to accomplish this: (1) by comparison to gages with longer-term sediment records in the area (Grass Valley Creek) and other gages with shorter

records that extend from 1997 to present (Deadwood, Rush, and Indian Creeks), and (2) by computing sediment loads from a combination of synthetic and historic mean daily discharge values at each of the streamflow sites in the Upper Middle Assessment Area. For more information on the specific collection methods, data analysis and transport calculations, refer to GMA (2001b).

Summary of Sediment Transport Results

Analysis of the sediment transport data indicates the following: (1) the estimated sediment outputs from the tributaries in the Upper Middle Assessment Area are, for the most part, very similar to the estimated inputs from the sediment source analysis, and (2) the ROD flows improve (increase) the transport capacity of the mainstem compared to the recent flow record (1980-2000), however they are still insufficient to transport the current sediment load from the tributaries and mainstem. In other words, sediment reduction from the tributaries is necessary from the tributaries even under ROD flows.

GMA (2001b) compared the tributary sediment inputs estimated from the sediment source analysis (described in sections 4.1, 4.2 above) with the calculated tributary outputs based on the analysis of gaging station data. The results (Table 4-5) indicate that the difference between the two estimates is very similar for Deadwood Creek, Grass Valley Creek, Indian Creek, Reading Creek and Browns Creek. However, the input and output estimates for Rush Creek and Weaver Creek are significantly different. One explanation for differences in Rush and Weaver Creek may be the result of excessive sediment inputs from the fairly recent 1997 storm which have not yet migrated through the channel network and out of the tributary into the mainstem.

Table 4-6. Comparison of Tributary Sediment Inputs and Outputs in the Upper Middle Trinity Assessement Area, 1980 - 2000 (GMA 2001b)

Tributary	Sediment Source Analysis Results (Inputs), 1980-2000, tons/mi^2/year	Computed Sediment Transport Near Confluence with Mainstem (Outputs), 1981-2000, tons/mi^2/year	Difference between Tributary Inputs and Outputs
Deadwood Creek	646	530	116
Rush Creek	2452	407	2045
Grass Valley Creek	1673	1303	370
Indian Creek	2319	2106	213
Weaver Creek	2459	347	2112
Reading Creek	872	817	55
Browns Creek	541	512	30

As discussed in the habitat conditions assessment (Section 2.4) sediment accumulation in the upper middle mainstem (below the dam) is a problem, particularly below the confluence of several of the tributaries. GMA (2001b) compared the transport capacity of the mainstem under recent flow conditions (1980-2000) with the projected flow regime under the ROD, assuming sediment delivery to the mainstem remained the same. GMA determined that ROD flows are capable of transporting more total sediment load (1995 tons/mi2/year) than under recent flows (1145 tons/mi2/year). However, ROD flows are still not able to transport the amount of combined tributary and mainstem derived sediment at the gaging station near the confluence with Reading Creek. Consequently, sediment source reductions are necessary in order to allow the mainstem to “flush” out the existing, accumulated sediment and achieve dynamic equilibrium between mainstem transport capacity and tributary inputs.

Table 4-7. Comparison of sediment transport values for mainstem Trinity River and tributary sites, between historic flows (1981-2000) and projected ROD flows (GMA 2001b).

Location of transport measurement		Sediment transport based on recent flows, 1981-2000 (tons/mi2/year)	Sediment transport based on projected ROD flows (tons/mi2/year)
Combined tributary and mainstem transport[1] above gaging station[2]	Suspended	1,335	1,903
	Bedload	519	717
Total Upstream Load		1854	2620
Mainstem transport at gaging station	Suspended	892	1,517
	Bedload	253	478
Total Mainstem Load		1145	1995
Difference (Amount not transported)	Suspended	(443)	(386)
	Bedload	(266)	(239)

1. The tributary sediment outputs under both flow scenarios is the same since the tributary flows are the same. However, the mainstem transport upstream of the gaging station increases due to the increased mobilization of existing mainstem sediment under ROD flows.

2. The Trinity River Douglas City gaging station is located on the mainstem near the confluence of Reading Creek.

CHAPTER 5

TMDL AND ALLOCATIONS

The purpose of this chapter is to determine the total loading of sediment which the Trinity River and its tributaries can receive without exceeding water quality standards, and to apportion the total among the sources of sediment.

5.1. Approach

This TMDL is set equal to the loading capacity of the stream. It is the estimate of the total amount of sediment, from both natural and human-caused sources, that can be delivered to streams in the Trinity River watershed without exceeding applicable water quality standards. For North Coast sediment TMDLs, EPA has used three approaches for deriving the loading capacity: (1) a comparison with a reference time period; (2) a comparison with a reference stream; and (3) the estimated needed improvement from existing loading rates, based on a comparison between current and target instream conditions. The approach used in a particular TMDL depends on the availability of data and the characteristics of the specific watershed.

EPA is using the second approach, reference watersheds, for developing several TMDLs on a subarea basis for the Trinity River Basin. The reference watershed approach is an appropriate basis for TMDL development because the Trinity River Basin contains representative subwatersheds with healthy aquatic habitat and watershed conditions considered to be supporting beneficial uses. Reference watersheds are used as benchmarks against which to compare conditions and sediment delivery rates in watersheds where beneficial uses are not currently being met.

Based on sediment delivery rates in the reference watersheds, EPA determined the total percentage of background sediment delivery that could occur and still meet water quality objectives. EPA then applied this percent (125% of background) to the subareas throughout the basin to determine the loading capacity or TMDL for each subarea. EPA then apportioned the TMDLs between background and management sources and determined the percent reduction from management activities necessary to attain the TMDLs in each subarea.

Reference Watersheds

EPA is defining "reference watersheds" as those watersheds that are generally exhibiting high geomorphic, hydrologic, and biotic integrity relative to their natural potential condition. Physical and biological conditions suggest that aquatic and riparian systems are predominantly functional in terms of supporting dependent species and beneficial uses of water. The risks of management induced disturbance have not been expressed (i.e. any disturbance has not resulted in significant alteration of geomoprhic, hydrologic, and biotic processes) (definition from USFS 2000c). EPA selected reference watersheds based on evidence suggesting that beneficial uses, primarily cold water fish habitat, were being supported. Additionally, EPA considered potential threats to water quality by evaluating the level of management-related sediment delivery in relation to background rates. Reference subwatersheds are useful in determining the allowable level of disturbance that can occur in each of the assessment areas without negatively impacting beneficial uses.

Table 5-1 includes the list of reference subwatersheds for each area and, for each subwatershed, a summary of supporting information, including the total sediment delivery expressed as a percentage of background (e.g., if there was half as much management-related sediment as background, then the "percent of background" would be 150%). EPA did not identify reference watersheds in the Upper Middle Area. However, since the geology of the Upper Middle Area is generally similar to portions of the Upper Area (e.g., Granitic and Ultramafic Rocks) and Lower Middle Area (e.g., North Fork Terrane, Central Metamorphic Subprovince and Hayfork Terrane), EPA considers the reference watersheds for those areas of the basin as applicable to the Upper Middle area. See GMA (2001b) for more details on geology.

Table 5-1. Summary of Reference Watersheds and Supporting Information.

Reference Watershed by Assessment Area		**Aquatic Habitat Conditions (from Chapter 2)**		**Sediment Yield and Watershed Disturbance Risk**		
		Fish and Aquatic Habitat Information	**Channel rating[1]**	**Rate t/mi2/yr**	**Percent of background**	**Hazard rating [2]**
Upper	Stuart Fork	Focal watershed[3] (USFS 1998) SCI Habitat data[4] (USFS 2001) Potential Wild Trout Stream (CDFG 2001)	Properly Functioning	474	104%	Low
	Coffee Creek	Refugia Trout Stream (CDFG 2001) Middle Fork: Focal watershed (USFS 1998)	Properly Functioning	2258	137%	Low
	Swift Creek	Refugia Trout Stream (CDFG 2001) N. Fork Swift: Focal watershed (USFS 1998)	Properly Functioning	1081	138%	Low
Lower Middle	North Fork	Healthy summer steelhead pop. (USFS 2000) Key watershed[5] Focal watershed SCI Habitat Data (USFS)	Properly Functioning	1624	101%	Low
	East Fork North Fork	High juvenile steelhead densities (USFS 1989) Key watershed SCI Habitat Data (USFS)	Properly Functioning	252	117%	Low
	New River	Healthy summer steelhead pop. (USFS 2000) "Key"watershed "Focal" watershed	Properly Functioning	2138	101%	Moderate
	Manzanita	Healthy steelhead pop. (USFS 2000) Focal watershed	Properly Functioning	178	101%	Low
	Big French Creek	High juvenile salmonid densities (USFS 1989) Focal watershed	Properly Functioning	200	111%	Low

Lower	Horse Linto Creek	Stable Chinook and steelhead populations Tier-1 Key Watershed "properly functioning" rating	Properly Functioning	2706	128%	Moderate

1. Based on indicators that largely reflect the expression of watershed condition in the stream including floodplain connectivity, water quality, flow regime, stream corridor vegetation, stream channel condition, and native aquatic faunal integrity. Indicators are rated as impaired, functioning at risk, or properly functioning (USFS 2000)
2. Indicators that dominantly reflect the *hazard* or risk of impairment to watershed condition based on road condition, surface erosion, and mass wasting. Hazard indicators are rated as high, medium or low (USFS 2000)
3. Defined as "...critical areas supporting a mosaic of high-quality habitats that sustain a diverse or unusually productive complement of native species..." USFS 1998.
4. USFS is collecting baseline stream condition data following Stream Condition Inventory (SCI) methods
5. Key watersheds are intended to serve as refugia for maintaining and recovering habitat for at-risk stocks of anadromous salmonids (USDA and USDI 1994)

The sediment delivery rates vary tremendously between reference watersheds, from 178 t/mi2/year in Manzanita Creek to 2258 t/mi2/year in Coffee Creek (Table 5-1). This is due in part to differences in natural factors such as topography, soils, geology, storm events, etc. as well as different landuse histories during the assessment period. For example, a large storm in 1997 had a more profound effect on erosional processess in the Upper Assessment Area compared to the Lower Area. Consequently, channel conditions in portions of the upper reference subwatersheds are currently recovering as the system redistributes the sediment load. Whereas, the Lower Assessment Area was more strongly impacted by the 1964 flood event and consequently, Horse Linto Creek in the Lower Area has had more time to recover compared with Coffee Creek and Swift Creek in the Upper Area. Despite the differences in sediment delivery rates, these reference watersheds generally consist of functioning physical and biological processes and contain relatively few watershed risks that might disrupt the conditions outside the range of natural variability.

5.2. Loading Capacity (TMDL) and Allocation Calculations

Given the wide range in sediment delivery rates in the reference watersheds, it does not appear that a single sediment delivery rate is the best way to estimate the loading capacity for the Trinity River system. In several other TMDLs, EPA has calculated the loading capacity based on an analysis that the systems could tolerate about one part of sediment from management-related sources for every four parts of sediment from background sources without exceeding water quality standards (i.e., the loading capacity is 125% of the background sediment delivery rate). EPA believes that the latter approach is preferable for the Trinity River system as well.

Setting the loading capacity at 125% of the background sediment delivery rate is supported by an analysis of the reference watersheds. If the reference watersheds with very little management-related sediment (due, in part, to the fact that most of the lands in these watersheds are designated Wilderness and have not been actively managed in the recent past) are excluded[1], then the remaining reference watersheds have sediment delivery rates that cluster around 125%. EPA considered setting the loading capacity at 138%, because it is the loading rate for the reference watershed with the highest percent over background (i.e., Swift Creek), but we decided to take a more conservative approach and use 125% because the watersheds with delivery rates above 125% may have areas where water quality standards are not being met, even though the watersheds as a whole have good water quality, and reductions in those areas would be appropriate.

For the purpose of calculating TMDLs, EPA is further dividing the Assessment Areas into subareas,

[1] Exclusion of a watershed with very little management-related sediment is appropriate since the loading capacity is defined as the maximum amount of a pollutant that does not result in exceedance of water quality standards. Reference watersheds are those where there is some management and healthy watershed conditions.

because it provides a finer resolution to distinguish differences within each assessment area while at the same time combines small subwatersheds with similar characteristics. EPA calculated the TMDL for each subarea by multiplying the estimated background rate for the subarea by 125%. That is,

$$\text{Background Rate}_{subarea} \times 1.25 = \text{TMDL}_{subarea}.$$

In accordance with EPA regulations, the loading capacity (i.e., TMDL) is allocated to the various sources of sediment in the watershed, with a margin of safety. The margin of safety in this TMDL is not added as a separate component of the TMDL, but rather is incorporated into conservative assumptions used to develop the TMDL, as discussed in Section 5.3.

Although nonpoint sources are responsible for most sediment loading in the watershed, point sources may also discharge some sediment in the watershed. Current and prospective future point sources that may discharge in the watershed and are therefore at issue in this TMDL include:

- CalTrans facilities that discharge pursuant to the CalTrans' statewide NPDES permit issued by the State Water Resources Control Board, and
- Construction sites larger than 5 acres that discharge pursuant to California's NPDES general permit for construction site runoff.

The draft TMDL set wasteload allocations at zero. On further consideration prompted in part by public comments, however, EPA has determined that it is more accurate to consider the rates set forth in this TMDL as load allocations to also represent wasteload allocations for point sources in the watershed, as discussed below.

This TMDL identifies wasteload allocations for point sources and load allocations for nonpoint sources as pollutant loading rates (tons/square mile/year) for subareas within the Trinity Basin. The source analysis supporting these allocations evaluated sediment loading at a subarea scale, and did not attempt to distinguish sediment loading at the scale of specific land ownerships. Nor did the source analysis specifically distinguish between land areas subject to NPDES regulation and land areas not subject to NPDES regulation. Therefore, the TMDL includes separate but identical load allocations (LAs) for nonpoint sources and wasteload allocations (WLAs) for point sources for each subarea. (See US EPA 2001 for additional details concerning the WLAs.)

Identifying WLAs as well as LAs in this TMDL does not result in an increase in allowable loading from that set forth in the draft TMDL, because the allowable loading is expressed as a rate of tons/square mile/year. Rather, this change from the draft TMDL merely clarifies that the same rate applies to the existing and potential point sources noted above (CalTrans and construction sites) as to nonpoint sources.

Thus, the TMDL for sediment for the Trinity River and its tributaries is apportioned between background sources and total management-related sources of sediment within each of the subareas in the basin. The background load allocation was set at the current rate of background sediment delivery since controlling or reducing natural background sources is generally not beneficial nor feasible. EPA then subtracted the background load allocation from the TMDL to determine the management allocation.

$$\text{TMDL}_{subarea} - \text{Background Load Allocation} = \text{Management Allocation}$$

Finally, EPA determined the percent reduction needed from current rates of management-related sediment delivery to attain the TMDL in each subarea. The reduction levels are intended to provide resource managers with guidance regarding the magnitude of erosion control necessary to protect beneficial uses in

each subarea. EPA calculated the percent reduction by dividing the management load allocation by the current management-related sediment delivery rate then subtracting from 100.

100 - (Management Allocation/Current Management Load Rate) = % Reduction Needed

Unlike other sediment TMDLs on the North Coast, EPA did not further subdivide the management allocation of this TMDL into specific management sources such as roads and timber harvest. Instead, EPA divided the basin into subareas. Due to the wide range of sediment delivery rates in the subareas, EPA believes it is appropriate in this case to allow resource managers the flexibility of meeting the management load reduction through any combination of erosion control for roads, timber harvesting, or legacy activities depending on the degree to which each source is contributing to the problem within each subarea. Nevertheless, EPA recommends the use of the sediment source assessment, Chapter 4 or GMA (2001b), as a reference for identifying which management activities are contributing the most sediment on a subarea or subwatershed basis.

Tables 5-2, 5-3, 5-4, and 5-5 contain summaries of the current sediment loading rates by source category followed by the TMDL, associated allocations (for background and management) and percent reduction needed from management within each subarea within each assessment area.

Table 5-2. TMDL and Allocations by Source Category for Upper Area

Source Categories		Subareas within the Upper Assessment Area				
		Reference Subwatersheds[1] (235 mi2)	Westside Tributaries[2] (93 mi2)	Upper Trinity[3] (161 mi2)	East Fork Tributaries[4] (115 mi2)	East Side Tributaries[5] (89 mi2)
Current Sediment Delivery Rate						
Background (non-management)		1125	421	2759	258	241
Management	Roads	129	101	162	319	48
	Timber Harvest	240	31	1084	46	22
	Legacy (Roads,Mining)	7	25	21	26	26
	Total Management	376	157	1267	391	96
Total Sediment Delivery		1501	578	4026	649	337
Total as percent of background		133%	137%	146%	252%	140%
Loading Capacity (TMDL) and Allocations (tons/mi^2/yr)						
TMDL (= 1.25 x Background)		1406	526	3449	323	301
Background Allocation		1125	421	2759	258	241
Total Management Allocation (= TMDL - Background)		281	105	690	65	60
Percent reduction needed in management to attain TMDL		25%	33%	46%	83%	37%

1. Stuarts Fork, Swift Creek, Coffee Creek
2. Stuart Arm Area, Stoney Creek, Mule Creek, East Fork Stuart Fork, West Side Trinity Lake, Hatchet Creek, Buckeye Creek;
3. Upper Trinity River, Tangle Blue, Sunflower, Graves, Bear Upper Trinity Mainstem Area, Ramshorn Creek, Ripple Creek, Minnehaha Creek, Snowslide Gulch Area, Scorpion Creek
4. East Fork Trinity, Cedar Creek, Squirrel Gulch Area
5. East Side Tributaries, Trinity Lake

Table 5-3. TMDL and Allocations by Source Category for Upper Middle Area

Source Categories		Subareas within the Upper Middle Assessment Area					
		Weaver and Rush Creeks (72 mi2)	Deadwood Creek, Hoadley Gulch and Poker Bar Area (47 mi2)	Lewiston Lake Area (25mi2)	Grass Valley Creek[1] (37 mi2)	Indian Creek (34 mi2)	Reading and Browns Creek (104 mi2)
Current Sediment Delivery Rates (tons/mi^2/yr)							
Background (non-management)		675	273	195	175	324	263
Management	Roads	144	220	83	287	1570	126
	Timber Harvest	61	280	37	1136	330	204
	Legacy (Roads,Mining)	81	62	69	65	68	42
	Total Management	286	562	189	1488	1968	372
Total Sediment Delivery		961	835	384	1663	2292	635
Total as percent of background		142%	305%	197%	950%	707%	241%
Loading Capacity (TMDL) and Allocations							
TMDL (= Background x 1.25)		844	341	244	219	405	329
Background Allocation		675	273	195	175	324	263
Total Management Allocation (= TMDL - Background)		169	68	49	44	81	66
Percent reduction needed in management to attain TMDL		41%	88%	74%	97%	96%	82%

1. The rates in Grass Valley Creek do not account for the amount of sediment trapped by Buckhorn Dam and Hamilton Ponds.

Table 5-4. TMDL and Allocations by source category for Lower Middle Assessment Area

Source Categories		Subareas within the Lower Middle Assessment Area				
		Reference Subwatersheds[1] (434 mi2)	Canyon Creek (64 mi2)	Upper Tributaries [2] (72 mi2)	Middle Tributaries[3] (54 mi2)	Lower Tributaries[4] (96mi2)
Current Sediment Delivery Rates (tons/mi^2/yr)						
Background (non-management)		1568	1302	268	210	221
Management	Roads	11	2482	60	37	41
	Timber Harvest	4	4	29	16	20
	Legacy (Roads ,Mining)	9	17	46	28	29
	Total Management	24	2503	135	81	90
Total Sediment Delivery		1592	3805	403	291	311
Total as percent of background		102%	292%	150%	139%	141%
Loading Capacity (TMDL) and Allocations						
TMDL (= Background x 1.25)		1592	1628	335	263	276
Background Allocation		1568	1302	268	210	221
Total Management Allocation (= TMDL - Background)		24	326	67	53	55
Percent reduction needed in management to attain TMDL		0	87%	50%	35%	39%

1. New River, Big French, Manzanita, North Fork, East Fork North Fork.
2. Dutch, Soldier, Oregon Gulch, Conner Creek Area
3. Big Bar Area, Prairie Creek, Little French Creek.
4. Swede, Italian, Canadian, Cedar Flat, Mill, McDonald, Hennessy, Quinby Creek Area, Hawkins, Sharber.

Table 5-5. TMDL and Allocations by source category for Lower Assessment Area

Sediment Source Categories		Subareas within the Lower Assessment Area, outside of the Hoopa Valley Tribe Reservation boundaries				
		Reference Subwatershed (Horse Linto Creek: 64 mi2)	Mill Creek and Tish Tang (39 mi2)	Willow Creek (43 mi2)	Campbell Creek and Supply Creek (11 mi2)	Lower Mainstem Area and Coon Creek (32 mi2)[1]
Current Sediment Delivery Rates (tons/mi^2/yr)						
Background (non-management)		2110	839	374	7845	252
Management	Roads	483	703	854	14349	76
	Timber Harvest	87	83	201	785	15
	Legacy (Roads ,Mining)	26	26	26	26	22
	Total Management	596	812	1081	15160	113
Total Sediment Delivery		2706	1651	1455	23005	365
Total as percent of background		128%	197%	389%	293%	145%
Loading Capacity (TMDL) and Allocations						
TMDL (Management +Background)		2638	1049	468	9806	315
Background		2110	839	374	7845	252
Total Management		528	210	94	1961	63
Percent reduction needed in management to attain TMDL		11%	74%	91%	87%	44%

1. Since background rates for Lower Mainstem Area and Coon Creek were not available from GMA (2001), EPA used the same rate as was calculated for the Quinby Creek Area which is immediately upstream, because Quinby Creek Area is comparable in size and underlain by the same geology type (Galice Formation).

These levels are adequate to protect aquatic habitat, which is the most sensitive of the beneficial uses. Given the hydrologic variability typical of the Northern California Coast Ranges, EPA expects the TMDL to be evaluated as a ten-year rolling average. Moreover, EPA acknowledges that actual rates of sediment delivery differ tremendously between subwatersheds within each planning area. EPA believes expressing the TMDL as an average for each area and over a 10 year rolling average is an accurate estimation of the overall loading rate for each planning area that will achieve water quality standards. The sediment reduction levels can be achieved through implementing any combination of restoration practices, improved management techniques, and/or reduction in intensity of timber harvesting and road density. An assortment of existing regulatory, voluntary and assistance programs are available for achieving the load allocations, as discussed further under implementation recommendations (Chapter 6).

The allocations are expressed in terms of yearly averages (tons/mi^2/yr). They could be divided by 365 to derive daily loading rates (tons/mi^2/day), but EPA is expressing them as yearly averages, because sediment delivery to streams is naturally highly variable on a daily basis. In fact, EPA expects the allocations to be evaluated on a ten-year rolling average basis, because of the natural variability in sediment delivery rates. In addition, EPA does not expect each square mile within a particular source category to necessarily meet the load allocation; rather, EPA expects the average for the entire source category to meet the allocation for that category.

EPA would also like to emphasize that where current loading rates are below or meeting the TMDL threshold (e.g., several of the reference watersheds), the antidegradation provisions of the CWA and Basin Plan prohibit an "increase in pollution." In other words, high quality waters must be maintained as such. In particular, resource managers must continue to prevent, protect and restore conditions in the reference subwatersheds which provide critical refugia for aquatic species while habitat in other areas of the basin improve, in part due to TMDL implementation.

5.3. Margin of Safety

The margin of safety is included to account for uncertainties concerning the relationship between pollutant loads and instream water quality and other uncertainties in the analysis. The margin of safety can be incorporated into conservative assumptions used to develop the TMDL, or added as an explicit separate component of the TMDL.

EPA is incorporating an implicit margin of safety into the Trinity River TMDLs. Table 5.6. identifies the uncertainties in the TMDL and the adjustments or assumptions that were made to account for the uncertainty to ensure that the beneficial uses will be protected.

Table 5-6. Uncertainties in Trinity River TMDL

Uncertainty	Adjustment to Account for Uncertainty
Interpretation of the amount of sediment delivery associated with management activities versus natural background sources.	GMA (2001b) generally attributed most or all of the sediment load of any landslide occurring within a recent harvest unit as being harvest related. This is a conservative assumption because some slides may have occurred naturally even if the land had not been harvested recently. The USFS (2000) estimated that 25% of all slides attributed to management are actually natural.
Instream habitat and watershed condition data were not available for the entire Trinity River Basin.	In areas where water quality or watershed condition data were lacking, EPA generally assumed that conditions were not meeting water quality standards. EPA encourages further watershed monitoring to fill data gaps.
Will the ROD flows for the Upper Middle mainstem be capable of transporting the sediment loads called for in the TMDLs for this area?	The TMDLs established for the subareas within the Upper Middle Area (based on 125% of background) result in a total sediment load to the mainstem of 756 t/mi2/yr which is well below the transport capacity of the mainstem under ROD flows (1995 t/mi3/yr) calculated by GMA (2001). Based on this comparison, the ROD flows should be fully capable of transporting and achieving dynamic equilibrium with sediment TMDLs.
The target values for the instream water and watershed indicators may not be completely applicable to the Trinity Basin since many of the values are based on research or other watersheds.	The target levels for the sediment indicators (instream and watershed), against which existing conditions were compared, represent optimal conditions for beneficial use support (i.e., salmonid habitat). The targets are conservative since the represent "ideal" conditions that may not be attainable in all cases in the watershed.
There is inherent variability in the spacial scales and physical watershed conditions (terrain, channel type, slope, vegetation, etc.) of sediment delivery from the hillslope to the channel.	EPA does 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 subarea for that category.

There is inherent annual and seasonal variation in the delivery of sediment to the stream channel from the source mechanisms.	The allocations are expressed as 10-year rolling averages to account for variability in delivery rates. The TMDL also includes watershed indicators to reflect sediment delivery risks.

5.4. Seasonal Variation and Critical Conditions

The TMDL must describe how seasonal variations were considered. Sediment delivery in the Trinity River watershed inherently has considerable annual and seasonal variability. The magnitudes, timing, duration, and frequencies of sediment delivery fluctuate naturally depending on intra- and inter-annual storm patterns. Since the storm events and mechanisms of sediment delivery are largely unpredictable year to year, the TMDL and load allocations are designed to apply to the sources of sediment, not the movement of sediment across the landscape, and to be evaluated on a ten-year rolling average basis. EPA assumes that by controlling the sources to the extent specified in the load allocations, sediment delivery will occur within an acceptable range for supporting aquatic habitat, regardless of the variability of storm events.

This TMDL does not allocate flow, and the calculation of the loading capacity (TMDL) and allocations was not baed on any particular flow regime. However, TMDLs must take into account critical conditions for stream flow, loading, and water quality parameters. As discussed throughout this TMDL, the control of stream flow due to the TRD has greatly contributed to the impairment of the mainstem below Lewiston dam. EPA considered the current flow conditions (absent of ROD flows) and the estimated flows under the ROD when setting the TMDLs and allocations. In order for the TMDL to be fully effective in protecting beneficial uses and attaining water quality standards, the ROD flows and restoration program must be implemented. The ROD flows are intended to achieve several attributes of a healthy alluvial river system that sediment allocations through the TMDL cannot achieve alone. For example, the ROD flows include inter- and intra-annual flow variations that mimic the natural snowmelt period. These peak flows are critical to support several river functions including the mobilization of channelbed particles, scour pools, create point bars and connect the mainstem to the floodplain. Such conditions are necessary to support habitat elements for spawning, rearing and migration of salmonids. The TMDL sediment allocations will be more effective in supporting beneficial uses if implemented in consort with the ROD flows. Similarly, the ROD flows will be more effective in achieving the river health goals when the TMDL load allocations are implemented.

Because of the uncertainty concerning what the actual flows in the river will be, EPA considered in our analysis both existing flows and also the flow regime discussed in the ROD and the Trinity River Flow Evaluation on which the ROD was based. Although a preliminary injunction currently limits additional water releases into the Trinity River to implement the ROD to 28,600 acre feet (the amount in the ROD for critically dry years) over the statutorily-mandated 340,000 acre feet, the decision granting the preliminary injunction did not question the science supporting the need for more flows to restore Trinity River fisheries. EPA considered the flow regime recommended in the ROD because in EPA's opinion this flow regime is based on the best available scientific analysis, and also represents the most recent decision of the Department of Interior concerning Trinity River flows.

Another critical condition that affects beneficial uses in the Upper Middle Area is the deficit of coarse sediment in the upper most reach (just below Lewiston dam). Both Lewiston and Trinity dam block the mainstem supply of coarse sediment which is needed to support spawning fish below the dam. The US FWS and HVT (1999) recommended supplementing 10,000 yds^3 of properly graded gravel material on the short term to the reach immediately below the dam to offset gravel export and presumably enhance spawning capacity. Consistent with Trinity River Restoration Program, EPA is recommending the augmentation of clean gravel in appropriate locations of the upper mainstem and appropriate times of the year to further meet the needs of spawning salmonids in that area.

CHAPTER 6

IMPLEMENTATION AND MONITORING RECOMMENDATIONS

The main responsibility for water quality management and monitoring resides with the State. EPA fully expects the State to develop and submit implementation measures to EPA as part of revisions to the State water quality management plan, as provided by EPA regulations at 40 C.F.R. Sec. 130.6.

The State implementation measures should contain provisions for ensuring that the allocations (see Chapter 5) in the TMDL will in fact be achieved. These provisions may be non-regulatory, regulatory, or incentive-based, consistent with applicable laws and programs, including the State's recently upgraded nonpoint source control program. These provisions should also recognize the variable need to control sediment in each subarea of Tables 5-2 through 5-5. Sediment load reduction, appropriate for each subarea, may be accomplished through site-specific management practices, variable regulatory requirements, sediment trading credits or other mechanisms.

Furthermore, the State implementation and monitoring measures should be designed to determine if, in fact, the TMDL is successful in attaining water quality standards. To assist in this effort, the Trinity River TMDL contains water quality indicators (see Chapter 3) as well as allocations. Both the indicators and allocations are essentially extensions of the water quality standards, but they were developed using independent approaches. Different approaches were used because the relationship between land management practices and the effects on water quality related to sediment is highly complex, with factors such as highly variable seasonal and inter-annual precipitation and landscape response to disturbance, and complexities in geology and sediment routing mechanisms from watershed sources to and through streams. Given the complexities, EPA believes that using two approaches provides a better basis for evaluating the success of the TMDL in attaining water quality standards.

In addition, the implementation measures should include a public participation process and appropriate recognition of other relevant watershed management processes, such as local source water protection programs, State programs under Section 319 of the Clean Water Act, or State continuing planning activities under Section 303(e) of the Clean Water Act.

Summary of Existing Erosion Control Programs

Several existing programs in the Trinity Basin are intended to control pollution from the types of nonpoint sources of sediment (i.e. roads and timber harvest) that are identified in this TMDL. On Federal land for

example, the Aquatic Conservation Strategy (ACS) of the Northwest Forest Plan calls for an aggressive program of watershed analysis, riparian buffer protection, road rehabilitation and aquatic monitoring. The implementation of the ACS is critical to achieving the allocations and target conditions identified in the TMDL on federal land which composes approximately 70% of the basin. Some of the existing programs, however, are not currently being implemented in a manner that will achieve allocations. The sediment source analysis (chapter 4) identified several subareas where management-related sediment delivery is significantly above background levels and resulting in water quality impairment. EPA has summarized some of the key management programs intended to address sediment control in the Trinity Basin and provided recommendations for improving effectiveness in meeting the TMDLs and protecting beneficial uses (Table 6-1). This should not be considered a complete list of sediment control programs.

Table 6-1. Summary of Implementation Recommendations for the Trinity River Basin

Management Jurisdiction	Existing Program	Recommendations
U.S. Forest Service (Six Rivers and Shasta Trinity) and Bureau of Land Management (70% of basin)	Aquatic Conservation Strategy, Northwest Forest Plan - Watershed Analysis (WAs) - Riparian Buffer network - Key Watershed Best Management Practices per MAA[1] Fisheries/Water Programs per LRMPs National Road Plan	- Complete WAs, particularly in Upper Assessment Area, and implement recommendations; - Complete roads analysis (USDA 1999) and implement findings with focus on TMDL hillslope targets. - Continue cooperative watershed restoration with local watershed groups, TCRCD, and TMC. - Evaluate and limit effects of suction dredge operations in stream reaches that overlap spawning sites. - Development and implement a Comprehensive Aquatic Monitoring Plan for the Basin including: habitat, fish populations, management effectiveness.
Private Industrial Timber (15% of basin)	California Forest Practice Rules (FPRs), - MAA between BOF/CDF and SWRCB[2] - Timber Harvest Plan (THP) Process	- Incorporate TMDL assessment, load reduction information, and hillslope targets into THP development. - Improve cumulative watershed effects (CWE) assessment and reduce CWE's on a subwatershed scale (UC Committee on Cumulative Effects 2001). - Improve monitoring of THP/BMP implementation and effectiveness throughout basin.
Smaller Private Landowners (8% of basin)	Technical and Financial Assistance Programs: Trinity County Resource Conservation District (TCRCD) and the Natural Resources Conservation Service (NRCS)	- Continue and expand small landowner technical and financial assistance for road inventory/maintenance, erosion control and fuels management.
County (Trinity and Humboldt)	5 County Salmon Recovery Program County General Plan	Continue implementation of the 5 County Program, particularly fixing the county roads, developing a grading ordinance and monitoring water quality.
Tribes and other federal, state, and local entities	Trinity River Restoration Program CalTrans statewide NPDES permit and maintenance program	- Implement the ROD, signed in Dec. 2000, including flow regime, mainstem/watershed restoration, and adaptive management[3] - Implement the erosion control measures setforth in the CalTrans NPDES permit and conduct routine maintenance to minimize sediment delivery.

1. The US Forest Service signed a Management Agency Agreement (MAA) with the State Water Resources Control Board (SWRCB) in 1981 resulting in the designation of the USFS as the water quality management agency for the public lands it administers. EPA approved the MAA and practices established by USFS to serve as Best Management Practices (BMPs).
2. EPA has not certified the California FPRs as BMPs according to section 208 of the CWA. As such, EPA expects the NCRWQCB to actively participate in the THP review team process to ensure water quality is protected.
3. EPA recognizes that currently a preliminary injunction limits implementation of ROD flows, other than those for critically dry years, and that the Department of Interior is currently preparing a supplemental environmental impact statement, which could result in changes to the ROD. EPA notes that the preliminary injunction was based on inadequate consideration by DOI of the California energy crisis and biological opinions concerning species outside of the Trinity River basin, and did not question the science supporting the need for more flows to restore Trinity River fisheries. Therefore, EPA is hopeful that if changes are made to the ROD, the increased flows currently included in the ROD will be retained.

Monitoring Recommendations:

Through the process of identifying the "best available information" for the Trinity River TMDL, EPA found that fish habitat and watershed condition information was not well coordinated nor easy to locate and obtain. Although some central repositories of information exist, such as the Trinity County Library in Weaverville and the Klamath Resource Information System (KRIS) compact disc database, much of the information is still spread amongst several agencies and organizations in different locations. The various types of information collected to date, did not appear to be well-coordinated or integrated. For example, tributaries in the upper middle area were assessed separately from the mainstem, fish data was not integrated with fish habitat data and very little information was collected at all regarding conditions above the reservoirs. There did not appear to be a clear strategy or plan consisting of goals, objectives, methodologies, locations, etc. for all the various types of water quality, fish habitat, channel morphology and/or watershed-related monitoring that is occurring throughout the basin. The lack of a basin-wide monitoring strategy will continue to inhibit the ability of resource managers, including those charged with implementing, assessing or updating the TMDLs, to determine the overall health and condition of the entire basin in the future.

To remedy the situation, EPA supports the formation of a Technical Modeling and Analysis Group (TMAG), as set forth in the ROD, to work with all the representative stakeholder groups, to develop a basin-wide monitoring strategy that would include areas of the basin beyond just the upper middle mainstem. The strategy should address the following: goals, objectives, parameters (biological, physical, chemical), protocols, locations, responsibilities, data quality assurance/control, data management, documentation and dissemination. The strategy should integrate all the disciplines (fisheries biology, water quality, fluvial geomorphology, riparian ecology, watershed hydrology, computer modeling, etc.) and coordinate the collection, analysis and reporting of such information. Such a strategy would result in the long-term evaluation of TMDLs along with the numerous other programs intended to protect and restore the health of the Trinity River Basin.

For TMDL purposes, EPA specifically recommends the continuation of the following types of sediment-related monitoring:

- Substrate quality on the mainstem and some tributaries;
- Turbidity and suspended sediment on specific tributaries (reference and impaired for comparison purposes) as well as periodic locations on the mainstem;
- Annual stream condition assessment in tributaries following the US Forest Service Stream Condition Inventory;
- Hypothesis testing on the middle mainstem as part of the adaptive management program; and
- Adult spawner escapement estimates and outmigrant trapping on the mainstem and certain tributaries.
- Implementation and effectiveness monitoring of watershed restoration activities, including those identified in Table 3-3.

CHAPTER 7: PUBLIC PARTICIPATION

EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). EPA is provided public notice of the draft Trinity River sediment TMDL by placing a notice in the Times Standard, Trinity Journal, Record Searchlight and Sacramento Bee, newspapers of general circulation in the Trinity River watershed area and in other areas potentially affected by the decision. EPA has prepared a written response to all written comments on the draft TMDLs received by EPA through the close of the comment period on November 19, 2001.

EPA held a public information meeting regarding the purpose and scope of the Trinity TMDL at the initiation of the assessment process on July 6, 2000 in Weaverville. EPA gave TMDL information presentations to the Natural Resource Advisory Committee of Trinity County and also attended several Trinity River Task Force and Technical Advisory Committee meetings to keep their members informed of the TMDL development process. On August 21 and 22, 2001, in Trinity Center and Douglas City, the Trinity County Resource Conservation District and a landowners group, sponsored workshops for local residents to learn about TMDLs. EPA has also met individually with numerous agencies, citizens, businesses and organizations during the process of developing this TMDL. Finally, public informational meetings were held on October 30 and November 6, 2001 (during the public comment period to provide any interested parties opportunities to obtain further information and present comments regarding the draft TMDL.

References

Aguilar, Bernard. Associate Fisheries Biologist, California Department of Fish and Game. 2001. Personal communication. September.

Bias, Paul. 2001. Trinity River interviews. Prepared as a class requirement at Humboldt State University.

Bilby, Robert E. and James W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in western Washington. Transactions of the American Fisheries Society, 126.

Boles, G.L. 1980. Macroinvertebrates abundance and diversity as influenced by substrate size in the Trinity River. Department of Water Resources, Northern District. January, 1980.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Historical decline and current status of coho salmon in California. North America Journal of Fisheries Management. Vol. 4, No. 2.

Chapman, D.W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Transactions of the American Fisheries Society. Volume 117, No. 1.

CDFG (California Department of Fish and Game). 1994a. Petition to the Board of Forestry to list Coho Salmon (Oncorhynchus Kisutch) as a Sensitive Species. California Department of Fish and Game. Sacramento CA.

CDFG (California Department of Fish and Game). 1994b. Annual Report, Trinity River Basin salmon and steelhead monitoring project, 1991-1992 season. Inland Fisheries Division, Sacramento, CA.

CDFG (California Department of Fish and Game). 1996. Annual Report, Trinity River Basin salmon and steelhead monitoring project, 1991-1992 season. Inland Fisheries Division, Sacramento, CA.

CDFG (California Department of Fish and Game). 2001. Letter from Robert McAllister (CDFG). June 7.

CDFG-Water Pollution Control Laboratory. 1996. California stream bioassessment procedure. Rancho Cordova, CA.

CDWR (Department of Water Resources). 1980. Mainstem Trinity River watershed erosion investigation.

De la Fuente, J., T. Lauent, D. Elder, R. VendeWater, A. Olsen. 2000. Watershed condition assessment beta-test results of northern province forests. Pacific Southwest Region, US Forest Service.

Everest, Loren. Fisheries Biologist, Shasta Trinity National Forest. August, 2001. Personal communication.

Flosi, Gary, S. Downier, J. Hopelain, M. Bird, R. Coey and B. Collins. 1998. California salmonid stream habitat restoration manual, third edition. California Department of Fish and Game. Inland Fisheries Division. Sacramento, CA.

Fredericksen, Kamine, and Associates. 1980. Proposed Trinity River Basin fish and wildlife management program, Appendix B - sediment and related analysis. Report prepared for Bureau of Reclamation by Trinity River Basin Fish and Wildlife Task Force, Sacramento, CA.

Glase, J.D. 1994. Monitoring juvenile salmon and steelhead outmigrants produced in the upper Trinity River, Northern California, 1991-1993 progress report. U.S. Fish and Wildlife Service, Trinity River Restoration Program, progress report.

GMA (Graham Matthews and Associates). 2001a. Gravel quality monitoring in the mainstem Trinity River. Prepared for Trinity County Board of Supervisors. Weaverville, CA.

GMA (Graham Matthews and Associates). 2001b. Trinity River sediment source analysis for the Trinity River, Trinity County, CA. Prepared for Tetra Tech, Inc.

Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. Stream channel reference sites: an illustrated guide to field technique. USDA Forest Service, General Technical Report RM-245.

Harvey, Bret C., and Thomas E. Lisle. 1998. Effects of suction dredging on streams: a review and an evaluation strategy. fisheries 23(8): 8-17.

HVT (Hoopa Valley Tribe). 2000. Water quality control plan Hoopa Valley Indian Reservation. Prepared by the Hoopa Valley Tribal Environmental Protection Agency.

Knopp, Chris. 1993. Testing indices of cold water fish habitat. North Coast Regional Water Quality Control Board and California Department of Forestry, Santa Rosa. CA.

Kondolf, G.M. 2000. Assessing salmonid spawning gravel quality. Transactions of the American fisheries Society 129:262-281.

LaFaunce, D.A. 1963. King (chinook) salmon spawning escapement in the upper Trinity River, 1963. Marine Resources Administrative Report No. 65-3. California Department of Fish and Game.

Leland, David, North Coast Regional Water Quality Control Board. 2001. Personal communication. August.

Lewis, Jack. 1998. Evaluating the impacts of logging activities on erosion and suspended sediment transport in the Casper Creek watersheds. In: Proceedings of the Conference on Coastal Watersheds: The Casper Creek Story. USDA Forest Service Gen. Tech. Rep. PSW-GTR-168.

Lisle, Thomas E. 1989. Sediment transport and resulting deposition in spawning gravels, north coastal California. Water Resources Research. Vol. 25., no. 6. Pp. 1303-1319. June.

Lisle, T.E. and S. Hilton. 1992. The volume of fine sediment in pools: an index of sediment supply in gravelbed streams. Water Res. Bulletin. 28:2. Paper No. 981120. April 1992.

Matthews, G. and Anderson. 1997. Mainstem Trinity River draft sediment total maximum daily load reconnaissance survey.

McBain, S. and W. Trush. 1997. Trinity River maintenance flow study final report. Prepared for the Hoopa Valley Tribe, Trinity River Task Force.

McBain, S. and W. Trush. 2000. Spawning gravel composition and permeability within the Garcia River watershed, CA. Report submitted to Mendocino County RCD, Ukiah, CA.

McNeil, W.J. and W.H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed materials. U.S. Fish and Wildlife Service Special Scientific Report-Fisheries 469. January.

Moffett, J.W. and S.H. Smith. 1950. Biological investigations of the fishery resources of Trinity River, California. Special Scientific Report No. 12. US Fish and Wildlife Service.

Montgomery, D.R. and J.M. Buffington. 1993. Channel classification prediction of channel response and assessmetn of channel condition. Final report TFW-SH10-93-2002.

NMFS (National Marine Fisheries Service). 1995. Endangered and threatened species: Proposed threatened status for three contiguous ESUs of Coho Salmon ranging from Oregon through Central California. Department of Commerce. National Oceanic and Atmospheric Administration. Federal Register/Vol. 60, No. 142/Tuesday, July 25, 1995/Proposed Rules.

NMFS (National Marine Fisheries Service). 1996. Making Endangered Species Act determinations of effect for individual or grouped actions at the watershed scale. US Department of Commerce. National Oceanic and Atmospheric Administration.

Pacific Watershed Associates. 2000. Results of stream channel survey and sampling Grass Valley Creek watershed Trinity County California. Final Report. Prepared for County of Trinity and the Trinity River Restoration Program.

Phillips, R.W., R.L. Lantz, E.W. Claire, and J.W. Moring. 1975 Some effects of gravel mixtures on emergence of coho salmon and steelhead trout fry, Trans. Am. Fish. Soc., 104: 461-466.

Quihillalt, Rick R. 1999. Mainstem Trinity River fall chinook salmon spawning redd survey, 1996 through 1998. Prepared for US Fish and Wildlife Service. Arcata, CA.

Raines, M. 1998. South Fork Trinity River sediment source analysis, draft. Tetra Tech, Inc. October, 1998.

Reid, L.M. and T. Dunne. 1996. Rapid evaluation of sediment budgets. Reiskirchen: Catena Verlag, Germany..

Regional Water Board (North Coast Regional Water Quality Control Board). 1996. Water quality control plan for the North Coast Region. Adopted May 23, 1996. Santa Rosa. CA.

University of California Committee on Cumulative Watershed Effects. 2001. A scientific basis for the prediction of cumulative watershed effects. University of California Wildland Resource Center Report No. 46.

Sigler, J.W., T.C. Bjornn and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transactions of the American Fisheries Society 113:142-150.

Tappel, P.D. and T.C. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. Idaho Cooperative Fishery Research Unit. North American Journal of Fisheries Management 2:123-135.

USBLM (Bureau of Land Management). 1995. Mainstem Trinity River watershed analysis. Section VI, Detailed Investigations. Redding Resource Area.

USDA Forest Service and USDI Bureau of Land Management. 1994. Record of decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl, and standards and guidelines for management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl (FSEIS ROD). Volumes I and II. Portland, OR. Apr. 1994.

USFS (Forest Service). 1988. Habitat typing report Canyon Creek. Prepared by Shasta-Trinity National Forest under contract to the Bureau of Reclamation.

USFS. 1989. Habitat typing survey of Big French Creek. Prepared by Shasta-Trinity National Forest under contract to the US Bureau of Reclamation.

USFS. 1991. Stream habitat report. Shasta-Trinity National Forest. Weaverville, CA

USFS. 1997. An ecosystem strategy for maintaining the ecological processes that create and sustain good aquatic habitat in the basins of the Shasta-Trinity National Forests. Adopted by Forest Leadership Team. May 8, 1997.

USFS. 1998. Stream condition inventory guidebook version 4.0. Final Draft. Pacific Southwest Region.

USFS. 1999. Roads Analysis: Informing Decisions about managing the National Forest Transportation System. Misc. Rep. FS-643. Washington, D.C.: U.S. Dept. of Agriculture Forest Service. 222 p.

USFS. 2000a. New River watershed analysis. Pacific Southwest Region, Shasta-Trinity National Forest. May.

USFS. 2000b. Horse Linto, Mill, and Tish Tang watershed analysis. Six Rivers National Forest, Eureka, CA.

USFS. 2000c. Rating watershed condition: Reconnaissance level assessment for the National Forests of the Pacific Southwest Region. Pacific Southwest Region. June.

USFS. 2000d. Effects of the 19999 Big Bar Fire on selected streams in the New River watershed. Shasta Trinity National Forest report.

USFS. 2001a. 2000-01 Chinook and Coho spawning report. Lower Trinity Ranger District. Six Rivers National Forest. Prepared by Kenneth Fetcho and Bryan Drew.

USFS. 2001b. Final environmental impact statement fuels reduction for community protection phase 1. Pacific Southwest Region. Six Rivers National Forest..

USDI. 2000. Record of decision for the Trinity river mainstem fishery restoration final environmental impact statement/environmental impact report. December, 2000.

US EPA. 1991. Guidance for water quality-based decisions: The TMDL process, EPA 440/4-91-001.

US EPA. 1998. South Fork Trinity river and Hayfork Creek sediment total maximum daily loads. Region IX Water Division. San Francisco, CA. December 1998.

US EPA. 1999. Noyo River TMDL for Sediment. San Francisco, CA.

US EPA. 2001. Memo to file re: wasteload allocations for Trinity River TMDL.

US FWS and CDFG. 1956. A plan for the protection of fish and wildlife resources affected by the Trinity River Division, Central Valley Project.

US FWS and HVT (Hoopa Valley Tribe). 1999. Trinity River flow evaluation final report. June.

US FWS. 1983. Final environmental impact statement. Trinity River Basin fish and wildlife management program. U.S. Department of Interior, U.S. Fish and Wildlife Service, Sacramento, CA. INT/FES 83-53.

US FWS, US Bureau of Reclamation, Hoopa Valley Tribe, Trinity County. 1999. Public draft Trinity River mainstem fishery restoration: Environmental impact statement/report.

Weaver, W.E. and D.K. Hagans. 1994. Handbook for forest and ranch roads: a guide for planning, designing, constructing, reconstructing, maintaining and closing wildland roads. Prepared for the Mendocino County Resource Conservation District, Ukiah, CA, in cooperation with the California Department of Forestry and Fire Protection and the USDA Soil Conservation Service.

Wilcock, P.R., G.M. Kondolf, A.F. Barta, W.V.G. Matthews, C.C. Shea. 1995. Spawning gravel flushing during trial reservoir releases on the Trinity River.

Ziemer, Robert. 1998. Proceedings of the conference on coastal watersheds: The Casper Creek story. USDA Forest Service Gen. Tech. Rep. PSW-GTR-168.

Glossary

Aggradation	Elevated stream channel bed resulting from deposition of sediment.
Anadromous	Refers to aquatic species which migrate up rivers from the sea to breed in fresh water.
Beneficial Use	Uses of waters of the state designated in the Basin Plan as being beneficial. Beneficial uses that may be protected against quality degradation include, but are not limited to: domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and the preservation and enhancement of fish, wildlife and other aquatic resources or preserves.
Basin Plan	The Water Quality Control Plan, North Coast Region-- Region 1.
CDF	The California Department of Forestry and Fire Protection.
CDFG	The California Department of Fish and Game.
CWE	Cumulative Watershed Effects. "Cumulative impacts are defined in the Board of Forestry Forest Practice Rules (CDF 2000) by reference to the CEQA Guidelines (Section 14 CCR 15355). Paraphrased, they are defined as two or more individual effects, which, when considered together, make a significant (usually adverse) change to some biological population, water quality, or other valued resource, or which compound or increase other environmental effects. The individual effects may be changes resulting from a single project or a number of separate projects…"(UC Committee on Cumulative Effects 2001).
Debris torrents	Long stretches of bare, generally unstable land areas or stream channel banks scoured and eroded by the extremely rapid movement of water-laden debris, commonly caused by debris sliding or road stream crossing failure in the upper part of a drainage during a high intensity storm.
Deep-seated landslide	Landslides involving deep regolith, weathered rock, and/or bedrock, as well as surficial soil. Deep seated landslides commonly include large (acres to hundreds of acres) slope features and are associated with geologic materials and structures.
Drainage structure	A structure or facility constructed to control road runoff, including (but not limited to) fords, inside ditches, water bars, outsloping, rolling dips, culverts or ditch drains.
Embeddedness	The degree that larger stream bed sediment particles (boulders, rubble or gravel) are surrounded or covered by fine sediment. It is usually visually estimated in classes (<25%, 25-50%, 50-75%, and >75%) according to percentage of random large particles that are covered by fine sediment.
EPA	The United States Environmental Protection Agency.
Erosion	The group of processes whereby sediment (earthen or rock material) is loosened, dissolved, or removed from the landscape surface. It includes weathering, solubilization, and transportation.
ESU	An Evolutionarily Significant Unit is a term used by NMFS to identify a distinctive group of Pacific salmon or steelhead for purposes of the federal Endangered Species Act.
Flooding	The overflowing of water onto land that is normally dry.
FWS	The United States Fish and Wildlife Service
Fry	A young juvenile salmon after it has absorbed its egg sac and emerged from the redd.
GIS	Geographic Information System.
Head of Riffle	The beginning (i.e., upstream end) of a riffle.
HVT	Hoopa Valley Tribe
Inner gorge	A geomorphic feature generally identified as that area of stream bank situated immediately adjacent to the stream, having a slope generally over 65% and being situated below the first break in slope above the channel.
Inside ditch	The ditch on the inside of the road, usually at the foot of the cutbank.
KRIS	Klamath Resource Information System
Landslide	Any mass movement process characterized by downslope transport of soil and rock, under gravitational stress by sliding over a discrete failure surface-- or the resultant landform.
Large woody debris	A piece of woody material having a diameter greater than 30 cm (12 inches) and a length greater than 2 m (6 feet) located in a position where it may enter the watercourse channel.
LRMP	Land and Resource Management Plans for US Forest Service lands.
Mass wasting	Downslope movement of soil mass under force of gravity-- often used synonymously with "landslide." Common types if mass soil movement include rock falls, soil creep, slumps, earthflows, debris avalanches, debris slides and debris torrents.
NMFS	The United State National Marine Fisheries Service.

Pool Tail-out	The downstream end of a pool, where the main current narrows, forming a “tail.”
Reach	The stretch of water visible between bends in a river or channel.
Redd	A gravel nest or depression in the stream substrate formed by a female salmonid in which eggs are laid, fertilized and covered with gravel for a period of incubation.
Regional Water Board	The California Regional Water Quality Control Board, North Coast Region.
Riffle	A rocky shoal or sandbar lying just below the surface of a stream, or the stretch of choppy water caused by such a shoal or sandbar.
ROD	Record of Decision, Trinity River Mainstem Fishery Restoration Final Environmental Impact Statement / Environmental Impact Report (December 2000)
Sediment	Fragmented material that originates from weathering of rocks and decomposed organic material that is transported by, suspended in, and eventually deposited by water or air.
Sediment delivery	Material (usually referring to sediment) which is delivered to a watercourse channel by wind, water or direct placement.
Sediment discharge	The mass or volume of sediment (usually mass) passing a watercourse transect in a unit of time.
Sediment source	The physical location on the landscape where earthen material resides which has or may have the ability to discharge into a watercourse.
Sediment yield	The total amount of sediment (dissolved, suspended, and bed load) passing through a given cross section of a watercourse channel in a given period of time.
Shallow -seated landslide	A landslide produced by failure of the soil mantle on a steep slope (typically to a depth of one or two meters; sometimes includes some weathered bedrock). It includes debris slides, soil slips and failure of road cut-slopes and sidecast. The debris moves quickly (commonly breaking up and developing into a debris flow) leaving an elongated, concave scar.
Skid trail	Constructed trails or established paths used by tractors or other vehicles for skidding logs. Also known as tractor roads.
Steep slope	A hillslope, generally with a gradient greater than 50%, that leads without a significant break in slope to a watercourse.
Stream	See watercourse.
Stream order	The designation (1,2,3, etc.) of the relative position of stream segments in the drainage basin network. For example, a first order stream is the smallest, unbranched, perennial tributary which terminates at the upper point. A second order stream is formed when two first order streams join. Etc.
Tail-out	The lower end of a pool where flow from the pool, in low flow conditions, discharges into the next habitat unit, usually a riffle. Location where spawning generally occurs.
TCRCD	Trinity County Resource Conservation District
Thalweg	The deepest part of a stream channel at any given cross section.
Thalweg profile	Change in elevation of the thalweg as surveyed in an upstream-downstream direction against a fixed elevation.
TRFE	Trinity River Flow Evaluation
TRMFR EIS	Trinity River mainstem Fishery Restoration Environmental Impact Statement
TMDL	Total Maximum Daily Load.
Unstable areas	Locations on the landscape which have a higher than average potential to erode and discharge sediment to a watercourse, including slide areas, gullies, eroding stream banks, or unstable soils. Slide areas include shallow and deep seated landslides, debris flows, debris slides, debris torrents, earthflows, inner gorges, and hummocky ground. Unstable soils include unconsolidated, non-cohesive soils and colluvial debris.
V*	A numerical value which represents the proportion of fine sediment that occupies the scoured residual volume of a pool, as described by Lisle and Hilton (1992). Pronounced "V-star."
Watercourse	Any well-defined channel with a distinguishable bed and bank showing evidence of having contained flowing water indicated by deposit of rock, sand, gravel, or soil.
Waters of the state	Any ground or surface water, including saline water, within the boundaries of the state.
Watershed	Total land area draining to any point in a watercourse, as measured on a map, aerial photo or other horizontal plane. Also called a basin, drainage area, or catchment area.
Water Quality Criteria	Numeric or narrative criteria established under the Clean Water Act to protect the designated uses of a water.

Water Quality Indicator	An expression of the desired instream or watershed environment. For each pollutant or stressor addressed in the problem statement, an indicator and target value is developed.
Water quality objective	A State Basin Plan term equivalent to the Clean Water Act's water quality criteria. Water quality criteria are limits or levels of water quality constituents or characteristics established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area.
Water quality standard	A Clean Water Act term which includes the designated uses of a water, the water quality criteria established to protect the designated uses, and an antidegradation policy.