U.S. Environmental Protection Agency
Region IX

Trinity River
Total Maximum Daily Load
for Sediment

Approved by:

/s/ 20 December 2001

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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)

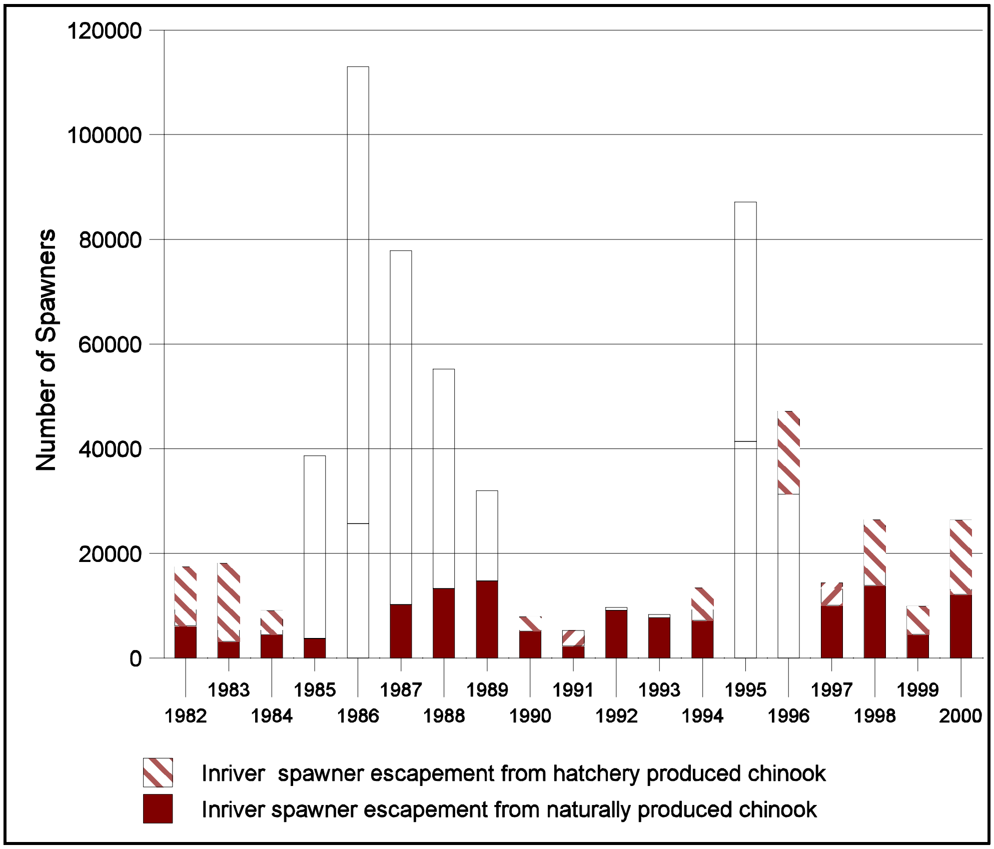
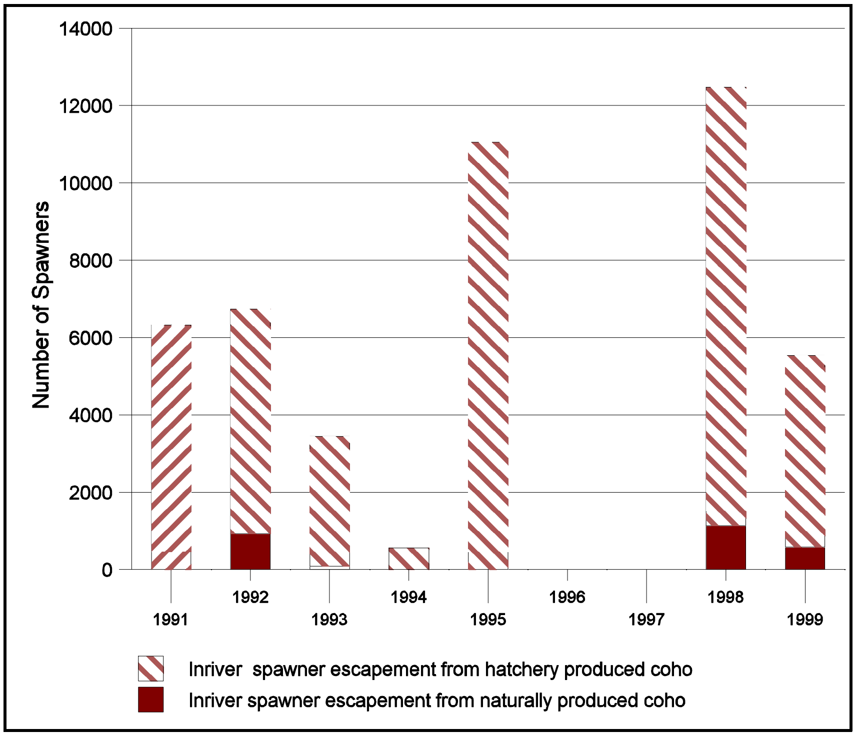


Figure 2-2. Coho spawner escapement in the Trinity river above Willow Creek, 1991-1999, data not available ‘96, ‘97. (Source: CDFG 2001, US FWS 1999)



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

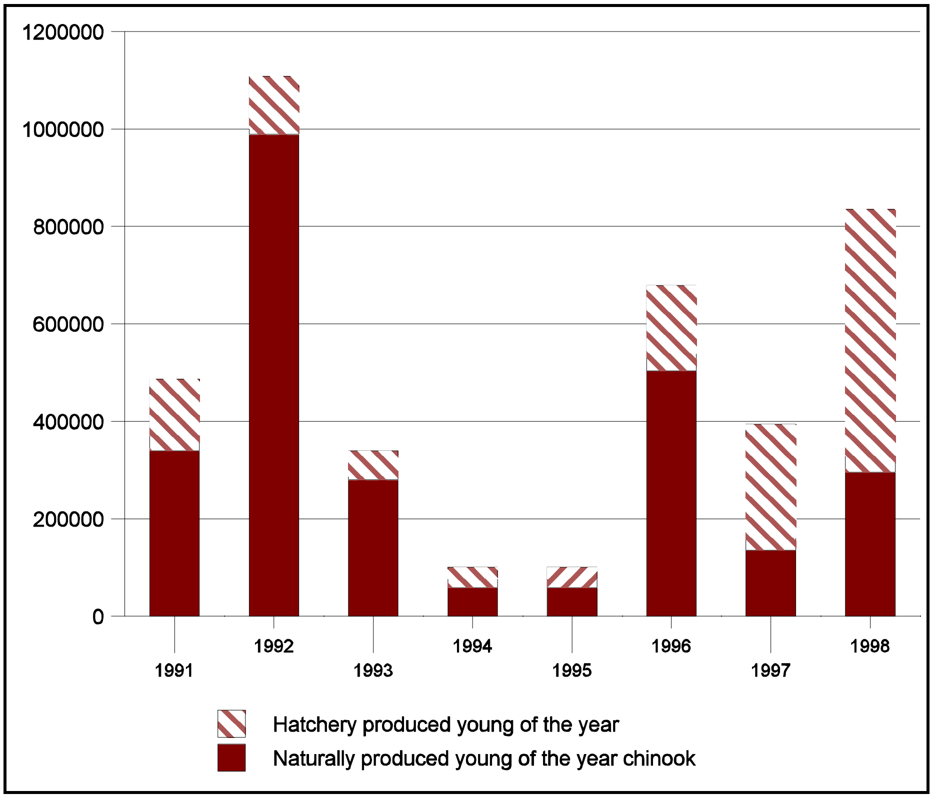
The annual pre-dam estimates of fall chinook escapement averaged 45,600 based on a few studies conducted between 1944 and 1963. Based on yearly estimates from 1982 through 2000, the CDFG estimated that the river below Lewiston produced an average of 11,932 fall chinook salmon which is 19 percent of the 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)

Tributary impairment:
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.

Healthy Subwatersheds:
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.

<u>Impaired areas</u>:
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.

<u>Healthy Subwatersheds</u>:
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.

<u>Impaired areas</u>:
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.

Target: Improving trend (increase) in particle size distribution as measured by median particle diameter (D_{50}) and geometric mean (Dg).

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*

<u>Target: <0.21 (Franciscan geology) or <0.10 (stable geology)</u>
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).

<u>Trinity Data</u>: 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

<u>Target: improving trends in EPT, % dominant taxa and species richness indices</u>
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.

<u>Trinity Data</u>: 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.

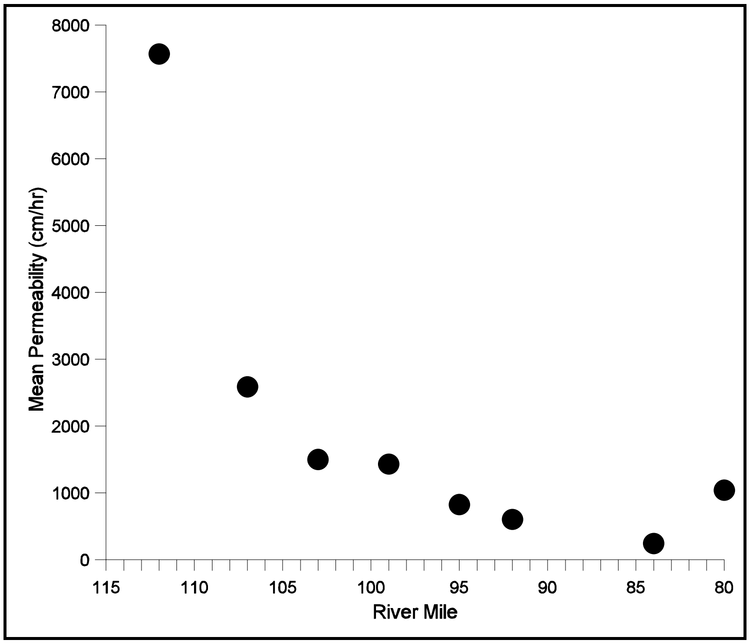
Permeability:

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

Road Surface Erosion

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.

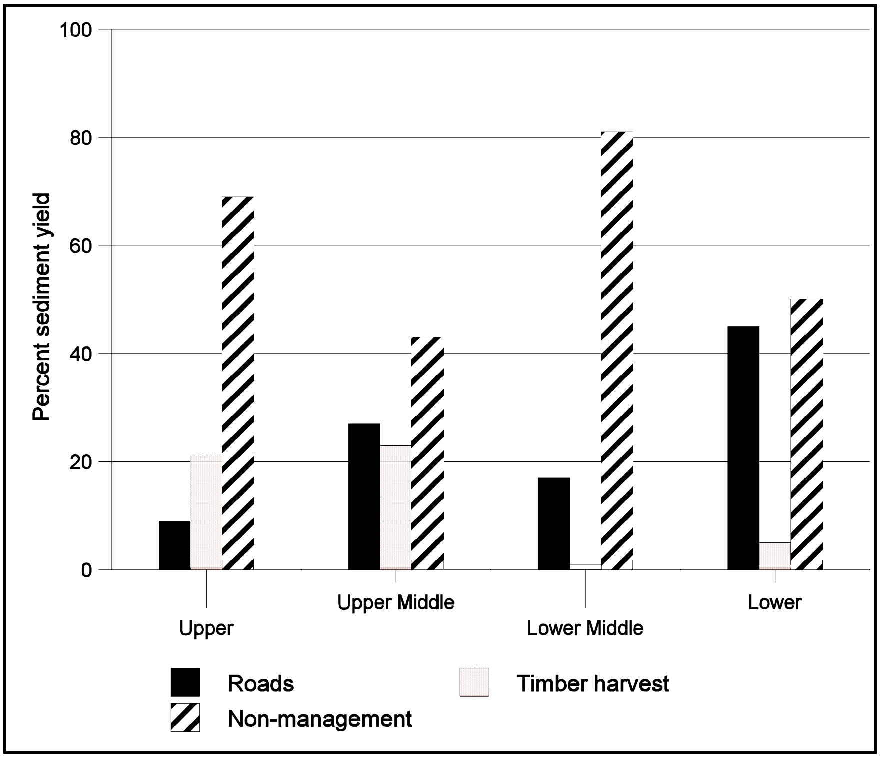
4.2. Summary of Sediment Source Inputs

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)				
		<u>Reference Subwatersheds</u>[1] (235 mi2)	<u>Westside Tributaries</u>[2] (93 mi2)	<u>Upper Trinity</u>[3] (161 mi2)	<u>East Fork Tributaries</u>[4] (115 mi2)	<u>East Side Tributaries</u>[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)					
		<u>Weaver and Rush Creeks</u> *(72 mi2)*	<u>Deadwood Creek, Hoadley Gulch and Poker Bar Area</u> *(47 mi2)*	<u>Lewiston Lake Area</u> (25mi2)	<u>Grass Valley Creek</u> [1] *(37 mi2)*	<u>Indian Creek</u> *(34 mi2)*	<u>Reading and Browns Creek</u> *(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
Manage ment	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
Manage ment	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,

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[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,

$$\text{Background Rate}_{\text{subarea}} \times 1.25 = \text{TMDL}_{\text{subarea}}.$$

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.

$$\text{TMDL}_{\text{subarea}} - \text{Background Load Allocation} = \text{Management Allocation}$$

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
Manage ment	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)	<u>Aquatic Conservation Strategy, Northwest Forest Plan</u> - Watershed Analysis (WAs) - Riparian Buffer network - Key Watershed <u>Best Management Practices per MAA</u>[1] <u>Fisheries/Water Programs per LRMPs</u> <u>National Road Plan</u>	- 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)	<u>California Forest Practice Rules (FPRs),</u> - 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)	<u>Technical and Financial Assistance Programs</u>: 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)	<u>5 County Salmon Recovery Program</u> <u>County General Plan</u>	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	<u>Trinity River Restoration Program</u> <u>CalTrans statewide NPDES permit</u> 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.

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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.