Mad River Watershed Assessment

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In memory of Brian J. Hunt, Mad River Watershed Management Plan Stakeholder Advisory Group Member, who grew up on the Mad River and helped us tell its story.

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1 INTRODUCTION

In 1992, the Environmental Protection Agency added the Mad River to California's Clean Water Act Section 303(d) impaired water list due to elevated sedimentation/siltation and turbidity. The North Coast Regional Water Quality Control Board (RWQCB) identified water temperature as an additional impairment to the watershed in 2006. The Total Maximum Daily Loads (TMDL) for sediment and turbidity were established in accordance with Section 303(d) of the Clean Water Act on 21 December 2007. The TMDL for temperature had not been developed during preparation of this assessment.

The purpose of the Mad River TMDL is to identify the total amount (or load) of sediment or turbidity (expressed as suspended sediment) that can be delivered to the Mad River and tributaries without exceeding water quality standards and to subsequently allocate the total amount among the sources of sediment in the watershed. The allocations, when implemented, are expected to achieve the applicable water quality standards for sediment and turbidity in the Mad River basin.

The goal of the Mad River Watershed Management Plan (MRWMP), of which this watershed assessment is a part, is to set forth a strategy to protect and restore the beneficial uses of the Mad River, particularly as they relate to sediment and temperature effects. One way to help achieve this goal is to develop a watershed assessment that describes the historical and current conditions within the basin, provides information that can be used to prioritize areas that could benefit from beneficial management and restorative activities, and establishes baseline data against which the effectiveness of future management and restoration actions can be measured.

This assessment focuses on potential sediment influences on instream salmonid habitat and channel processes. It is not intended to answer a larger set of questions that relate to managed flow, growth and survival of estuarine species, recreation, amphibians, mammals, or other subjects. These are left for other researchers to assess at a later date.

1.1 Analysis Overview

The overall goal of this Watershed Assessment is to describe the vegetation, hydrologic, geomorphic, and aquatic habitat conditions in the Mad River basin and the land use patterns that have affected these conditions over the historical time period. To achieve this goal, the assessment (1) characterizes the hydrology of the Mad River basin, (2) describes erosion and sedimentation processes in the basin, (3) discusses the relative abundance and distribution of salmonids, and (4) describes aquatic habitat conditions at a sub-basin level. The assessment focuses on sediment and temperature issues that have led to 303d listings in the basin.

This assessment utilized some of the procedures contained in the Washington Forest Practice Board Level One methodology (Version 4.0) and the USDA Forest Service's Federal Guide for Watershed Analysis (Version 2.2). The assessment approach was generally a literature review and compilation, which helped generate answers to a variety of critical questions. Literature was collected from many published and unpublished sources including work by local government (e.g., Humboldt County Department of Public Works, Humboldt Bay Municipal Water District, Humboldt County Board of Supervisors), state and federal resource agencies (e.g., USDA Forest Service, US Geological Survey, Environmental Protection Agency, US Army Corps of Engineers, California Department of Water Resources, California Department of Fish and Game, California Department of Transportation), private industry (e.g., industrial timber companies and commercial aggregate extractors), large landowners, and graduate students. This watershed assessment also draws extensively from historical archives, including historic and current aerial photographs, and from communications with landowners and land managers in the Mad River watershed. The critical questions that will be addressed in this assessment include:

Hydrology and Water Quality

- What are the hydrologic characteristics of the Mad River basin?
- What is the flood history in the basin?
- What are the known or perceived water quality impairments in the Mad River?
- What are the causes and sources of these water quality impairments?
- What are the historic and ongoing management efforts aimed at controlling the causes and sources?

Geology/Erosion Processes

- What are the dominant sediment sources and source areas in the watershed?
- What is the relative importance of different erosion processes in source areas?
- What are the relative sediment delivery rates from source areas and how have they changed over time?
- How much sediment is stored in stream channels and how has it changed over time?

Fisheries/Stream Channel

- What is the distribution of salmonids in the basin? What barriers may affect upstream or downstream fish movement?
- What are the current salmonid habitat conditions (pool:riffle:flatwater percentages, residual pool depths, shade canopy) in the various subwatersheds and how do these compare to conditions observed during historic surveys?
- Is spawning gravel suitable for successful incubation and emergence of young fish?
- What are the relatively recent and/or current water temperatures in the WAA? Are regional air temperature patterns reflected in basin water temperature patterns?
- Are some subwatersheds experiencing higher water temperatures than others?

Synthesis

- How have stream channels been affected by sediment delivery in the watershed?
- Do instream habitat conditions (pool:riffle:run lengths; residual pool depths) follow sediment delivery trends?
- What are the natural and human-caused changes in the historic and current channel condition?
- What are the potential effects of suspended sediment and turbidity on salmonids in the Mad River watershed?
- Are there reaches where stream temperatures exceed preferred and stressful thresholds? What may be the reasons for the observed water temperatures?

1.2 Report Organization

The remainder of this report includes compilation of available information on human management history, hydrology and water resources (Section 2), erosion processes and sediment dynamics (Section 3), distribution and abundance of salmonids (Section 4), and historical and current fish habitat (Section 5). Summary of these individual resource areas is followed by a synthesis of the available physical and biological information, focusing on the influence of management-related sediment delivery and water temperature influences on listed salmonids and their habitat (Section 6), and identification of critical information gaps that limit effective management of salmonids in the basin (Section 7). The report concludes with recommendations for future monitoring and data collection (Section 8).

2 WATERSHED SETTING

The Mad River drains approximately 497 square miles of the Coast Range Geomorphic Province and empties into the Pacific Ocean north of Humboldt Bay in Humboldt County, California. The basin is about 100 miles in length and averages six miles wide. Elevations range from sea level at the mouth to 3,000 feet along the western ridge to 6,000 feet in the headwaters. Vegetation in the watershed is composed of early to late seral coniferous forests, hardwoods, and grasslands. Rainfall averages 40 inches along the coast to over 80 inches at the higher elevations.

2.1.1 Primary subwatersheds, sub-basins, and tributaries

Principal tributaries to the Mad River include South Fork Mad River, North Fork Mad River, Barry Creek, Pilot Creek, Deer Creek, Bug Creek, Graham Creek, Blue Slide Creek, Boulder Creek, Maple Creek, Canõn Creek, Lindsey Creek, and Mill (Hall) Creek. Matthews Dam impounds Ruth Lake and releases water that serves the industrial and residential customers of the Humboldt Bay Municipal Water District. For the purposes of this watershed assessment (WA), the watershed was broken into 3 subwatershed areas and 13 sub-basins based on similar characteristics (Figure A-1):

The 3 subwatershed areas, based on geomorphic characteristics are:

- The Upper Mad River extending from the headwaters to Matthews Dam on Ruth Reservoir (120 square miles comprising 24% of the basin),
- The Middle Mad River between Matthews Dam and about the confluence of Cowen Creek (157 square miles comprising 29% of the basin), and
- The Lower Mad River from about Cowan Creek to the mouth (226 square miles comprising 45% of the basin).

The 13 sub-basins, which are nested within the 3 subwatersheds, are:

- Upper Mad River, which covers 41,920 acres, begins in the headwaters and extends to about one-mile downstream of Barry Creek,
- Ruth Lake, which encompasses 35,200 acres, begins about 2 miles above Armstrong Creek and extends downstream to Matthews Dam (RM [RM] 84),
- Upper Middle Mad River, which covers approximately 23,168 acres and begins at Matthews Dam and extends downstream for about 23 miles before ending about a mile downstream of County Line Creek,
- Pilot Creek, is located at about RM 58, the approximate midpoint of the Mad River basin, encompasses approximately 25,408 acres, and is mostly contained within the Six Rivers National Forest with less than 5% privately owned,
- Lower Middle Mad River sub-basin encompasses approximately 52,032 acres, begins upstream of Pilot Creek at approximately RM 61 and continues downstream for about 19 miles before ending at Cowan Creek,
- Boulder Creek enters the Mad River at about RM 30 and encompasses approximately 12,160 acres,
- The Maple Creek sub-basin enters the Mad River at about RM 28 covers approximately 9,984 acres,

- Cañon Creek, Cañon Creek enters the Mad River at about RM 20 and encompasses approximately 10,432 acres,
- Lower Mad River, sub-basin covers approximately 41,152 acres, extends upstream from the Mad River Hatchery (RM 17) to Graham Creek, a distance of 27 miles. The sub-basin encompasses approximately 41,167 acres,
- North Fork Mad River, which enters the Mad River at the town of Blue Lake covers approximately 31,232 acres,
- Lindsay Creek sub-basin that enters the lower reach of the Mad River near the community of Glendale and encompasses approximately 11,328 acres,
- Powers Creek sub-basin, which is located between RMs 4 and 17, extends from approximately the Highway 101 Bridge to the Mad River Hatchery, and encompasses approximately 17,088 acres, and
- Mouth of Mad River sub-basin is located between the Highway 101 Bridge and the Pacific Ocean, contains approximately 10,944 acres, and is mostly intertidal in nature.

Several native Endangered Species Act (ESA) listed and nonlisted fish species currently inhabit the watershed including, but not limited to, Chinook and coho salmon, summer and winter-run steelhead, resident rainbow trout, coastal cutthroat trout, California roach, three-spine stickleback, riffle and prickly sculpins, Pacific lamprey, brook lamprey, and green sturgeon. Non-native fish species include brown bullhead, channel catfish, Sacramento sucker, largemouth bass, crappie, and bluegills.

The USDA Forest Service and Bureau of Land Management manage most of the upper one-third of the watershed. Private ownership includes industrial timber lands (Green Diamond Resource Company, Sierra Pacific Industries, and Humboldt Redwood Company), smaller private non-industrial timber and ranch lands, and rural residential properties. Land uses in the watershed include industrial and nonindustrial timber management, ranching and agriculture, gravel mining, urban and rural residential development, road infrastructure, and power and gas line operations (Table **2-1**).

Table 2-1. Land use within the Mad River basin.

Sub-watershed	Sub-basin	Sub-basin area (mi^2)	Channel length (mi)	Road density (mi/mi^2)	Land use					
					Timber	Recreation	Water supply	Ranching	Infrastructure	Residential
Upper	Upper Mad River	65.5	241.9	3.1	✓	✓	✓			
	Ruth Lake	55.0	228.9	3.3	✓	✓	✓		✓	✓
Middle	Upper Middle Mad River	36.2	158.1	3.4	✓	✓		✓	✓	✓
	Pilot Creek	39.7	169.8	2.6	✓	✓				
	Lower Middle Mad River	81.3	378.4	3.0	✓			✓		

Sub-watershed	Sub-basin	Sub-basin area (mi^2)	Channel length (mi)	Road density (mi/mi^2)	Land use					
					Timber	Recreation	Water supply	Ranching	Infrastructure	Residential
Lower	Boulder Creek	19.0	85.7	3.0	✓			✓	✓	
	Maple Creek	15.6	65.2	4.7	✓			✓	✓	
	Cañon Creek	16.3	66.9	7.0	✓			✓		
	Lower Mad River	64.3	280.4	4.5	✓	✓	✓	✓	✓	
	North Fork Mad River	48.8	188.5	7.4	✓				✓	
	Lindsay Creek	17.7	67.0	7.6	✓			✓		✓
	Powers Creek	26.7	91.5	6.9	✓	✓	✓	✓	✓	✓
	Mouth of Mad River	17.1	54.8	6.9		✓		✓	✓	✓

2.1.2 Vegetative regimes and classification method

The Mad River watershed is characterized by predominantly conifer, and mixed conifer and hardwood stands, which total more than 68% of the entire Mad River basin. About 13% of the watershed's area is dominated by other hardwoods and mixed oak woodland. Approximately 11% of the watershed is comprised of various shrub species, with an additional 7% of grassland area remaining. See Table 2-2 for Mad River watershed vegetation types, species, size classes and exact acreages. Three vegetation maps, representing the lower, middle, and upper watershed are presented in Appendix A (Figures A2a–c). The vegetative regime of the watershed has been altered by human management practices, as discussed in greater detail within Section 1.4 of this document. The vegetation types used in the appended Mad River Watershed Maps are aggregated from the original 159 classes of the vegetation classification (Fox et al. 1997).

The spectral classification system was patterned after California's Wildlife-Habitat Relationships (WHR) Classification System (Mayer and Laudenslayer 1988). The team could not match the WHR classification system exactly because spectral signatures from the Landsat Thematic Mapper Sensor sometimes failed to discriminate specific WHR habitat types and sometimes discriminated more detail than is required by WHR. Therefore, the WHR Classification System was modified to match the spectral capabilities and limitations of Landsat satellite imagery. Essentially, the team provided a physiognomic habitat type emphasizing vegetation structure and leaf shape (broadleaf or needle-leaf). The data source, Landsat Thematic Mapper satellite imagery, was acquired between 22 June and 9 August 1994.

Table 2-2. Vegetative Classes and acreage within the Mad River Watershed.

Map class	Includes vegetation types	Examples	Size class	Percent herbaceous, shrub, or canopy closure	Mad River watershed acreage
Grass	Green and dead grass and forbs, wet meadows and marsh	Grass, sedges, reeds	N/A	2–100	23,557
Conifers & Mixed Conifer-Hardwoods	Ranges from mixed conifer <20% broadleaf to mixed hardwood-conifer >50% broadleaf	Redwoods, fir, pine, cottonwood, alder, maple	1"+ DBH	2–100	215,567
Hardwoods	<20% needle-leaf	Cottonwood, alder, maple, madrone	1"+ DBH	2–100	18,612
Mixed Oak Woodland	Oak dominated broad-leaf	Coast live oak, California black oak	1"+ DBH	2–100	21552
Shrubs	Greenleaf Shrubs, deadstick shrubs, soft shrubs	Blackberry, Ceanothus, chaparral, manzanita, sage	N/A	10–100	36,098

2.2 Mad River Watershed Management History

The Mad River watershed has been significantly influenced by a host of natural and anthropogenic events (Table 2-3). Land use practices have evolved from the Native American use of fire as a tool to promote the development of cultural materials and food resources to industrial forestry as a means of maintaining economic opportunity. Human habitation has also changed from scattered Native villages to urban centers located around the floodplains and bay. Euro-American development of the Mad River basin began in the mid-1800s and continues today.

2.2.1 Pre-European native management practices and history in the watershed: pre-ethnographic- mid-1800s

2.2.1.1 Climate

The climate within the area has been temperate/ moderate within the last 3,000 years, with warmer temperatures and a drier vegetative regime preceding this period. Prior to the present cooling period, the temperature was approximately 1 to 2 degrees Celcius warmer, and open grasslands with mixed open woodland stands predominated. Since this period, the climate has been very similar to present conditions, and has supported larger stands of Douglas fir and conifers, with increased rainfall and cooler temperatures (USDA Forest Service 1998).

2.2.1.2 Human population and settlement patterns

The first human influence in the Mad River watershed occurred between 5,000 and 10,000 years ago with the migration of early aboriginal peoples and their settlement throughout the region (USDA Forest Service 1998). Archaeological research on South Fork Mountain in Six Rivers National Forest has yielded the earliest reliable radiocarbon date of ca. 8000 years before present (or ca. 6500 B.C.) for the oldest dated prehistoric house structure.

Table 2-3. Mad River Watershed management history timeline

1854 – Humboldt Bay and Mad River Canal Company formed

1854-1900 – Some flow diverted into Humboldt Bay via Mad River Canal used for log transport

Feb. 1, 1905 – U.S. Forest Service established

April 1905 – Trinity National Forest est. (encompassed Mad River Ranger District at the time)

1908 – Small parcel at Blue Lake designated as a "land for homeless Indians" under Executive Order

1910 – Gaging stations constructed to study Mad River flows

1933 – Mad River water first diverted to City of Eureka

1938 – Sweasey Dam constructed

1947 – Six Rivers National Forest est. by President Truman (includes Mad River Ranger District)

1954 – Blue Lake Rancheria wrongfully terminated under Public Law 85-671 with trust lands dissolved

1955 – Major flood event

1956 – Humboldt Bay Municipal Water District formed

1960s – Sweasey Dam filled and no longer functional

1961- Matthews Dam and Ruth Reservoir constructed

1964 – Major flood event (Ruth Reservoir overflowed spillway)

August 1970 – Sweasey Dam removed by dynamiting

1970s – Butler Valley Dam proposed and reviewed

February 1971 – Mad River Fish Hatchery facilities completed

1972 – Forest Practice Rules (FPR) introduced

1972 – Major storm events

1976-1977 - Drought

1983 – Blue Lake Rancheria federally re-recognized with settlement of Tillie-Harwick Lawsuit

1989 – Blue Lake Rancheria tribal government organized under IRA Constitution approved by the Secretary of the Interior

1992 – Major upgrade to FPRs

1994 – Mad River PEIR for gravel mining

1995 – Six Rivers Nat'l Forest Land and Resource Management Plan

1995 – Major storm event

1996 – Final EIS for Pilot Creek published

1996 – Corps of Engineers Letter of Permission (LOP) of instream gravel extraction operations

1997 – Major storm events

1997 – Coho salmon federally ESA listed as Threatened in the Mad River

1998 – Upper Mad River Watershed Assessment

1999 – Chinook salmon federally ESA listed as Threatened in the Mad River

2000 – Steelhead trout federally ESA listed as Threatened in the Mad River

2000 – Threatened and impaired FPRs introduced.

2004 – Humboldt Bay Municipal Water District Habitat Conservation Plan

2004 – New LOP and Individual Clean Water Act 404 Permits, NMFS Biological Opinions, and adaptive management strategies for instream gravel extraction operations

2004 – CDFG Recovery Strategy for California Coho Salmon published

2005 – Coho salmon state-listed as Threatened under CESA

2007 – Green Diamond Resource Company Aquatic Habitat Conservation Plan published

2008 – Mad River TMDL established for sediment impairment

Prior to the arrival and sustained settlement of Euro-American settlers in the mid-1800s, the native peoples occupying the lower Mad River watershed were the Wiyot (from approximately Blue Lake to its mouth, plus the greater Humboldt Bay region) who spoke a dialect affiliated with the Algonquian language family, with upriver reaches controlled by three different groups whose languages are related to the Athabascan family, the Whilkut, Nongatl and Lassik (Baumhoff 1958). Today, among these distinct groups, only the Wiyot-affiliated Blue Lake Rancheria is a Federally-recognized tribe and holds lands in trust for its citizens. The Whilkut, Nongatl and Lassik were essentially annihilated during the Indian Wars of the 1860s.

Based on existing resources/ resource patterns and limited archaeological and ethnographic information, a basic understanding about the subsistence practices, settlement and land use patterns and resource management practices of the resident aboriginal groups inhabiting the Mad River watershed in prehistory can be constructed. Each group practiced a hunter-gatherer subsistence regime, moving about within their territories in a seasonal round to fish, hunt, gather and collect animal, plant and geological resources according to natural growth and reproductive cycles. Each group occupied a portion of the Mad River watershed (plus adjacent lands, with some overlapping with Redwood Creek as well) that was generally recognized by neighboring groups, where they controlled primary access to a range of terrestrial and riverine resources. Limited ethnographic data infer that the Whilkut (and their neighbors the Chilula, who occupied the lower portion of Redwood Creek), were expanding their control westerly into Wiyot territory through warfare just prior to historic contact.

Key subsistence resources included deer and elk, steelhead, salmon and other native fishes, acorns and a variety of native seeds, berries, bulbs and corms. A broad range of medicinal plants were gathered. Redwood trees provided an important source for making houses made of split planks; and nearer the bay and coast, the Wiyot made hand-hewn canoes from redwood logs. Locally available chert was mined for making flaked-stone tools, and cobbles and pebbles were gathered for making grinding implements (important to acorn and seed consumption), hammerstones and other ground and battered stone tools. Basket weaving was (and continues to be) an important tradition and involved the tending and gathering of suitable materials including willow, redbud, deergrass, woodwardia and five-fingered ferns and other plant fibers. Each group participated in trade networks to obtain more distant, desirable resources (e.g., obsidian, marine shells used for regalia), and many participated in intertribal ceremonials and gatherings. An extensive trail network linked the communities together, and these routes were largely adapted by the early Euro-American settlers as foot and horse trails, and later used for mule pack trains to transport supplies from the coast to the interior gold mines.

Winter-occupied villages were typically focused along the larger rivers and streams, with warm, southern exposures and near secondary freshwater sources (spring seeps and creeks). Smaller, more seasonally used base camps were often located no more than a one to two day walk from the permanent village. The seasonal camps, including ones located at higher elevations (especially at prairie margins on major trending ridges), were places used by smaller family groups that dispersed in the late spring and returned to their villages in the fall with extra stores to get through the leaner winter months.

The region's mosaic patterning of vegetative communities is recognized as being among the most biologically rich, diverse and productive environments in the world. It is observed that, "the population density within the North Coast Ranges during the ethnographic period equaled, or in some cases surpassed, the population density of agricultural societies in other portions of aboriginal North America"(USDA Forest Service 1998).

Native American sites are represented archaeologically in the watershed as deposits characterized as villages, camps, resource extraction and processing locales, task-specific sites (e.g., chert quarries) and trail scatters. Additionally, places important to tribal histories and current tribal identities are characterized as traditional cultural properties, and these may or may not have archaeological signatures (e.g., basket material plant resource areas).

2.2.1.3 Fire, wildlife and vegetation management

As was the case across California, native peoples of the area practiced frequent burning of forests and grasslands, as evidenced by "historical accounts in their description of open, park-like forests in the mid-1800s" (USDA Forest Service 1994). According to the Watershed Analysis for Pilot Creek, a major lower Mad River tributary,

> Fire scars on 200- to 300-year-old trees in the upper Mad River basin show fire recurrence of about 13 years. The multiple-aged nature of Douglas fir stands in the area and the high fire frequency suggest that low intensity ground fires were the common mode of burning by natives. (USDA Forest Service 1994).

There were likely higher groundwater levels during the pre-Euro-American period of human management, primarily due to the temperature decrease and precipitation increase, and prescribed fire practices, since "oak woodlands use less water than conifer forests" (Keter 1993).

The impacts of prehistoric native hunting and fishing are largely unknown, especially since little archaeological excavation or investigation has been conducted. Brush weirs and nets were most likely employed by the tribes of the Mad River watershed for catching anadromous fishes. Later, European settlers enlisted the help of native peoples in hunting and trapping, therefore it can be assumed that there was an extensive aboriginal history of hunting/ trapping wildlife and knowledge of animal migration patterns. Tribes throughout the watershed and region are known to have relied heavily on the abundant fishery, both for subsistence and cultural identity. Fishery information prior to European settlement is lacking, and early anecdotal accounts from this period are the primary source of knowledge about prior ways of life.

2.2.2 Early European influence: mid-1800s-1930s

2.2.2.1 Human population, settlement patterns and conflict

The primary early Euro-American influence in the watershed was that of, trappers and fur traders, homesteaders, U.S. military, and pack trains capitalizing upon the gold miners' need for supplies in the Trinity, Klamath and Salmon rivers of the interior. The period from the late-1700s through the mid- to late-1800s was characterized by patchy, rugged Euro-American settlements, violent skirmishes between the tribes and newcomers triggered in large part by the establishment of pack train routes through the interior tribal territories, military use of fire to burn out resident peoples, and small grazing and agricultural operations associated with homesteads. The period from 1900 to 1930 marked the beginning of public lands management, a transitioning agricultural economy, increased timber interests, and waning isolated homesteads/ more consolidation of human communities.

The U.S. Army attempted to rid Humboldt County of its native population throughout the mid - 1800s, and the Mad River area became a primary staging ground for this effort. The period from roughly 1850 to the 1860s, now dubbed the "Indian Wars," resulted in "the 'Two Years Wars during which the military actively pursued the local Indians. During this period, the remote areas of Board Camp Mountain, Pilot Ridge, South Fork Mountain and Grouse Creek provided refuge for people of several tribes. The Army in turn used South Fork Mountain as a vantage point for locating the Indians they were pursuing" (USDA Forest Service 1994). Though this information is specific to the Pilot Creek sub-watershed, much of the lower and middle Mad River watershed served as protection for escaping coastal and inland resident tribes. The Army retaliated and attempted to oust those hiding in the forest by setting enormous fires. This destroyed extensive portions of the watershed due to the unnatural fire pattern, and may be a key to the changes in vegetation that followed. The impact on the tribes was catastrophic – innumerable people were massacred, and "captured Indians were placed on the Round Valley, Smith River, Klamath or Hoopa Valley Indian Reservations" (USDA Forest Service 1994). Those who escaped the introduced deadly diseases, starvation, extermination, or resettlement experienced difficulty practicing traditional subsistence practices and retaining a tribal identity, especially the Whilkut, Lassik and Nongatl groups.

In 1908, a small parcel adjacent to the town of Blue Lake was set aside by the U.S. Government as a "land for homeless Indians," where a small community of survivors from several different groups were confined. This was the historical roots of the present Blue Lake Rancheria Tribe. Following the initial slaughter of area native groups, there is little evidence of native management; being limited almost entirely to Forest Service accounts of fires set by Indians (and by homesteaders who often married Indian wives) in the early 1900s.

The initial Euro-American interest in the Mad River watershed was related to the interior northwest California gold mining rush, and the purpose of early exploration was to "establish a transportation link between the coastal communities [Union/ Union Town {now Arcata}, Eureka and Trinidad Bay] and the gold mines… The first trail linking these communities was developed in 1852, and passed along the southern edge of Pilot Creek" (USDA Forest Service 1994). The Josiah Gregg expedition is credited with extensive exploration of what is now Humboldt County, as well as the incident that purportedly gave the Mad River its name. A member of the exploration team called the river the Mad after Dr. Gregg unleashed his raging temper on his crew (CDWR 1965). The Gregg party first crossed the mouth of the Mad River in December 1849 and observed that its mouth was located quite near the present-day mouth (Haynes n.d.).

Although there may have been some isolated fur trappers and traders visiting or residing in the watershed prior to the mid-1800s, most information that exists points to homesteading families and trade suppliers as the first Euro-American permanent residents of the Mad River watershed (excluding the very lower watershed immediately adjacent to the mouth, which included the thriving settlement of Union Town, now Arcata). Euro-American settlers began to establish homesteads along the mainstem and in tributary sub-basins of the Mad River in the mid-1800s. These early homesteading families lived very rugged, subsistence-based lifestyles that relied on hunting and fishing, supplemented by some livestock and harvests from kitchen gardens and orchards. While the coastal communities around Humboldt and Trinidad Bays were flourishing and growing rapidly, inland areas along the Mad River remained remote and far less populous.

The rapid growth of communities along coastal Humboldt County resulted in an equally rapid need for infrastructure, development and resources. Drinking water and large quantities of industrial water were needed for the swelling populace, and flooding had increased due to the recent major changes in the watershed caused by logging, diking and intensive grazing. Sweasey Dam was constructed in 1938 slightly upstream of the City of Blue Lake, which was incorporated in 1910. Sweasey Dam provided water to the City of Eureka for a relatively short period of time, and filled with sediment much sooner than expected. Residents of the City of Arcata (outside of the Mad River watershed boundaries) predominantly received water from the Jolly Giant Creek Dam, which was build in 1937 and still exists, though it no longer serves any water supply needs. Flow studies began to be conducted on the Mad River as early as 1910.

One seemingly minor development in the early 20th century shaped the future development of the lower Mad River/ the City of Arcata immensely: the birth of a local university. By the early 1900s, the population in the Humboldt Bay area had grown large enough to need an institution for higher education. Arcata competed fiercely with Eureka and, to some degree, Fortuna, to host a University. The college, now known as Humboldt State University, was formally designated in 1913 by then-governor Hiram Johnson, and was initially referred to as the “Humboldt County Normal School”. The school opened in 1914 with 55 students, and occupied a different location in Arcata than it now does, on 11th and M streets. In the first two years of its existence, the school was moved to its current grounds and was temporarily housed in simple wooden structures. The name of the school was altered in 1921 and it was then called the Humboldt State Teachers College, and became simply Humboldt State College in 1935. The College began to offer bachelor’s degrees in 1927, and took on a role different from its early one as a teacher’s college.

2.2.2.2 Resource-based economy and development

The coastal towns quickly grew, with strong fisheries (whale, salmon and shark), early logging and milling, some agriculture, and the ongoing economic boom associated with inland gold. The Trinity River experienced the well-documented gold rush, and the town of Weaverville became the county seat for Trinity County in 1851, which encompassed Humboldt County at the time. “In 1853, the State Legislature divided Trinity County into two parts, designating the western portion as Humboldt County” (CDWR 1965). Logging began in Humboldt County and in portions of the Mad River in the 1850s, and these coastal communities were immediately instrumental to the transport and milling of lumber. The Humboldt Bay and Mad River Canal Company, formed in 1854, established a year-round channel between the Mad River and Humboldt Bay by deepening and widening natural sloughs. This channel was utilized for floating logs, predominantly spruce, from the Mad River – where logging was occurring in conjunction with grazing/ farmland creation – to Humboldt Bay for milling. Logging in the lower watershed in the 1850s consisted of smaller timber which little “pioneer” mills could handle, not the enormous redwoods milled from the late 1860s onward (Haynes n.d.). By the 1860s – ‘70s, logging and railroad technologies had improved rapidly and massive trees could be felled and transported to the mills.

Early logging practices in the Mad River basin brought extreme impacts due to primitive road-building technologies and inherently destructive log and equipment ground transportation practices, which often involved dragging logs in or near streams. Until 1915, animals were used to skid logs down “corduroy roads” (logs placed adjacent to each other and perpendicular to the channel with soil placed in cracks and voids) that were built in lower order streams and draws. Later, use of animals gave way to steam power for both ground lead yarding and log transport on rail. The “Dolbeer” steam donkey engine took the place of horse and oxen teams for skidding logs downhill to rail spurs that were built on or alongside area watercourses. In the 1930s, this method was replaced by tractor skidding with arches, which created wide skid trails usually located low on slopes. Early removal of old-growth stands involved clearcutting, ground-based logging methods (corduroy roads, steam donkeys, railroads), use of fire to clear slash and debris, and lack of erosion control. Size limitations for harvestable trees and requirements for minimization of impacts were not implemented until well into the 20th century. These early practices resulted in changes in hydrology, increased landsliding, and channel headcutting.

The Union Wharf and Plank Walk Company (Union Company having been the major impetus behind the development and naming of Union Town, now Arcata) constructed a large raised railway that extended for miles into Humboldt Bay in 1854. This provided the town of Union with access to the deep-water areas of Humboldt Bay, allowed use of the Bay as a major port and enabled Union to compete economically with the nearby municipality of Eureka. Initially, this railway was horse-powered, and later became a steam-powered railway when the Arcata Transportation Company took over in 1875. In 1881, the railway was incorporated as the Arcata and Mad River Railroad (locally referred to as the Annie and Mary line), infrastructure was vastly improved, and the railroad served an area from the port in Arcata to the town of Korbel, about 7.5 miles distance total. The primary usage of the railroad was transport of timber, as floating logs downriver had proved to be extremely difficult – it could only be accomplished during high flows, but then it was difficult to manage the movement of the logs. The railroad also transported passengers, predominantly millworkers and lumbermen, until about 1931.

The Euro-American settlement of the watershed resulted in extensive grazing, agricultural changes and rangeland/ vegetation impacts. Vast wooded areas were logged to create suitable grazing lands, trees were felled slowly by girdling, brush and understory were frequently cleared by burning, and invasive grass species were introduced. Additionally, hunting of wildlife seems to have increased, as "over 125,000 deer were killed in the Mad River area between 1855 and 1885" (USDA Forest Service 1994), however, exact numbers of animals hunted by the area's tribes previously is unknown and comparisons are difficult to draw.

Cattle were introduced immediately upon Euro-American arrival, especially throughout the lower watershed. The creation of farm and grazing land in former forests, wetlands, and seasonal grazing areas for wildlife required immense effort and a complete landscape transformation. The 'Arcata Bottoms' were cleared of forested stands, inland public land areas of the watershed supported large numbers of cattle and sheep, and ultimately, animal densities and needs altered the natural setting. Sheep grazing increased in the 1870s and remained high through the 1890s, since "a high tariff had been placed on wool immediately after the Civil War" (USDA Forest Service 1994). High-density grazing increased soil compaction, particularly near springs and waterways, and "had some of the same effects as fire: tree seedlings were destroyed, shrubs repressed, and the forest understory kept clear" (USDA Forest Service 1994). The introduction of invasive annual grasses altered vegetation, wildlife habitat and fire behavior.

While the timber industry was booming in the lower watershed and Humboldt Bay communities in the later 1800s, the upper portion of the Mad River and several large sub-basins saw high cattle production. Although many of the new timber companies purchased land throughout the watershed, often the land was used to raise cattle in order to feed their burgeoning populations of timber workers. Timber began to be extracted at significantly higher rates in the mid-1900s.

Gravel mining first occurred in the 1930s in the lower watershed near Blue Lake, although it occurred at low levels. Wet pits and trenches were the preferred extraction method of the only operator at the time, Mercer-Fraser.

2.2.2.3 Public lands establishment and management

The U.S. Forest Service was established on February 1, 1905, an act that eventually served as a major agent of change. The Trinity National Forest, which encompassed what is now the Mad River Ranger District, was amongst the first designated National Forests, also established in 1905. However, when the Forest Service first came into being it had little effect on grazing, the primary watershed land use at the time. The Forest Service did try to suppress fires, though "limited technology allowed little suppression success" (USDA Forest Service 1994) until after World War II, when a technology leap occurred. The USDA Forest Service continuously opposed controlled and intentional burns from its inception until much later in the 1900s. Homesteaders had largely abandoned their lands and sold their parcels to timber companies by the early 1930s, and much of the damage from overgrazing had been done. "Because of overgrazing and deterioration of the grasslands, the Forest Service closed the watershed to open range grazing in about 1934…[remaining livestock] were regulated by permit" (USDA Forest Service 1994), yet grazing on remaining private lands continued with decreased intensity.

Hatchery fish from Quinnat River stock were introduced to the Mad River in 1912. This coincides with the push in the early 1910s to designate the Mad River for sportfishing only, a departure from some early commercial fishing that occurred in the lower watershed. The California Department of Fish and Game began fish counts and monitoring in the late 1930s in conjunction with the construction of Sweasey Dam, tracking fish that passed through the fish ladder. The populations of coho, Chinook and steelhead observed at the time are given in Section 5 of this document.

2.2.3 1940s–1990

2.2.3.1 Watershed conditions and weather

Due to increased population, human activity, and monitoring in the watershed, more notable weather events have been recorded for this time period. In 1955 and 1964, some of the largest and most devastating floods occurred in the region, and the effects of intensive grazing, road-building and timber harvesting began to be evident. The mid- to late-1970s brought several instances of major winter storms and summer/ fall droughts, which impacted physical processes as well as land usage and management, especially grazing and fires. Anecdotal information from long-time residents suggests that water quality was noticeably affected by major weather events during the 1950s – 1970s. Observers have repeatedly indicated that water was cleaner and less turbid/ clearer prior to the flooding and storms of this approximately 20-year period.

2.2.3.2 Human population, settlement patterns and water usage

The Mad River again experienced a tide of human influence and interest in the mid-20th century. For approximately two decades, the middle and upper watershed had been largely abandoned by settlers, National Forest management had reduced impacts on vegetation from grazing and was exercising more control over public lands, and many of the largest landowners were timber companies sitting on their holdings. In 1947, Six Rivers National Forest was established, which included the Mad River Ranger District. Although the watershed had been a part of Trinity National Forest since the early 1900s, the new designation provided more funding and oversight for public forest lands, which remained primarily in the upper half of the watershed. The lower watershed continued to see much higher rates of growth and development than the remainder of the watershed, predominantly due to the lucrative timber/ lumber industry and still-abundant fishery. During the later part of the century – the 1980s and especially the 1990s – management efforts emphasized increased mitigation or minimization of environmental impacts.

In 1983, Blue Lake Rancheria (BLR) was re-recognized by the Federal Government as a sovereign Indian nation and assigned 32 acres of land adjacent to the City of Blue Lake, after decades of unlawful termination. The Tribe's environmental program has been active since 1998, and its activities are discussed in section 2.4.4.1.

In 1947, Humboldt State College in Arcata offered its first post-graduate degrees. From 1950 – 1973, Humboldt State grew rapidly under college president Cornelius Siemens. Construction on the campus was ongoing, to keep up with interest and enrollment in the university. More than 20 buildings were added to the university complex between 1950 and 1990. The population growth associated with the university assumed more and more influence on the economy and community of Arcata throughout this period of rapid expansion. Businesses and economic activities centered on students, and appealing to students became an important element of Arcata's economy. Although Humboldt State offered a junior college for a time, the program was terminated in 1962 and another institution took up the post to offer two-year, technical and trade degrees. The Redwood Community College District, formed in 1964, established the primary campus of the College of the Redwoods on the southern end of Humboldt Bay, south of Eureka. This community college has provided lower-cost educational opportunities and has also influenced the area greatly since its inception. Since the establishment of several strong natural resources programs in their early history, both colleges have been known for their training in ecological understanding and management, a legacy that influences the communities in the lower Mad River immensely.

The Humboldt Bay Municipal Water District was chartered in 1956 to provide water to several lower Mad River communities for both domestic and industrial use. Various water diversions and impoundments were proposed and enthusiastically pursued during the mid-century period, yet Matthews Dam, built in 1961, was the sole modification created of this size and scope. The storage capacity of Ruth Reservoir is approximately 48,800 acre-feet. The dam includes a 2-megawatt hydroelectric facility, in operation since 1981. The Water District sells energy produced by the plant to Pacific Gas and Electric Company. The creation of Ruth Reservoir via Matthews Dam increased recreation, especially fishing and boating, in the inland portions of the watershed. The reservoir also increased interest in second-home buying along the "lake"shore, and hunting/fishing cabins popped up throughout the area. In 1976, the Water District installed a surface water diversion facility in addition to the existing Ranney Wells, from which the District's industrial customers get their water. The total amount of water distributed from the surface collection unit and the Ranney Wells varies widely based on industrial production, population and water consumption levels and activities of the communities receiving Mad River water.

2.2.3.3 Resource-based economy and development

The mid-20th century saw the largest logging boom in the history of the watershed as a whole. According to the USDA Forest Service, "by the 1950s, the market for Douglas fir was increasing, and logging and road-building were steadily pushing into eastern Humboldt County" (USDA Forest Service 1994). Logging occurred throughout the watershed on both private and public lands (e.g., USDA Forest Service and Bureau of Land Management holdings). Use of railroads for log transport diminished and transitioned into truck roads in the 1940s. Truck roads were commonly built in place of the pre-existing railroad grades. These legacy activities occurred without regulation, watercourse protection concerns, or erosion control and heavily impacted water resources and stored aquatic habitat. In 1973, the California Forest Practice Act (Z'berg-Negedly) was passed which applied to all privately held timberland and included requirements for water resource protection. Forest Practice Rules (FPR) adopted under the Act included measures for watercourse protection and erosion control, clearcut size and spacing limitations, and equipment exclusion in stream channels and other sensitive areas. Tractor exclusion allowed the initiation of recovery of streambeds from direct impacts associated with logging. Riparian canopy retention standards were also established which were directed at reducing timber harvest-related increases in water temperatures. The FPR have been subsequently modified to include wider stream buffer zones, increased canopy retention standards, inner gorge protection, road management measures, and a host of other protective rules. The most notable FPR changes were implemented in 2000 and 2009 with the Threatened and Impaired Watershed Rules and the Anadromous Salmonid Protection Rules in response to continued decline in anadromous salmonid populations.

Large scale gravel mining began in the watershed in the 1950s, with instream pits and trenches being the primary extraction method. Prior to this period of intensive extraction, small scale extraction occurred in the reach between the Blue Lake Bridge and the Annie and Mary Railroad Bridge. Gravel mining was conducted by multiple operators, including Mercer-Fraser and Mad River Sand and Gravel. Until the early 1990s, extraction exceeded recruitment levels, resulting in streambed downcutting.

As of 1965, the "principal agricultural commodities…were dairy products, horticultural products and range livestock… [with the] first two produced mainly along the coast. The total production… of horticultural products – lilies and cut flowers – developed rapidly since 1940" (CDWR 1965). Hunting continued to occur at low to moderate levels in the middle/ upper watershed and the major sub basins, primarily because trails and roads remained minimal until the later 20th century.

2.2.3.4 Public resources and land management

The USDA Forest Service and, to some extent, the Bureau of Land Management which has very limited holdings in the Mad River, experienced an increase in fires. In the Pilot Creek sub-basin alone, there were over 60 fires between 1930 and the early 1990s. At least half of these were determined to be caused by human activity, with the remainder attributed to lightning strikes. Increased summer temperatures and drier winters throughout the 1980s brought significantly higher fire risk and culminated in widespread fire towards the end of the decade. Post-World War II, firefighting technology experienced a drastic leap, and aerial firefighting techniques became common. Fire suppression was one of the primary foci of the USDA Forest Service for much of this 50-year span.

The last population abundance study to date of wild-reared Mad River Chinook salmon was conducted in 1954. Coho salmon and steelhead spawner surveys and other counts were noted throughout the mid-1900s but did not attempt to estimate population. In 1971, the Mad River Fish Hatchery facility near the City of Blue Lake was completed. The hatchery currently rears steelhead for stocking in the Mad River and resident rainbow trout for planting in regional lakes. There has been an ongoing effort to mark and monitor hatchery steelhead separately from wild fish, though it is known that hatchery steelhead do spawn elsewhere in the watershed. It has been popular with the recreational fishing community, and has been supported financially by this community as well.

2.2.4 Recent human management and land use: 1990s-2008

2.2.4.1 Human population, settlement patterns and resource management changes

From the 1990s until 2008, the Mad River watershed has experienced relatively steady population growth, heightened environmental management, and more careful assessment of human impacts. The designation of habitat and water quality impairments, as well as threatened species present in and around the Mad River, have necessitated planning and coordination amongst historically isolated and independent stakeholders. State- and federally-mandated improvements to watershed health have also been accompanied by increased funding for watershed planning and assessment.

The 1990s saw increased emphasis on environmental effects, mitigation and responsibility. The gravel mining industry present in the lower Mad River began to assess the environmental impacts of their activities in the 1990s, and extraction methods and quantities were altered to improve watershed conditions. In 1994, the Mad River Program Environmental Impact Report (PEIR) was finalized and is currently being updated. The Mad River PEIR established a scientific review committee (CHERT) and led to a reduction in the volume of gravel that could be removed from the river. In 1997, the Letter of Permission (LOP) process was developed whereby the U.S. Army Corps of Engineers programmatically permitted instream gravel extraction operations and set specific requirements related to mining extraction, planning, and monitoring. The LOP process was refined in 2004 along with the issuance of individual CWA 404 permits and associated biological opinions for gravel mining operation in the Mad River. The individual 404 permits included an adaptive management strategy, site-specific extraction and mitigation measures, improved monitoring requirements, and additional measures to control sediment discharge. Gravel mining also requires a CDFG Code 1600 streambed alteration agreement.

While the amount of water collected by the Humboldt Bay Municipal Water District has slowly and steadily grown, the water usage for industrial purposes has diminished. The District operated five Ranney wells and one surface diversion facility concurrently at one time, however, the fifth Ranney well was decommissioned and the industrial water need for the primary clients around Humboldt Bay has dropped enormously, though the surface collector remains in use. In 2004, the HBMWD published the final version of their Habitat Conservation Plan, which specifies impacts and mitigating activities for the operation and maintenance of their facilities, with special emphasis on water releases from Ruth Reservoir and fish exclusion from the surface diversion facility.

In the late 2000s, Humboldt State University sought to increase the size of the student body to bring in income and balance out education budget cuts. The result was a jump in student numbers and surge of new students adding to the population of the lower Mad River vicinity. As of late 2008, Humboldt State University is still in the process of creating a Stormwater Management Plan. The University has seen extensive new construction with an emphasis on the energy conservation capacity of the new buildings. Many of the newer buildings have been certified "green" according to rigorous criteria for energy conservation. As a California State University System school, Humboldt State University has been aggressively recruiting people of color, women and other prospective minority student groups in an attempt to increase the diversity of the student body and meet state requirements. The result has been an increase in the school's ethnic and cultural diversity, as well as that of the nearby communities where these students reside.

The Blue Lake Rancheria (BLR) acquired an additional 40 acres in 2002, which included a portion of land reaching across the Mad River, that are now held in trust for the Tribe by the Bureau of Indian Affairs. As of 2008, the Tribe's holdings total about 80 acres, including both trust and fee lands. The Rancheria's congressionally-allocated lands do not include any Mad River frontage. In 2005, the BLR Environmental Programs Department began an EPA-funded water quality monitoring project that includes 4 sites on the Mad River from Pump Station #4 at the downstream end to the hatchery upstream. There are two sites on Powers Creek at the mouth and below the rodeo grounds, as well as two wetland sites. While extensive development has occurred on BLR lands, the Tribe has worked to minimize the impacts of these activities through careful planning. Parking lots and other paved surfaces have been designed to maximize infiltration and more than meet stormwater requirements. The Rancheria's Environmental Programs Department is working to monitor water quality conditions on the Mad River and is planning restoration activities for a wetland on tribal land to improve water quality and habitat conditions. While the TMDL does not apply to BLR, the Tribe fully supports regulation aimed at improving water quality and habitat in the watershed. In addition, in 2004, BLR entered into an Agreement with the National Park Service to assume certain responsibilities for heritage resources management pursuant to the 1992 amendments to the National Historic Preservation Act. The Tribe's Heritage Preservation Officer (THPO) is responsible for maintaining an inventory of Wiyot heritage places within the Tribe's geographic area of concern, which includes the lower half of the Mad River watershed, plus other lands in ancestral Wiyot territory. The THPO is versed in both Federal and State laws, policies and guidelines protecting Native American cultural places and resources, participating in environmental impact analyses for projects on and off the Rancheria and participating in tribal consultations with outside entities on a government-to-government basis.

2.2.4.2 Timber lands management

Green Diamond Resource Company (GDRCO), the largest landowner of timber-producing lands in the watershed, completed their Aquatic Habitat Conservation Plan (AHCP) in 2007. In 2008, Green Diamond obtained a consistency determination from the CDFG for protection of coho salmon under the California Endangered Species Act (CESA). Under the consistency determination, the AHCP, with minor modifications, was determined to be "consistent" with those measures deemed necessary by CDFG to minimize and fully mitigate impacts to coho salmon associated with Green Diamond's Federal incidental take permit.

Green Diamond has contributed information and personnel time to this watershed assessment and stakeholder advisory groups for the development of a management plan. Green Diamond Resource Company has gathered extensive data on wildlife and watershed conditions. Present regulatory requirements in the Mad River watershed include those emphasizing road-related protection measures necessary for anadromous salmonids. Extensive fisheries data has also been collected. These include road sediment source assessments and implementation of corrective measures to reduce road-related sediment delivery to area waters. Current rules require that as timber operations occur, those correctable legacy road problems are brought into compliance with today's standards providing a means to reduce sediment delivery and conduct watershed improvement. In 2008, GDRCO obtained a consistency determination from the California Department of Fish and Game (CDFG) for protection of coho salmon under the California Endangered Species Act (CESA). Under the consistency determination, GDRCO's AHCP, with minor modifications, was determined to be "consistent" with those measures deemed necessary by CDFG to minimize and fully mitigate impacts to coho salmon associated with GDRCO's federal incidental take permit.

Non-industrial timber management plans (NTMPs) and individual timber harvesting plans operate under the most recent forest practice rules developed for anadromous salmonid protection. The current rules require that roads are to be constructed and maintained to be "hydrologically disconnected" and as "hydrologically invisible" as possible to minimize sediment-related effects to area waters over the life of the road.

The current Forest Practice Rules specific to listed anadromous salmonids mandate the use of techniques to avoid or minimize road-related erosion and sediment delivery to watercourses. These techniques include installation of critical dips over fill crossings to prevent watercourse diversion, disconnection of inboard ditches to direct surface runoff into vegetative buffers, crossing assessment and armoring as needed, mulching for additional erosion control, energy dissipation to minimize scouring, rocking road surfaces near some crossings, and other site-specific stabilization methods. Given the potential for road-related sediment to affect aquatic habitat, the recent improvement of the FPRs, pending FPR updating relative to roads, and advances in erosion control techniques, it is expected that a substantial reduction in road-related sediment delivery is being realized and will continue.

2.2.4.3 Resource assessment, planning and regulation

More frequent fish surveys at various life stages were conducted in the 1990s by the California Department of Fish and Game and other wildlife and fisheries agencies, as discussed in Section 4 of this document. In 1997, coho salmon became the first salmonid species to be Federally-listed as threatened in the Mad River and its tributaries. In 1999 and 2000, Chinook and steelhead were also federally listed as threatened, respectively. Coho salmon were listed as threatened under the California Endangered Species Act (CESA) in the Mad River watershed in March 2005.

The US Forest Service also prepared more comprehensive management planning documents during this time period. The Six Rivers National Forest Land and Resource Management Plan was published in 1995, with several management documents related to smaller subbasins or segments of the watershed released earlier in the decade. The Forest Service adopted very different fire management techniques following the peak of fire suppression activities in the mid-20th century, and these more natural strategies continued into the 1990s and 2000s.

The US Environmental Protection Agency (EPA) enlisted Graham Matthews and Associates to conduct an analysis of sediment sources in the watershed; the final document was published in December 2007 following a peer review and public comment period. Concurrently, the EPA developed Total Maximum Daily Loads for Sediment and Turbidity, and by the end of December 2007 had released the document, appended by the Sediment Source Analysis. Additionally, as final reviews and edits were incorporated into the SSA and TMDL documents, the State of California quickly developed a sediment control task list and work plan and released the plan for public comment. Together with this Watershed Assessment and the subsequent watershed-wide management plan, the sediment assessment and criteria established in 2007 and 2008 represent the most cohesive watershed-wide management actions in the watershed's post-1800s human-influenced history.

2.2.4.4 Watershed restoration efforts

The Lower Mad River area and the Lindsay Creek subwatershed have become a primary focus for watershed restoration activities, including riparian revegetation, sediment reduction efforts, livestock exclusionary fencing, wetland habitat improvement and restoration, and roads improvement. Residents of the Lindsay Creek watershed have expressed willingness to work towards restoration and provide access for certain projects. Students and volunteers have participated in several volunteer work days in the Lower Mad River area near Arcata through 2008. The California Department of Fish and Game and the Humboldt Fish Action Council expect volunteer restoration work to continue in the Lower Mad River area. Additionally, local AmeriCorps programs and other volunteer service groups conduct trash and debris cleanups along the Mad River and tributaries on occasion.

The Blue Lake Rancheria's Environmental Programs Department has developed restoration components to some of their projects, including a riparian revegetation plan to be enacted in conjunction with a NOAA bridge replacement and streambed realignment project along Powers

Creek. Thus far, the only restoration project underway is at a wetland on the Rancheria, but BLR is drafting plans and seeking funding for restoration projects on Powers Creek and the Mad River.

2.2.5 Projected management and land use in the watershed

2.2.5.1 Population and settlement patterns

Population in the Mad River watershed is expected to increase moderately and steadily, particularly in the Lower Mad River area. As of 2008, the colleges in the area are attempting to increase the size of the student body and draw new residents to the area. Also as of 2008, Humboldt County is still in the process of updating their General Plan, including alterations to county zoning. Depending upon changes to the County's Plan or other rezoning projects, additional development could occur on land that is currently limited to rural or agricultural uses.

2.2.5.2 Public lands management

Public land areas are not expected to decrease. Additional lands could be acquired but the Mad River Ranger District does not expect the public land holdings to increase dramatically. The US Forest Service is an actively participating stakeholder in the Mad River Management Plan planning process. Their existing planning documents specify management priorities and criteria within certain subwatershed areas. The California Board of Forestry will be revising the roads section of the Forest Practice Rules to reflect the best available science and better organize the many road rules, starting in 2010.

2.2.5.3 Water quality and beneficial uses

The sediment and turbidty TMDLs established for the Mad River by the EPA and the associated Sediment Work Plan will inform the Mad River Management Plan with respect to sediment reduction. Additionally, the Mad River Management Plan will establish landowner and stakeholder actions to maintain beneficial uses of the waters of the State and U.S. within the watershed.

The Humboldt Bay Municipal Water District does not anticipate any drastic changes in their activities. They expect to continue fulfilling the requirements of their public charter. As of 2008, one of their primary industrial water users ceased industrial processing activities. Therefore, demand on Mad River water supplies decreased significantly. The District is currently assessing their operations and planning for their future.

The Blue Lake Rancheria will continue to monitor surface water and groundwater quality at multiple locations in the lower watershed as an element of their long-term water quality monitoring program funded by the U.S. EPA. Air quality data is also taken and compiled by the Rancheria's environmental program. The upper watershed will continue to be monitored by Green Diamond and the USDA Forest Service, the two largest landholders in that area.

1.4.1.1 Resource-based economic activities and land use

It is anticipated that resource-based economic activities currently underway in the watershed, including ranching, timber harvesting, and gravel mining, will continue at relatively the same levels. Limited yet continued expansion of residential development in the lower and middle watershed is expected. Additional commercial ventures and recreational river activities/access are currently proposed in the Giuntoli area of the City of Arcata, but are meeting resistance from existing area landowners who are concerned about degradation of the area.

1.4.1.2 Enhancement, outreach and education activities

Blue Lake Rancheria's Environmental Programs Department produces an Annual Water Quality report for Rancheria residents in December of each year. The Rancheria also reports all monitoring data to the U.S. EPA. The Tribe is seeking funding for enhancement projects at the mouth of Powers Creek and in the mainstem Mad River. Volunteer efforts including river cleanups and restoration work components are expected to continue and grow, as several local non-profits seek to involve more residents and students in these actions. Humboldt Fish Action Council has stated that they are planning enhancement/ restoration activities throughout the lower watershed and subwatersheds, including the Lindsay Creek area. Green Diamond Resource Company continues to fulfill the specified actions given in their HCP, which include road upgrades and other enhancement. CDFG has an ongoing salmonid lifecycle educational program affiliated with the Mad River hatchery, Salmon in the Classroom, and is open to the public for visits and information. Both of these opportunities for public education will be sustained. The AmeriCorps Watershed Stewards Project conducts salmonid lifecycle, habitat and watershed education throughout the lower Mad River area in K-12 schools, and its volunteer members participate in hatchery education, Salmon in the Classroom fish releases, and restoration activities/ workdays. Local planner and restorationist Aldaron Laird is planning estuary enhancement, and the Mad River bluffs are also a site for possible stabilization, monitoring, public trail access, and education.

3 HYDROLOGY AND WATER RESOURCES

3.1 Watershed Morphometry

The physiography of the Mad River drainage basin is controlled largely by regional geologic structure oriented in a north–northwesterly direction. The basin has an elongated drainage pattern and flows through a narrow and entrenched, V-shaped canyon throughout most of its length before entering a wide valley floor near the City of Blue Lake. The basin averages 6 miles wide varying from 3.5 miles wide near Forest Glen to about 11 miles downstream of Blue Lake. Elevations in the basin range from sea level at the river mouth near McKinleyville to 6,000 ft above mean sea level on the northern boundary of the basin.

The mainstem Mad River is 109 miles long with an estuary located at the mouth of the river where it empties into the Pacific Ocean. The longitudinal profile varies throughout the basin and can be best stratified into three segments (Figure 1). The upper basin segment upstream of Ruth Lake has a concave profile with slope decreasing near Ruth Lake. The low gradient mainstem channel in this segment occupies a wide floodplain where flow may become intermittent during dry summer months. The mid-basin segment between Ruth Lake and about the Cowan Creek confluence has a convex profile punctuated by alternating steeper and more gently sloping sections. The mid-basin river segment flows through unstable bedrock geology and is confined by steep side slopes. The lower basin river segment downstream of the Cowan Creek confluence returns to a concave profile as the valley bottom widens and the river begins to meander.

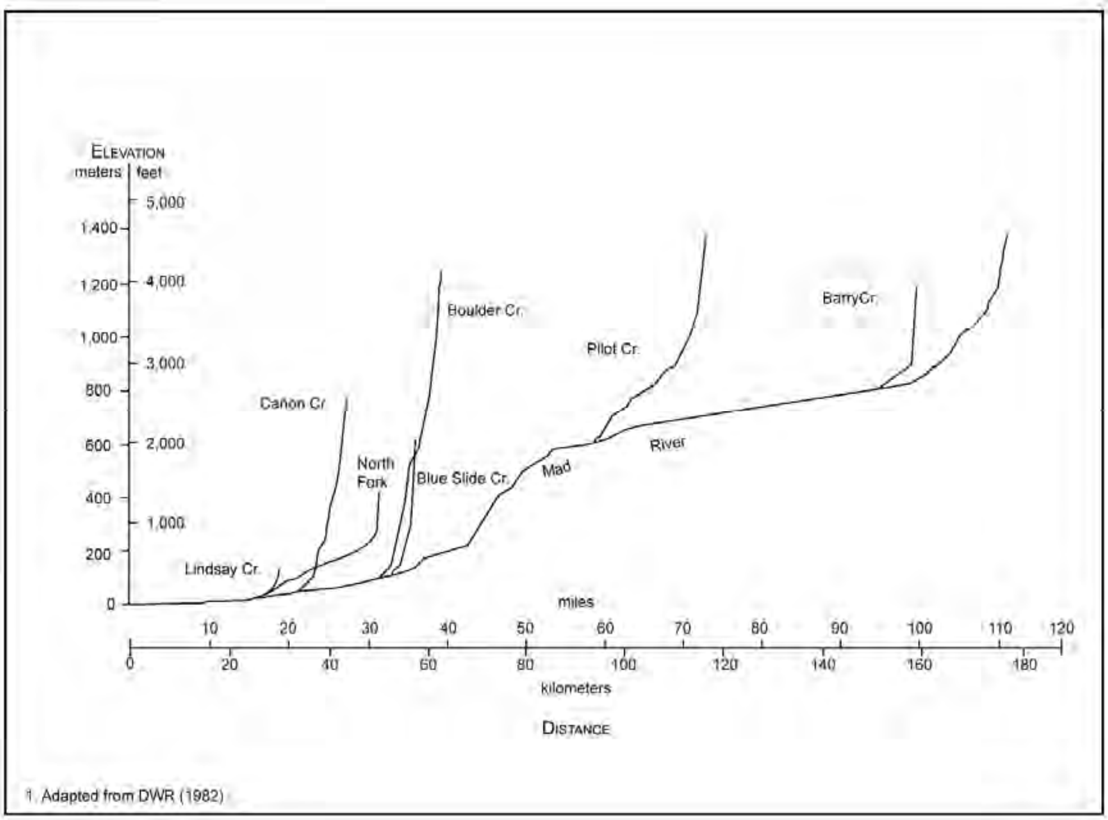


Figure 1. Long profiles of the Mad River and major tributaries.

The Mad River watershed generally has low groundwater storage and recharge rates due to the Franciscan bedrock geology. Groundwater tends to move along zones of weakness (e.g., shear zones, fault lines, and joint planes) and surfaces as springs and seeps. These factors indicate efficient routing of water through the Mad River drainage network. The drainage network derived from a 10-m Digital Elevation Model (DEM) includes 2,086 miles of channel, of which 1,977 miles are tributaries. Average drainage density of the DEM derived tributary network is 3.6 mi/mi^2. Approximately 1,471 miles (74%) of the drainage network are *source reach types* (slopes 10% or greater) that transport most sediment delivered by upland sources (Table 3-1). Approximately 413 miles (21%) of the drainage network are *transport reach types* (slopes between 1.5 and 10%). Gradient in these reaches is generally controlled by bedrock, boulders, and woody debris. Sediment in these reaches is typically coarse, is transported during high flows, and is only locally stored in patches associated with large roughness (e.g., boulders and woody debris) or planform curvature. Most sediment in the drainage network is stored in *response reach types* (slopes 1.5% or less) where transport capacity is less than or equal to the sediment supply. Response reaches account for approximately 94 miles (5%) of the drainage network. Transport-limited mass sediment balance in response reaches typically results in alluvial channel morphology within a broad valley bottom.

Table 3-1. Tributary channel network characteristics in the Mad River watershed.

Sub-watershed	Sub-basin	Channel length by reach type (mi)			Total length (mi)	Sub-basin area (mi^2)	Drainage density (mi/mi^2)
		Response[1]	Transport[2]	Source[3]			
Upper Mad River	Upper Mad River	4.8	76.04	145.64	226.45	65.5	3.5
	Ruth Lake	15.0	48.22	162.24	225.48	55.1	4.1
Middle Mad River	Upper Middle Mad	2.4	15.0	125.7	143.1	36.2	4.0
	Pilot Creek	5.7	19.7	144.4	169.8	39.7	4.3
	Lower Middle Mad	0.1	36.9	318.2	355.2	81.3	4.4
Lower Mad River	Lower Mad River	0.8	47.9	205.5	254.2	64.3	4.0
	Boulder Creek	0.6	17.2	68.0	85.7	19.0	4.5
	Maple Creek	2.7	14.5	48.1	65.2	15.7	4.2
	Canon Creek	2.1	10.6	54.4	67.1	16.4	4.1
	North Fork Mad River	14.3	35.3	138.9	188.5	48.8	3.9
	Lindsey	15.1	27.5	23.9	66.5	17.8	3.8
	Powers Creek	12.6	34.4	33.6	80.6	26.7	3.0
	Mouth of the Mad River	17.3	29.7	2.4	49.4	17.2	2.9
Total		**93.5**	**412.96**	**1470.98**	**1977.23**	**503.7**	**Ave. 3.62**

[1] Channel gradient less than 1.5%.
[2] Channel gradient 1.5–10%.
[3] Channel gradient greater than 10%.

3.1.1 Upper Mad River

The upper Mad River watershed encompasses 120 square miles (24% of the basin) from the headwaters of the Mad River to Matthews Dam which impounds Ruth Reservoir. Most of the upper Mad River occurs within Six Rivers National Forest (89%) and is managed as General Forest land with a small allocation of Late-Successional Reserve. The Yolla Bolly-Middle Eel Wilderness occupies 5.6 square miles of the region. The remaining area is held by the Humboldt

Bay Municipal Water District (HBMWD) or is privately owned. The primary beneficial uses of water in the Upper Mad River include domestic and industrial water supply, camping and boating recreation, and sport fishing. Ruth Reservoir, which is owned and operated by the HBMWD, supplies water to about 63% of Humboldt County's residents and provides recreational fishing and boating opportunities.

The tributary channel network in the upper watershed is approximately 452 miles long (Table 3-1). Most of these channels are steep and confined within inner gorges, and almost all of these (95%) are *source* or *transport* reach types. Immediately upstream of Ruth Lake, the mainstem channel is low gradient and flows within a broad alluvial valley before entering Ruth Lake. Surface flow during the summer is often intermittent. The USDA Forest Service maintains over 300 miles of road within the watershed with varying road densities throughout the area. The effect of the road network on the routing, quantity, and timing of surface flow within the sub-basins has not been investigated within the Upper Mad. SRNF is currently conducting road assessments to determine the effects of the road network on the hydrology and sediment delivery.

3.1.2 Middle Mad River

The middle Mad River watershed between Matthews Dam and the confluence of Cowen Creek encompasses 120 square miles (31% of basin) and is primarily owned by commercial timber companies and private non-commercial landowners. Six Rivers National Forest has jurisdiction over a small area near Bug Creek. Commercial timber operations and cattle ranching are the primary activities in this area. The two largest effects of land use on water quality and routing are roads and water diversion for residential and commercial use.

The Mad River channel in the middle basin area has a steeper average gradient than the upper and lower watersheds, averaging 61 feet per mile. The steepest gradient occurs from Bug Creek (RM 50) to Wilson Creek (RM 45), with a drop of 640 feet in about 4 miles (LACO Associates 1994). With its relatively steep gradient and stepped morphology, the channel in the middle basin area is dominantly comprised of transport reach types. Under natural conditions, the upper section of this compartment had intermittent flow in late summer to early fall.

The tributary channel network in the middle watershed is approximately 668 miles long (Table 3-1). Major tributaries in the middle basin area include Pilot Creek, Bug Creek, and Deer Creek. Approximately 87% of the drainage network in the middle basin area are *source* reach types, approximately 11% are transport reach types, and the remaining 2% are response reach types (Table 3-1) Pilot Creek, the largest tributary, is a Class I perennial stream draining 25,422 aces. The primary water quality beneficial uses of Pilot Creek are fish habitat and downstream domestic water use (USDA Forest Service 1996). While water quality in Pilot Creek is considered good, it has been impacted by logging, road construction, and cattle grazing (USDA Forest Service 1994).

3.1.3 Lower Mad River

The lower Mad River watershed encompasses 226 square miles (45% of the basin) downstream of the Cowan Creek confluence, including the lower 37 miles of mainstem river channel. This section of the mainstem river channel has a gentle gradient of 12 feet per mile. The river enters a wide alluvial valley at Blue Lake. This reach also contains the remnants of Sweasey Dam, which was built in 1938 approximately seven miles upstream from Blue Lake. While operational, it impounded approximately 2,000–3,000 acre-ft (af) of water and diverted about 3.5 million gallons per day (mgd) to the city of Eureka via pipeline (CDWR 1982). The dam's sediment-flushing valve was inoperable by 1941, and the dam was filled in the early 1960s (CDWR 1982). Sweasey Dam was subsequently removed in 1970.

The tributary channel network in the lower watershed is approximately 857 miles long (Table 3-1). These sub-basins have a greater percentage (8%) of *response-type* stream length than upstream sub-basins and provide rearing and spawning habitat for salmonids. The percentage of *source-type* (67%) reaches was similar to the upper watershed. The remaining stream lengths (25%) were classified as *transport-type* reaches. The lower Mad River watershed is the most densely populated, with many rural residents drafting domestic water from tributaries. The mouth and lower section of the Mad River have undergone significant changes over historical time (Refer to Section 1.4 for a discussion of geomorphic changes in the lower river and mouth).

3.2 Beneficial Uses

3.2.1 Types of beneficial uses

State policy for water quality control in California is directed toward achieving the highest water quality consistent with maximum benefit to the people of the state. Aquatic ecosystems and underground aquifers provide many different benefits and uses to the people of the state. The Regional Board is charged with protecting all these uses from pollution and nuisance that may occur as a result of waste discharges (including sediment) in the region. Table 3-2 lists the beneficial uses of water within the Mad River basin as identified by the State Water Resources Control Board.

Table 3-2. California State Water Resources Control Board (SWRCB) beneficial uses for the Mad River.

Beneficial use (BU)	Watershed location	Comment
Agricultural supply (AGR)	Throughout	
Cold freshwater habitat (COLD)	Throughout	Impacted BU
Commercial or sport fishing (COMM)	Throughout	
Estuarine habitat (EST)	Lower	Impacted BU
Flood peak attenuation (FLD)	Upper	
Freshwater replenishment (FRSH)	Throughout	Impacted BU
Groundwater recharge (GWR)	Throughout	Impacted BU
Industrial service supply (IND)	Lower	
Migration of aquatic organisms (MIGR)	Throughout	
Municipal water supply (MUN)	Upper and Lower	
Native American culture (NAT)	Throughout	
Navigation (NAV)	Lower	Not a primary BU
Non-contact water recreation (REC-2)	Throughout	
Rare threatened or endangered species (RARE)	Throughout	Impacted BU
Shellfish harvesting (SHELL)	Lower	Not a primary BU
Spawning, reproduction, and/or early development (SPWN)	Throughout	Impacted BU
Water contact recreation (REC-1)	Upper and Lower	
Wildlife habitat (WILD)	Throughout	Impacted BU

3.2.2 Water supply and use

The Mad River has an annual average water yield of approximately 1 million acre feet, with 85% of the discharge occurring between November and March (HBMWD and Trinity Associates 2004). Robert Matthews Dam, which impounds runoff from the upper watershed in Ruth Lake Reservoir (the only existing impoundment on the Mad River), was built in 1961 by the HBMWD. The reservoir has a storage capacity of about 48,800 acre-feet and was designed to provide a safe yield of 75 million gallons per day (mgd) (84,000 acre-feet/day), approximately 8% of the total annual runoff for the watershed.

Prior to construction of Matthews Dam, late summer and early fall flows in the Mad River above Pilot Creek were intermittent. At the former USGS gage near Forest Glen (No. 11480500 located approximately 9 miles downstream of Matthews Dam), mean daily flow for the month of August 1953–1961 ranged from 2 to 8 cfs, with an average of 4cfs. Currently the HBMWD manages the release of water from Ruth Reservoir to meet domestic and industrial water needs as well as in-stream flow requirements for the protection of listed fish species (HBMWD 2004). As a result of these releases, mean daily flow at USGS gage near Forest Glen for the month of August 1962–1994 ranged from 73 to 97 cfs and averaged 85 cfs (HBMWD 2004). According to HBMWD (2004), the HBMWD:

> "…believes that the net benefits resulting from its operations are far greater than the adverse impacts associated with its operations. The net benefits are derived from the District's flow releases from Ruth Lake, especially during the critical low-flow months (summer and early fall). Before District operations, the Mad River would regularly "go dry" in the summer. Since the District began its operations, flows in the Mad River have been consistent and reliable year-round, and flow augmentation has occurred in every month except December. It is estimated that the District's operations increase aquatic habitat by approximately 450 acres during the critical low-flow months. More flow creates more aquatic and riparian habitat; therefore, the District's operations benefit the listed salmonid species, as well as other aquatic species."

Matthews Dam houses a 2 mega watt hydroelectric plant that was permitted for operation in 1981. The HBMWD contracts with PG&E to store and sell energy. According to HBMWD (2004), the HBMWD:

> "…does not operate the (hydroelectric) plant as an electric "peaking" facility, nor does the District "ramp" its flow releases (e.g., change dramatically in a short period of time in response to power needs). Power production is incidental to water released for the District's water supply function."

The HBMWD also operates diversion facilities on the Mad River in the vicinity of Essex, located approximately 9 miles upstream from the mouth and four miles downriver of the City of Blue Lake. The diversion facilities in Essex draw between 25 – 30 mgd (28,000 to 34,000 acre-feet/year) which accounts for approximately 3% of the total annual runoff for the watershed (HBMWD 2004). The facility supplies treated drinking water to approximately 80,000 people in the cities of Eureka, Arcata, Blue Lake and to the Humboldt, McKinleyville, Fieldbrook-Glendale, and Manila Community Services Districts, which accounts for nearly 63% of the population of Humboldt County (HBMWD 2004). HBMWD currently operates four Ranney collectors that draw water from an aquifer sixty to ninety feet below the channel bed. A fifth Ranney well, initially constructed in 1976, was mothballed (taken out of service) in 1995 due to low production and the ability of the other four collectors to meet demand. Water extracted by the Ranney wells is classified as "groundwater, not under the significant direct influence of surface water" (EPA 2007). In 2005, HBMWD completed a Turbidity Reduction Facility (TRF) as an additional element of its domestic water treatment system. Citing a Department of Health Services of California (CDHS) 2005 report, the EPA (2007) noted:

> The TRF now operates to treat domestic water during winter storm flow periods to "less than or equal 1.0 NTU in at least 90 percent of the samples analyzed each month," and no samples exceeding 5.0 NTU. Thus, turbidity in the Mad River is no longer a domestic water supply problem. Treating the causes of high turbidity in the Mad River basin may eventually reduce the frequency of TRF operations.

HBMWD sells untreated "raw" water to industrial users located on the Samoa Peninsula via a surface water diversion facility capable of delivering 60 mgd (67,200 af/year). As of 2008, the sole industrial customer was Evergreen Pulp, Inc. who had a contract with the HBMWD for 15 mgd (16,800 af/year), one quarter of the industrial system's current capacity. In October 2008, Evergreen Pulp, Inc closed the Mill for an estimated three to six months due to world economic downturn and reduced demand for pulp. The Mill was later sold to Samoa Acquisition Group (renamed Freshwater Tissue Company). As of early 2010, the mill remains closed and the HBMWD has ceased delivering water to the facility.

3.3 Climate and Precipitation

The climate of the lower watershed is dominated by marine influences associated with the Pacific Ocean. The coastal area experiences 40–50 inches of rain per year, mostly falling between November and March. Upwelling of deep, cold ocean currents result in coastal fog throughout the summer months that moderates temperature extremes. High temperatures during the summer are commonly in the 50s and low 60s (°F), while winter high temperatures average in the low 40s to mid-50s. Winter low temperatures range from the mid-30s to the lower 40s (Figure A-3). The coastal influence diminishes inland resulting in higher daytime temperatures and lower night time temperatures.

Climate in the mid- to upper watershed is characterized as having hot and dry summers with cold and wet winters. Temperatures in the daytime summer average 80–90°F reaching over 100°F for short periods of time. Precipitation is predominately rain up to 3,000 feet and predominantly snow above 4,000 feet. Average annual precipitation in the watershed is approximately 60 inches with up to 75 inches in the high headwaters primarily falling between October and April (Figure A-4). Long duration snow and rain storms are common during the winter with short duration thunderstorms occur infrequently during the summer and fall. The highest average precipitation is in the middle of the watershed in Bug Creek and Boulder Creek, averaging over 100 inches per year in the mountains (Figure A-4). The highest precipitation in the watershed is in the vicinity of Bug Creek Butte, averaging over 120 inches a year.

3.4 Surface Hydrology

3.4.1 Stream gages

There are currently two continuous streamflow gages in the watershed, both operated by the U.S. Geological Survey (USGS). The USGS #11481000 (Mad River Near Arcata California [MRALM]) streamflow gage is located in the lower basin below the Highway 299 Bridge between the towns of Arcata and Blue Lake. This gage was installed in 1910 with field measurements beginning in 1951 (Graham Matthews & Associates 2007). The USGS #11480390

(Mad River Above Ruth Reservoir Near Forest Glen California [MRRTH]) gage is located above Ruth Reservoir at the Trinity County Road 514 Bridge. This gage was established in 1980.

3.4.2 Annual discharge

Daily average discharge in the watershed is seasonally dependent with most large runoff events occurring during the winter. During November–March, the high flow period, the average daily discharge is approximately 2,000–5,000 cfs. Flows can vary greatly during the winter with maximum mean daily discharges exceeding 30,000 cfs during wet years while under 1,000 cfs in dry years (Graham Matthews & Associates 2007). High flows in the watershed tend to be of short duration, returning to winter base flow within a week flowing the peak event (Graham Matthews & Associates 2007).

At the USGS Arcata gage, the average annual discharge of the Mad River Basin is approximately 1,000,000 acre-ft. For the record period of 1982 - 2000, the "drier than normal years" average annual discharge was 488,629 acre-feet while the "wetter than normal years" average annual discharge was 1,434,857 acre-feet (HBMWD 2004). Notable years with above average annual discharge include 1953, 1958, 1964, 1973, 1982, 1983, 1995, 1996, 1998, and 2006. Extended periods of higher than average annual discharges include 1969–1975, 1981–1986, and 1995–1998. Years with less than half the average annual discharge (500,000 acre-feet) include 1976, 1977, 1985, 1992, 1993, 2001, and 2007. The ten year period between 1985-1994 saw continual lower than average annual flow in the basin.

3.4.3 Large flood events

Since the 1850s, the effects of floods in the Mad River basin have been well documented. The largest flood event in the late 1800s occurred in December 1861. The flood inundated the Arcata Bottoms with 2–4 inches of water and channel avulsions left oxbow lakes in Blue Lake Valley. A dramatic effect in the lower reach of the Mad River was the bypassing of the "West Valley" meander located approximately 4.5 miles upstream of the river mouth. The cut-off reduced the river length in the upper delta by 5,940 ft (Scalici 1993).

The logging boom during the period 1870–1880 resulted in increased timber harvest rates and construction of lumber mills in Fieldbrook, Blue Lake, and the North Fork Mad River. During this time, old-growth trees were cleared along the main stem Mad River and tributaries. In 1890, a rain on snow event resulted in 10.25 inches of rain in Arcata between 1–4 February. Scalici (1993) described the resulting flood event:

> The most catastrophic flood year was 1890 when several winter storms resulted in erosion in a number of places along the river in Blue Lake and the Arcata Bottom. By this time, logging was in full swing with most of the railroads already built and a growing population. It was the January flood that repositioned the confluence of the North Fork with Mad River in the mid-valley position which has persisted ever since…The effects of this were a shortening of the length of river channel through the valley, an increase in channel gradient, a more rapid transport of sediment though the Blue Lake valley and the entrainment of previously store sediments into the river. A late February rain-on-snow event reportedly did severe damage in Blue Lake and West End; and in the delta, at Valley West, and near the old canal.

By the turn of the century railroad and timber harvest practices had expanded further up the Mad River and tributaries, making the watershed more susceptible to accelerated rainfall runoff and erosion. The first decade (1900–1910) saw major storm events in 1902, 1903, 1906, and 1907 resulting in increased landslides, bank erosion, channel degradation, and the loss of infrastructure

(Scalici 1993). A rain-on-snow event in 1914 flooded the lower reaches of the Mad River and caused severe channel erosion. The 1938 storm was the considered the worst in the prior 25 years and was accompanied by a strong storm surge leading to severe coastal erosion (Scalici 1993).

The two largest storms on record in the Mad River were in January 1955 and December 1964. The January 1955 storm event resulted in the highest average daily discharge (63,100 cfs) and the second highest peak discharge (77,800 cfs) measured at the Mad River gage. A shift in the mouth of the Mad River resulted in erosion of the bluff at the west end of School Road. The storm of December 1964 is the largest storm of record in Humboldt Bay watersheds and caused major flooding in the area. The peak discharge at the MRALM gage near Arcata was 81,000 cfs and had a recurrence interval of 40–50 years. Flood damage to the Mad River included channel degradation in the lower reaches, which increased the extent of the tidal influence (Scalici 1993). During the event, the mouth of the river widened to 3,600 ft and encompassed the north pond of the Mad River Lagoon, introducing ocean water to the pond for the first time in recent history (Scalici 1993).

Graham Matthews & Associates (2007) examined the influence of precipitation events on peak flows by comparing annual maximum instantaneous discharges recorded for Mad River at Arcata and Mad River above Ruth reservoir near Forest Glen. They found that precipitation events resulting in large storm flows are variable in their distribution throughout the watershed. Large precipitation events above Matthews Dam are attenuated in fall and early winter as Ruth reservoir fills to capacity. Once the reservoir is filled, flows from large storm events above the reservoir are released downstream and reflected in the MRALM gage record. This correlation is evident in the February 1986 and December 2006 storm events.

3.4.4 Flood frequency

Graham Matthews & Associates (2007) conducted a flood frequency analysis of the annual maximum peak discharges for both stream gaging stations on the Mad River. Flood frequency (or flood return period) refers to an annual maximum peak stream flow that has a specified percent chance of being equaled or exceeded in any given year. For example, a 100-year flood occurs on average once every 100 years and thus has a 1-percent chance of occurring in a given year. Graham Matthews & Associates (2007) used annual maximum peak discharge data fit to a log-Pearson Type II distribution to create flood frequency curves for the MRALM and MRRTH gage sites (Table 3-3).

Table 3-3. Log Pearson III analysis of annual maximum peak discharges (Graham Matthews & Associates 2007).

Return period (years)	Exceedence probability (%)	MRRTH predicted discharge (cfs)	MRALM predicted discharge (cfs)
1.2	83.3	3,100	13,700
1.5	66.7	4,500	20,300
2	50.0	6,100	27,000
2.33	42.9	6,800	30,100
5	20.0	10,200	44,200
10	10.0	13,100	57,000
25	4.0	16,900	69,800
50	2.0	19,800	79,900
100	1.0	22,700	89,600

4 SEDIMENT DYNAMICS

The Mad River watershed is listed as temperature and sediment impaired under Section 303(d) of the Clean Water Act, in large part, due to accelerated erosion and sediment delivery. Erosive terrain, intense winter rainfall, and a history of human occupation and land use contribute to the high rates of erosion and sediment delivery in the basin. The following section summarizes the geology and geomorphology of the Mad River watershed, the dominant erosion and depositional processes influencing hillslopes and channels, and some of the ways in which land uses have altered these processes to change water quality and the physical characteristics of stream habitat. This characterization of sediment dynamics draws extensively from a large body of published and unpublished work related to geology and geomorphology, erosion process, channel conditions, and resource management in the watershed.

4.1 Geologic and Geomorphic Setting

Mad River watershed drains about 500 mi^2 of the geologically complex northern Coast Ranges geologic province in Humboldt and Trinity Counties. The watershed lies northeast of the Mendocino Triple Junction region where the Pacific, North American, and Gorda crustal plates intersect. Tectonic regimes in the watershed transition west to east from northeastward directed contraction associated with the southern Cascadia subduction zone margin, distinguished by north-east dipping thrust faults and associated asymmetric folds, to translation associated with the northern extension of the San Andreas transform, distinguished by linear ridges and valleys oriented north-northwest. Imbricate thrust faults and associated folds of Mad River Fault Zone trend through the western portion of the watershed, offsetting 50 ka to >200 ka raised marine platforms at the coast and having multiple episodes of Holocene deformation (Burke et al. 1986, Carver et al. 1987, Clarke and Carver 1992). The Mad River Fault Zone includes the Trinidad, Blue Lake, McKinleyville, Mad River, and Fickle Hill faults as well as the Blue Lake and Fickle Hill anticlines. The Mad River Fault Zone extends approximately 40 km inland from the coast to the vicinity of Maple Creek. The fault zone has been active for approximately the last 0.7 million years. Accretion, uplift and deformation have resulted in rapid denudation rates in the watershed.

The Mad River watershed is predominately comprised of sedimentary and metamorphic rocks of Mesozoic through Cenozoic age that form northwest trending ridges and valleys. The highly variable topography in the Mad River watershed ranges from steep, dissected terrain to gently sloping and flat-lying terrain with less deeply incised drainage networks. Steep mountain slopes and narrow gorges predominate in the headwaters and middle basin areas where intense seasonal rainfall, steep topography, and erodible parent materials result in high rates of sediment delivery and transport. The upper reaches of the drainages in these areas are sculpted by landsliding. Downstream of Maple Creek, the valley bottom broadens and the Mad River is bordered by floodplains and terraces of late Pleistocene and Holocene age. After a short confined reach between Annie and Mary Bridge and the Highway 299 Bridge, the valley opens into a broad alluvial plain referred to as the Arcata Bottoms. The lower 3 miles of the Mad River downstream of Highway 299 Bridge are tidally influenced, and terminate in a historically dynamic river mouth.

4.1.1 Franciscan Complex

The Franciscan Complex of upper Jurassic through Cretaceous age underlies most of the Mad River watershed (Figure A-5,Table 4-1). The Franciscan Complex in north coastal California was deposited in a deep marine trench on oceanic crustal basement and subsequently accreted to North America, uplifted, and deformed. Rocks of the Franciscan Complex vary greatly in lithology, structure, and degree of metamorphism. The compilation of regional geologic mapping by McLaughlin et al. (2000) subdivides the Franciscan Complex into the Eastern, Central, and Coastal belts. The three belts progressively young in age from east to west. Only the Eastern and Central belts of the Franciscan Complex occur in the Mad River watershed. The Eastern and Central belts are furthered subdivided into rock units based on structure, lithology, and degree of metamorphism (Manning and Ogle 1950, Irwin 1960, Harden et al. 1982). Blake et al. (1967) grouped rock units of the Franciscan Complex into five textural categories with relevance to geomorphic processes: melange, unmetamorphosed, semi-metamorphosed, undifferentiated, and South Fork Mountain Schist. Green Diamond Resource Company characterized geology across their Habitat Conservation Plan Area using similar nomenclature (Green Diamond Resource Company 2006). The Mad River Sediment Source Analysis (Graham Matthews & Associates 2007) grouped rock units of the Franciscan Complex into three general textural categories: Franciscan assemblage (non-melange), Franciscan melange, and South Fork Mountain Schist (Figure A-5).

4.1.1.1 Eastern belt

The Eastern belt of the Franciscan Complex occurs in the eastern part of the Mad River basin and is bound on the west by the Grogan-Red Mountain fault zone, where the eastern belt is in contact with rocks of the Central belt of the Franciscan Complex. The Eastern belt consists predominantly of moderately metamorphosed greywacke sandstone that forms steep topography with sharp ridge crests. Hillslopes formed in sandstone rocks of the Eastern belt of the Franciscan Complex are generally stable, with mass wasting occurring predominantly as shallow landsliding on steep streamside slopes, inner gorges, and headwall areas. The Eastern belt in the Mad River basin also includes the South Fork Mountain Schist, comprised of schistose metasedimentary and metavolcanic rocks which have been highly sheared, folded, and metamorphosed. These rocks are weakly resistant to weathering and commonly form slopes with broad curvature and a thick colluvial soil mantle (CDWR 1982). The western flanks of South Fork Mountain northeast of Ruth Lake are underlain by South Fork Mountain Schist and show evidence of deep-seated landsliding and earthflow.

4.1.1.2 Central belt

The Central belt of the Franciscan Complex occurs in the western part of the Mad River basin and is bounded on the east by the Grogan-Red Mountain fault zone, where the Central belt is in contact with the Eastern belt of the Franciscan Complex. The Central belt consists predominantly of a mélange matrix of sheared argillite surrounding blocks of more coherent broken and folded schist, greywacke sandstone, and shale (McLaughlin et al. 2000). The coherent blocks may also include chert, greenstone, limestone, and metabasalt. Areas underlain by mélange are characterized by hummocky topography with grassland and brush vegetation cover. Melange commonly fails in large earthflows and by debris slides on steep headwall, inner gorge, and streamside slopes (CDWR 1982). Slopes underlain by mélange are susceptible to gully erosion in response to vegetation removal, soil compaction, and concentrated surface runoff from roads and other disturbed surfaces (LACO Associates 1994, Graham Matthews & Associates 2007). Coherent blocks commonly form prominent outcrops that stand above the otherwise hummocky topography of the mélange.

Table 4-1. Geology in the Mad River watershed.

Subwatershed	Sub-basin	Sub-basin area (mi²)	Area encompassed by geologic unit[1] (mi²)														
			Extrusive and intrusive rocks			Franciscan assemblage (non-melange)						Franciscan melange	Quaternary deposits				South Fork Mountain schist
			mb	mv	v	ch	KJfl	KJfr	KJfs	KJfsc	KJfu	KJfv	Qal	Qm	Qt	QTw	KJ3
Upper	Upper Mad River	65.5	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	62.6	0.1	0.2	0.0	0.0	0.0	1.5
	Ruth Lake	55.0	0.9	0.0	0.1	0.5	10.0	0.0	0.0	0.0	19.2	12.9	3.0	0.0	0.8	0.0	5.9
Middle	Upper Middle Mad River	36.2	0.1	0.0	0.4	0.0	10.8	0.0	0.0	0.0	14.1	3.6	0.8	0.0	0.8	0.0	5.7
	Pilot Creek	39.7	0.1	0.0	0.0	0.1	1.2	0.0	0.0	0.0	27.6	2.6	0.0	0.0	0.0	0.0	8.1
	Lower Middle Mad River	81.3	0.0	0.0	0.1	0.0	35.8	0.0	1.8	0.0	3.1	40.4	0.0	0.0	0.0	0.0	0.0
Lower	Boulder Creek	19.0	0.0	0.0	0.0	0.0	5.0	0.4	1.8	0.0	0.0	11.7	0.0	0.0	0.0	0.1	0.0
	Maple Creek	15.6	0.0	0.0	0.0	0.0	1.1	2.3	0.0	0.0	0.0	11.5	0.0	0.0	0.2	0.6	0.0
	Cañon Creek	16.3	0.0	0.0	0.0	0.0	0.0	1.0	0.5	0.0	0.0	13.3	0.0	0.0	0.0	1.6	0.0
	Lower Mad River	64.3	0.0	0.0	0.0	0.0	2.3	0.0	22.9	0.0	0.0	33.6	0.0	0.0	1.3	4.2	0.0
	North Fork Mad River	48.8	0.0	0.0	0.0	0.0	0.0	7.1	0.0	1.0	0.0	37.0	1.0	0.0	0.0	2.7	0.0
	Lindsay Creek	17.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.3	1.4	0.6	2.7	3.6	0.0
	Powers Creek	26.7	0.0	0.0	0.0	0.0	0.0	0.0	6.6	0.0	0.0	9.8	4.3	0.2	1.4	4.3	0.0
	Mouth of Mad River	17.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.5	10.0	0.0	5.5	0.0
Total		**504**	**1.1**	**0.0**	**0.0**	**1.6**	**66.3**	**10.8**	**33.6**	**1.0**	**126.7**	**186**	**12.2**	**10.9**	**7.2**	**22.6**	**21.2**

[1] Meta-basalt (mb), meta-volcanics (mv), volcanics (v), chert (ch), Franciscan Complex limestone (KJfl), Redwood Creek Schist (KJfr), Franciscan sandstone (KJfs), Snow Camp (KJfsc), Undifferentiated Franciscan (KJfu), Franciscan mélange (KJfv), alluvial deposits (Qal), marine terrace and dune deposits (Qm), non-marine terrace deposits (Qt), overlap deposits (including the Falor Formation)(QTw), South Fork Mountain schist (KJ3)..

4.1.2 Overlap deposits

In the lower Mad River watershed downstream of Maple Creek, the Central belt of the Franciscan Complex is unconformably overlain by the Falor formation of lower- to mid- Pliocene age. Falor deposits occur in a northwest-southwest trending block that has been downfaulted into the surrounding Franciscan bedrock (Manning and Ogle 1950). The Falor formation is composed of poorly cemented clay, silty clay, pebbly sandstone, and fine-grained sandstone. The Falor formation occurs primarily on gentle slopes surrounding the Mad River Valley between Maple Creek and North Fork Mad River. Falor deposits are prone to slumping under high pore water pressure (Manning and Ogle 1950).

4.1.3 Surficial deposits

Latest Pleistocene and Holocene fluvial terraces comprised of poorly consolidated silt, sand, gravel, and boulder deposits are preserved along the lower mainstem Mad River between Boulder Creek and Lindsay Creek and in major tributary valleys (Figure A-5). Fluvial terraces are most extensive where they occur adjacent to Lindsay Creek and adjacent to the Mad River at Blue Lake and Butler Valley (Berry 1981, Kelley 1984, Kilbourne 1985a, Kilbourne 1985b). These and other fluvial terraces in nearby coastal river valleys have formed by fluvial response to sea level change, regional uplift, active faulting, and climate change.

Late Pleistocene marine terraces are preserved within about 2 miles of the coastline, and up to 260 feet above sea level. These marine terraces, composed predominantly of slightly consolidated sands and gravels, are erosional remnants of uplifted shore platforms subsequently deformed in some places by faulting in the Mad River fault zone. Similar flights of marine terraces are preserved in other coastal areas along the southern Cascadia subduction zone (Carver and Burke 1992).

Ancient dune deposits composed of unconsolidated fine to coarse sand of Holocene to Pleistocene age occur up to four miles from the present coastline and up to 60 feet above sea level. These materials are very erodible where exposed and commonly fail by slumping where slopes are oversteepened by stream erosion or ground disturbance such as road construction. Modern dune and beach deposits are found along the coast.

Hillslopes in the watershed are typically mantled by weathered bedrock, soil, and colluvium. This poorly consolidated and loose soil mantle is typically thin on steep slopes with pronounced curvature, thicker on gentle slopes with less curvature, and thickest in the axis of swales and drainages. Thick unconsolidated deposits of landslide material are also found on hillslopes throughout the watershed.

Modern alluvium consists of unconsolidated, poorly sorted silt, sand, gravel, and boulders recently deposited by the Mad River and tributaries as channel and floodplain deposits. Alluvium in the Mad River valley ranges from a few feet thick near the edges of the valley to over 100 feet thick in the center near Blue Lake. Alluvium is the primary unconfined aquifer in the Mad River Valley (Lehre 1993).

4.2 Erosion Processes

4.2.1 Landslides

Mass wasting triggered by intense rainfall, rapid snowmelt, and earthquakes is an important natural process controlling the long-term (thousands of years) evolution of mountainous unglaciated landscapes like the Mad River watershed. Over shorter time scales, however, land use practices such as road construction and timber harvest can alter the size and frequency of mass wasting, often dramatically increasing sediment delivery to stream channels. Mass movement can occur in many forms (e.g., slides, spreads, flows, falls, and topples), but the most common types of movement in the Mad River watershed are generalized as shallow landslides or deep-seated landslides.

Common shallow landslide types in the Mad River watershed include debris slides, debris flows, rock falls, and channel bank failures. Shallow landslides commonly occur on steep streamside slopes, inner gorges, and headwall swales. Shallow landslide activity is commonly characterized as active or inactive (Cruden and Varnes 1996). Green Diamond Resource Company classifies shallow landslide activity as active, recent, historical, or old (Green Diamond Resource Company 2006). Large, deep-seated rotational/translational landslides and earthflows are widely distributed in the different units of the Franciscan Complex within the Mad River watershed, but are most commonly associated with Melange, schist, and shear zones. Deep-seated landslide morphology is typically characterized by crescent-shaped scarps; flat-lying and backtilted blocks; benched topography; and lobate accumulation zones with hummocky topography, seepage lines and springs, ponding, and deflected or irregular drainage patterns. Deep-seated landslide activity is commonly characterized as historically active, dormant young, and dormant mature (Cruden and Varnes 1996, CDMG 1997, Green Diamond Resource Company 2006).

There are several incomplete sources of historical landslide mapping that encompass different parts of the Mad River watershed. The earliest assessment of landslides in the Mad River watershed was conducted by the California Department of Water Resources using aerial photographs from 1973 (CDWR 1982). The USDA Forest Service maintains a landslide database for public land in the upper Mad River watershed (USDA Forest Service 2005a as cited in Graham Matthews & Associates 2007). Green Diamond Resource Company routinely identifies landslides and areas prone to mass wasting (including inner gorges, steep streamside slopes, and headwall swales) for individual timber harvest plans within their ownership. Green Diamond Resource Company compiled landslide inventories in pilot areas outside of the Mad River watershed and used a summary of these landslide rates to model long-term sediment delivery in their Habitat Conservation Plan Area (Green Diamond Resource Company 2006), but a compilation of landslide mapping on Green Diamond Resource Company lands within the Mad River basin was not available at the time of this watershed assessment.

The most recent and inclusive landslide assessment available for the Mad River watershed was conducted in 2007 as part of a sediment source analysis for establishing Total Maximum Daily Loads (TMDLs) for sediment and turbidity (Graham Matthews & Associates 2007, EPA 2007). The 2007 landslide assessment involved compiling existing landslide information (e.g., CDWR, USDA Forest Service, Green Diamond Resource Company, and other sources) and updating the landslide inventory using aerial photographic interpretation and limited field observation. The 2007 assessment classified all landslides into five categories: debris flows, debris slides, earth flows, inner gorge slides, rock falls, and rock slides. The air photo inventory documented the location, type, and geometry for each slide. Landslides were grouped into two time periods, those occurring prior to 1975 (CDWR 1982) and those occurring after 1975 (USDA Forest Service

2005a, Green Diamond Resource Company 2006, Graham Matthews & Associates 2007). A sample of the landslides identified in the inventory were field verified to determine landslide area, volume, surface erosion, land use association, triggering mechanisms, and sediment delivery. Landslides were grouped into three classes related to their origin: natural, road related, and timber harvest related. Almost half (45%) of the active landslides mapped in the inventory were debris flows, followed by earthflows (24%) and debris slides (18%). About 57% of the landslides (mainly earthflows) occurred in Franciscan Melange, while about 40% of the landslides occurred in other Franciscan Rock. Earthflows covered the most area and delivered most of the sediment to the channel network (Table 4-2). Graham Matthews & Associates (2007) noted that earthflows appeared to be reducing the width of the Mad River valley, causing destabilization of inner gorge slopes, and that most inner gorge erosion occurred as debris flows and rock slides on steep slopes (>65%) with a high sediment delivery potential. Large pulses of sediment delivery during wet water years (e.g., 1996) have episodically dammed the reach of the Mad River downstream of Bug Creek, resulting in channel aggradation (Graham Matthews & Associates 2007). The lower middle and lower sub-basins (29% of the total watershed area) have the largest estimated sediment delivery from background and management-related landslides, together accounting for about 70% of the total annual landslide sediment delivery in the basin (Table 4-3). Approximately 39% of the total annual landslide sediment delivery was from background sources comprised of naturally occurring slides and creep from deep seated features. Approximately 61% of the total annual landslide sediment delivery was from management related sources, 59% from road related landslides and 1.7% from harvest related landslides. Over half of the active landslides mapped in the inventory were triggered by natural processes. Roads produced about 33% of the slope failures and timber harvest activities triggered about 8%.

Note that the grouping of landslides into two large time periods (pre-1975 and post-1975) does not account for any reduced rate of management related landsliding that may have occurred with improved erosion control measures included in the Forest Practice Rules.

Table 4-2. Landslide area by geology.

Geology	Landslide area (acres)						
	Debris flow	**Debris slide**	**Earth flow**	**Inner gorge**	**Rock fall**	**Rock slide**	**Total**
Intrusive and extrusive rocks	0	0	6.8	0	0	0	6.8
Franciscan assemblage	498	72	2,583	133	14	97	3,397
Franciscan melange	379	251	3,899	37	48	0	4,614
Quaternary deposits	13	2.0	0.28	13	0	0	28
South Fork Mountain schist	0	11	176	2.7	0	0	190
Total	**890**	**336**	**6,665**	**186**	**62**	**97**	**8,236**
Percent of total	**10**	**4.1**	**81**	**2.3**	**0.75**	**1.2**	**100**

Table 4-3. Landslide sediment delivery by sub-basin (adapted from Graham Matthews & Associates 2007).

Subwatershed	Sub-basin	Sub-basin area (mi²)	Sediment delivery from landslides								Total	
			Background creep[1]		Background landslides		Road-related landslides		Harvest-related landslides			
			tons/yr	% of sub-basin total	tons/yr	% of sub-basin total	tons/yr	% of sub-basin total	tons/yr	% of sub-basin total	tons/yr	tons/mi²/yr
Upper	Upper Mad River	65.5	4,528	74.8	1,357	22.4	0	0.0	103	1.7	6,053	93
	Ruth Lake	55.0	11,662	22.2	8,437	16.1	32,231	61.4	119	0.2	52,504	955
Middle	Upper Middle Mad River	36.2	18,175	23.4	20,160	25.9	34,737	44.7	4,627	6.0	77,735	2,147
	Pilot Creek	39.7	11,910	15.5	64,949	84.4	0	0.0	80	0.1	76,979	1,939
	Lower Middle Mad River	81.3	41,561	8.9	99,505	21.4	322,095	69.4	1,130	0.2	464,372	5,719
Lower	Boulder Creek	19.0	3,344	4.9	37,297	54.1	25,561	37.1	2,694	3.9	68,915	3,627
	Maple Creek	15.6	1,560	81.3	343	17.9	0	0.0	0	0.0	1,919	123
	Cañon Creek	16.3	4,608	99.3	16	0.3	0	0.0	0	0.0	4,640	283
	Lower Mad River	64.3	28,503	10.5	32,183	11.8	205,296	75.4	6,341	2.3	272,387	4,236
	North Fork Mad River	48.8	14,738	80.7	439	2.4	3,022	16.6	9	0.0	18,257	374
	Lindsay Creek	17.7	3,133	99.4	0	0.0	0	0.0	0	0.0	3,151	178
	Powers Creek	26.7	8,258	72.9	0	0.0	0	0.0	3,049	26.9	11,328	424
	Mouth of Mad River	17.1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**0**	**0**
Total		**504**	**151,980**	**14.4**	**264,686**	**25.0**	**622,942**	**58.9**	**18,152**	**1.7**	**1,058,240**	**2,177**

[1] Background creep from deep-seated landslides determined using NetMap (GMA 2007).

4.2.2 Bank erosion

Various efforts have characterized bank erosion in large and small channels in the watershed. Green Diamond Resource Company evaluated bank erosion in tributaries during a study of erosion and sedimentation in Class III watercourses. Approximately 100 channels were inventoried from within a stratified random sample of timber harvesting plans in their Habitat Conservation Plan Area (Plan Area). Of these 100 channels, 20 were in the Mad River Hydrographic Planning Area, 14 were in the North Fork Mad River, and 3 were in areas of the Mad River outside of the Plan Area. Physical measurements of the channel bed and bank were taken at regular intervals, including (among other types of measurements) the area and location of significant bank erosion, length of exposed bank, bank angle, bed and bank material, and characteristics of bank vegetation. Surveys continued until the Class III channel ended at a headwall, or at the harvest unit boundary. Bank erosion was selected as one of four response variables that best reflects potential sediment delivery to the lower portions of a watershed. Stepwise regression indicated that there was greater bank erosion in unconsolidated geology, streams with more large wood, and areas with less canopy closure.

The volume of bank erosion in the Mad River was modeled at the watershed scale during development of the TMDL (EPA 2007, Graham Matthews & Associates 2007). Little field data were available, however, to validate these estimates or identify actual bank erosion at the reach scale. The amount of fluvial bank erosion in the watershed was estimated based on stream orders assigned to the DEM-derived channel network and corresponding erosion rates (t/mi^2/yr) derived by Raines (1998). Model estimates were qualitatively verified by inventorying bank erosion in four sample reaches of the mainstem Mad River and several sample reaches in headwater tributaries. Estimates of bank erosion accounted for 1.1% of the total estimated sediment production in the watershed. The measured rate of fluvial bank erosion varied by watershed area, with the highest rates occurring along stream channels within melange terrane. Bank erosion was also common in headwater channel reaches where the transport capacity exceeds sediment supply. Model estimates of bank erosion were incorporated into the background portion of the traditional sediment budget used in the TMDL.

Bank erosion in the mining reach of the mainstem Mad River (Hatchery to Highway 101) was evaluated for the period 1993–1997 (Klein et al. 1998) and 1998–2003 (Lehre et al. 2005) using a combination of measurements from cross sections and air photos. Bank erosion volumes were calculated for each feature and summed by year (Figure 2). The results suggest that bank erosion is strongly dependent on peak discharges; large floods appear to accelerate bank erosion. Active channel area follows a similar relationship.

4.2.3 Surface erosion

Surface erosion often constitutes a major source of sediment input to watersheds, particularly where suspended loads are high. Little or no field data is available documenting surface erosion from different geologic terrane types, land uses, and vegetation types in the Mad River watershed. Estimates of surface erosion in the Mad River watershed are based on modeling and extrapolation of surface erosion rates from other similar areas.

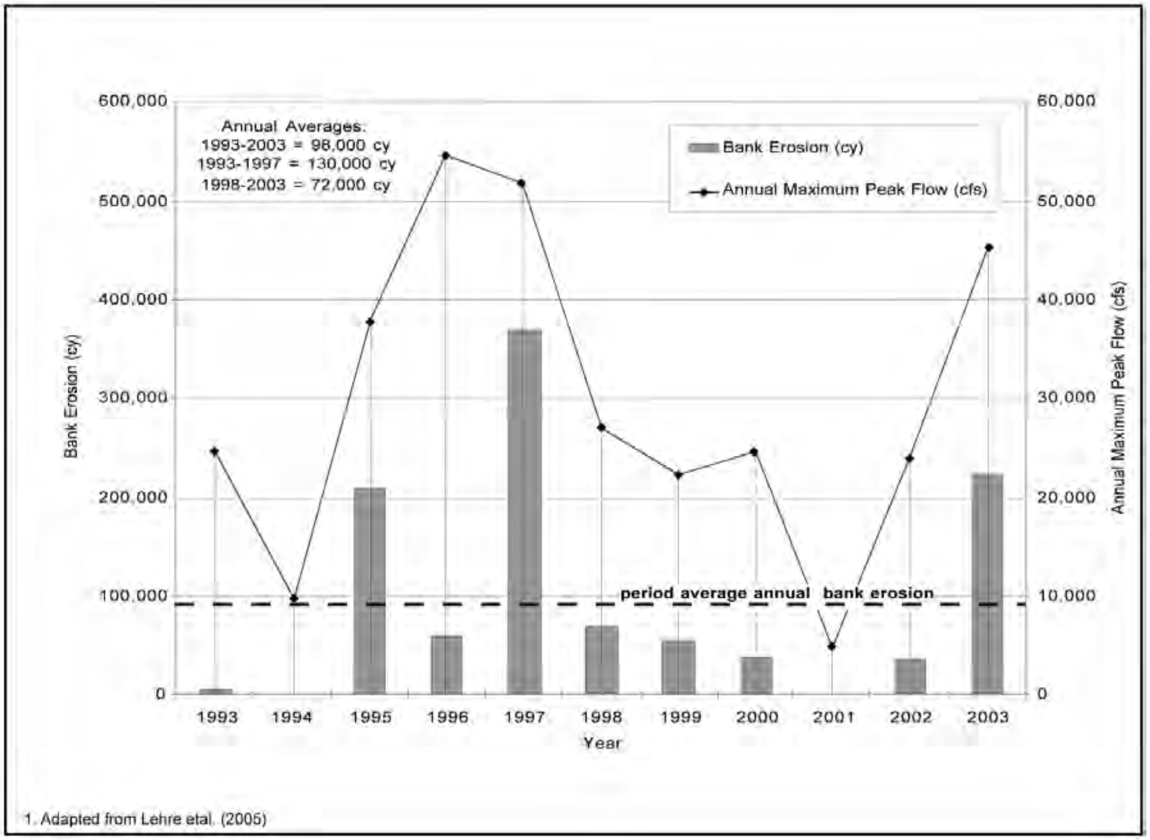


Figure 2. Bank erosion and peak discharges in the lower Mad River, 1993–2003.

4.2.3.1 Roads

Graham Matthews & Associates (2007) created a roads database for the Mad River watershed by digitizing roads from orthophotoquads and aerial photographs, and classifying the road system by surface type and lithotopo unit (terrain unit based on bedrock geology, slope, and topographic position). The roads database developed by Graham Matthews & Associates includes over 2,000 mi of roads in the watershed (Table 4-4). Road densities vary from 0.8 to 8.4 miles/mi^2, and average 4.2 miles/mi^2 for the entire watershed. Existing information on the type and condition of roads in the Mad River watershed is limited. About 74% of the roads in the database have a native surface, 20% are rocked, and 6% are paved. Graham Matthews & Associates rapidly inventoried 14% of the road system and determined that the roads layer was accurate for the main road system on public and private lands, but data for smaller roads was less accurate or missing.

Graham Matthews & Associates (2007) estimated sediment delivery to the stream network from surface erosion using the Watershed Erosion and Prediction Model (WEPP). Sediment delivery from road-related surface within Franciscan mélange was estimated using the Washington Department of Natural Resources Surface Erosion Module instead of WEPP, because WEPP overestimated sediment delivery from this terrain. Estimates of sediment delivery volume using the Surface Erosion Module Model were used in combination with characteristics of the road prism, drainage system, and traffic to estimate (1) erosion rates for a given type of road and (2) the total amount of erosion for discrete road segments. Erosion rates assigned to different types of road were verified by a limited sampling of road erosion during storm runoff in December 2005. Sediment delivery estimates did not account for recently implemented or planned road improvements designed to reduce concentrated runoff, surface erosion, and the potential for failure of road drainage infrastructure.

The North Fork Mad River has the largest estimated sediment delivery from road-related surface erosion, followed by the lower Mad River and lower middle Mad River sub-basins (Table 4-5). Most of the surface erosion occurs on heavily traveled roads with native surfaces that dissect the Franciscan mélange. These roads tend to have erosion and drainage problems that commonly result in gully erosion. Gully erosion was common where roads drained into active earthflows within the lower Mad River. Roads on the South Fork Mountain Schist also had higher average erosion rates by surface type, but only 3% of the total road length occurs on this geology type.

Although Green Diamond Resource Company's analysis of road erosion during development of the HCP did not include an assessment of fine sediment contributions from road surface erosion, the HCP included a road-related sediment delivery (turbidity) monitoring plan designed to isolate and quantify suspended sediment inputs from road surface and inboard ditch erosion. The effectiveness monitoring program involves turbidity monitoring and grab sampling of suspended sediment concentration on sample road segments in four watersheds, none of which are in the Mad River watershed. Approximately five years of initial trend monitoring are expected to be necessary to set appropriate biological objectives and threshold values.

A field based inventory of sediment sources and chronic non-point source erosion associated with roads on land owned by Simpson Timber Company and Sierra Pacific Industries in the Maple and Cañon Creek sub-basins was conducted in 1999 (NRM 1999). A total of 175 miles of roads and 413 drainage crossings were inventoried on active and legacy roads, and a culvert risk assessment was conducted using methods developed by Redwood National Park. Past and potential future erosion volumes at drainage crossings totaled 5,815 yd^3 and 2,732 yd^3, respectively. Sixty-four mass wasting sites were identified, the majority of which were shallow landslides originating in road fill. Past and potential future erosion volumes at mass wasting sites totaled 7,704 yd^3 and 6,665 yd^3, respectively. Roads underlain by the Falor Formation were prone to rill and gully erosion from surface runoff, particularly where water exited the road system. Block topple of steep cutslopes was a typical failure mechanism where benches were cut into the Falor Formation. Cutbank and road prism structures on roads that traversed pockets of Franciscan melange tended to actively creep in the wet season. Long in-board ditch lengths were the most pervasive problem associated with the road system. Prioritization of road segments, culvert locations, and mass wasting sites based on estimated volume of material at risk, proximity to watercourses, drainage area above a drainage crossing, and condition of drainage structures provided the basis for developing and implementing future erosion mitigation projects.

4.2.3.2 Timber harvest

Surface and fluvial erosion from areas disturbed by timber harvest activities is most often related to skid trails and harvest operations that result in impervious surfaces and increased rainfall runoff. Graham Matthews & Associates (2007) used WEPP to predict erosion rates from harvest areas. Erosion rates varied by type of harvest, yarding method, and geologic and topographic characteristics. Timber harvest history was developed from publicly available information which included the USDA Forest Service, CDF Forestry Resource Assessment (FRAP), and Multi-Resolution Land Cover (MRLC) data. Surface and fluvial erosion from areas harvested for timber is low relative to background, and road erosion sources account for a small fraction of the total sediment delivery (Table 4-5).

Table 4-4. Road length by surface type.

Subwatershed	Sub-basin	Sub-basin area (mi²)	Native		Rocked		Paved		Total		
			Length (mi)	% of sub-basin length	Length (mi)	% of sub-basin length	Length (mi)	% of sub-basin length	Length (mi)	% of watershed	Road density (mi/mi²)
Upper	Upper Mad River	65.5	99	48	84	41	23	11	205	9	3.1
	Ruth Lake	55.0	96	54	59	33	24	14	179	8	3.3
Middle	Upper Middle Mad River	36.2	65	54	33	27	24	19	122	6	3.4
	Pilot Creek	39.7	80	77	17	17	7	7	105	5	2.6
	Lower Middle Mad River	81.3	242	99	1	1	2	1	245	11	3.0
Lower	Boulder Creek	19.0	55	96	2	3	0	1	57	3	3.0
	Maple Creek	15.6	70	96	2	3	1	2	74	3	4.7
	Cañon Creek	16.3	103	90	6	5	5	4	114	5	7.0
	Lower Mad River	64.3	226	77	60	21	5	2	292	13	4.5
	North Fork Mad River	48.8	273	76	69	19	19	5	361	16	7.4
	Lindsay Creek	17.7	97	72	32	24	5	4	135	6	7.6
	Powers Creek	26.7	125	68	43	23	16	9	183	8	6.9
	Mouth of Mad River	17.1	32	27	63	53	24	20	118	5	6.9
Total		**504**	**1,563**	**71**	**471**	**22**	**155**	**7**	**2,190**	**100**	**4.3**

Table 4-5. Sediment delivery from surface erosion (modified from Graham Matthews & Associates 2007).

Subwatershed	Sub-basin	Sub-basin area (mi^2)	Road density, native surface (mi/mi^2)	Sediment delivery from surface erosion			
				Roads		Timber harvest	
				tons/yr	tons/mi^2/yr	tons/yr	tons/mi^2/yr
Upper	Upper Mad River	65.5	1.5	1,667	25	43	0.7
	Ruth Lake	55.0	1.7	5,939	108	40	0.7
Middle	Upper Middle Mad River	36.2	1.8	2,757	76	27	0.7
	Pilot Creek	39.7	2.0	2,938	74	40	1.0
	Lower Middle Mad River	81.3	3.0	17,212	212	190	2.3
Lower	Boulder Creek	19.0	2.9	4,009	210	6	0.3
	Maple Creek	15.6	4.5	5,429	347	42	2.7
	Cañon Creek	16.3	6.3	11,201	686	82	5.0
	Lower Mad River	64.3	3.5	18,105	282	208	3.2
	North Fork Mad River	48.8	5.6	31,866	653	161	3.3
	Lindsay Creek	17.7	5.5	7,788	439	152	8.6
	Powers Creek	26.7	4.7	7,446	279	121	4.5
	Mouth of Mad River	17.1	1.9	n/a	n/a	n/a	n/a
Total		**504**	**3.1**	**116,419**	**231**	**1,111**	**2.2**

Note: Sediment delivery estimates do not account for recently implemented or planned road improvements designed to reduce concentrated runoff, surface erosion, and the potential for failure of road drainage infrastructure.

4.3 Sediment Supply and Transport

4.3.1 Measured sediment load

Total sediment load is typically separated into suspended load and bedload. Annual suspended loads have been computed at locations throughout the Mad River Watershed over historical and recent time periods based on suspended sediment concentration (SSC) and turbidity. Few measurements of bedload discharge have been made in the basin, and consequently annual bedload has been estimated primarily in the gravel mining reach using bedload rating curves, changes in channel geometry, bedload transport equations, and the ratio of bedload to suspended load (refer to Section 4.4.2 below).

4.3.1.1 Suspended load

Suspended loads at the Mad River near Arcata gage and at the Mad River near Forest Glen gage were computed by the USGS (Brown 1973) for the period 1958–1974 and by Lehre (1993) for the period 1962–1992. The USGS (Brown 1973) related annual discharge to SSC and applied this relation to the instantaneous discharge record, while Lehre (1993) applied the relation from Brown (1975) to the mean daily record. Annual suspended loads computed for the overlapping period 1962–1974 for these two analyses vary considerably at Mad River near Arcata (Figure 3) but agree well at Mad River near Forest Glen.

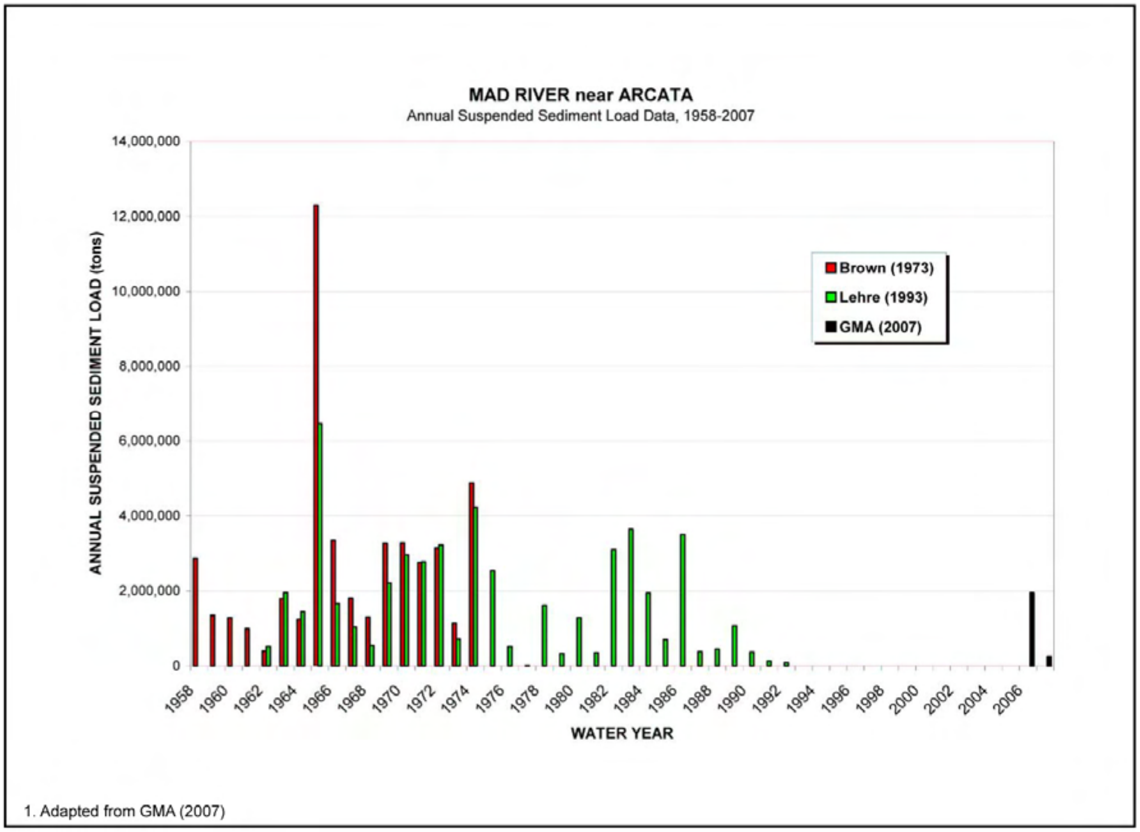


Figure 3. Comparison of measured suspended sediment load data.

Graham Matthews & Associates (2007) measured suspended sediment concentration (SSC) and turbidity at five continuous sites and 10 synoptic sites during Water Years 2006 and 2007 (Figure A-6). Relationships for SSC versus turbidity and SSC versus discharge were developed and used to compute suspended sediment discharge at all sites (Table 4-6). Turbidity records were analyzed for magnitude and duration and used to evaluate potential effects to aquatic organisms. Mainstem sites showed a downstream increase in turbidity, suspended sediment concentration, and suspended sediment load, with the highest values measured at Mad River near Arcata. Boulder Creek at Maple Creek Road Bridge was the most turbid tributary. Comparison of the SSC vs. discharge and turbidity vs. SSC relationships at the Mad River near Arcata for the 1958–1980 and 2006–2007 time periods suggests a large reduction in suspended sediment concentration for a given discharge. Synoptic sites within the South Fork Mountain Schist geology had measurably higher turbidity values than other sites. The Anada Creek watershed, for example, produces high turbidity and suspended sediment compared to Maple Creek, North Fork Mad River, and Mad River above Ruth Lake. Maple Creek has only slightly more than half the turbidity of its nearby mainstem site (Mad River below Butler Valley Ridge), highlighting the high erosion rates and sediment delivery in the middle watershed. Comparison of continuous turbidity records for the four mainstem sites indicates that Ruth Lake Reservoir reduces peak turbidity downstream of the dam but prolongs the event by slowly releasing turbid water.

Table 4-6. Measured suspended sediment loads[1].

Monitoring site		Source area (mi²)	WY 2006[1]		WY 2007[1]		Average	
			SSL (tons)	SSY (tons/mi²)	SSL (tons)	SSY (tons/mi²)	SSL (tons)	SSY (tons/mi²)
MRRTH	Mad River above Ruth Lake at County Road 514 Bridge	93.6	232,000	2,479	2,500	27	117,250	1,253
ACLM	Anada Creek	1.02	10,600	10,392	709	695	5,655	5,544
CCRTH	Clover Creek	0.47	16	34	2	4	9	19
BCLM	Blue Slide Creek	1.05	1,900	1,810	7	7	954	908
HCLM	Hobart Creek	1.62	2,190	1,352	21	13	1,106	682
TB3LM	Unnamed Tributary 3	0.28	38	136	1	4	20	70
OCLM	Olsen Creek	1.64	1,550	945	10	6	780	476
MR36	Mad River at Highway 36 Bridge	141.5	89,500	633	7,240	51	48,370	342
LMC36	Lamb Creek	3.12	17,500	5,609	88	28	8,794	2,819
BCMCB	Boulder Creek at Maple Creek Road Bridge	18.8	45,300	2,410	23,600	1,255	34,450	1,832
MRBVR	Mad River near Maple Creek below Butler Valley Bridge	352	1,400,000	3,977	140,000	398	770,000	2,188
MCMCB	Maple Creek at Maple Creek Road Bridge	12.2	12,300	1,008	6,210	509	9,255	759
NFMKB	North Fork Mad River at Korbel Bridge	44.5	31,800	715	10,500	236	21,150	475
MRHRB	Mad River at Hatchery Road Bridge	446	2,050,000	4,596	254,000	570	1,152,000	2,583

1 Suspended sediment monitoring was conducted by Graham Matthews & Associates (2007) as part of the Sediment Source Analysis for the Mad River TMDL (EPA 2007). Suspended sediment loads are for partial water years during the period of record ranging from 1 December 2005 to 20 March 2007. WY=water year, SSL=suspended sediment load, SSY=suspended sediment yield.

4.3.1.2 Bedload

There are few field measurements of bedload transport in the Mad River. Most of the work measuring and/or estimating bedload in Mad River has focused on the gravel mining reach (refer to Section 4.4.2 below). Brown (1975) reported nine measurements of bedload transport in the Mad River near Arcata (Highway 299 Bridge), five in the Mad River near Blue Lake (just upstream of the Mad River Fish Hatchery), and five in the Mad River near Kneeland (Butler Valley Bridge)(as cited in Lehre 1993). All bedload transport measurements by Brown were collected between January and April during water year 1972–73. Brown plotted bedload transport rate against water discharge to create bedload transport rating curves for the three sites. From these curves and the 1971–72 water discharge records, Brown estimated a 1971–72 bedload discharge of 60,000 tons at Arcata and 170,000 tons at Kneeland. These rough estimates were based on rating curves defined by only a few points. Lehre (1993) estimated bedload discharge in the Mad River near Arcata, near Kneeland, and near Blue Lake for the period 1962–1992 by applying Brown's bedload transport rating curves to measured and synthesized daily flow data (Figure 4). Lehre (1993) compared estimates derived from three methods: bedload rating curves, bedload equations, and bedload transport as a percentage of the computed suspended load (Table 4-7). Lehre (1993) recognized various sources of uncertainty in these estimates, but considered 150,000 to 200,000 tons/yr to be a reasonable estimate of the long-term average annual bedload recruitment for the upper end of the gravel mining reach in the Mad River Valley.

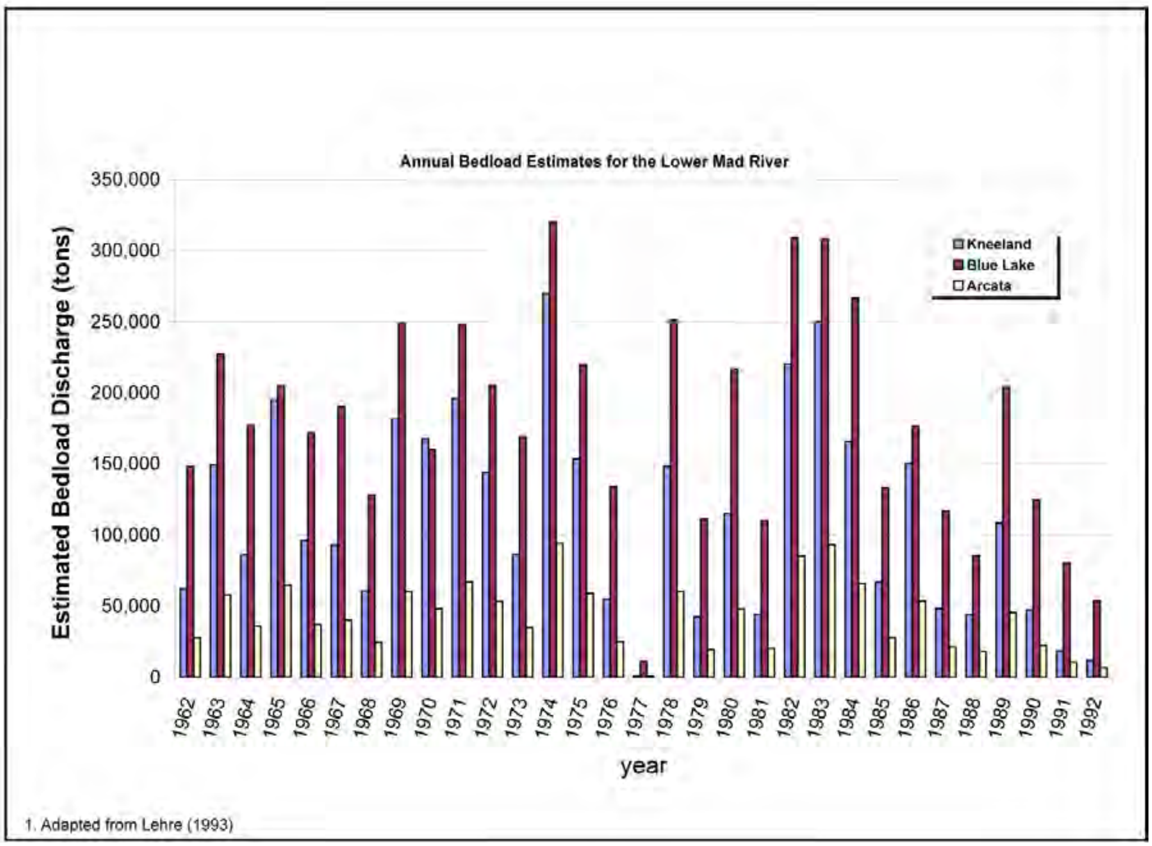


Figure 4. Annual bedload estimates for the lower Mad River.

Table 4-7. Comparison of long-term mean bedload transport estimates for the lower Mad River (from Lehre 1993).

Method	Mean bedload transport (tons/yr)		
	Mad River near Arcata (Hwy 299 Bridge)	Mad River near Blue Lake (upstream of hatchery)	Mad River near Kneeland (Butler Valley Bridge)
Bedload rating curve: Brown 1975	42,900	178,000	112,000
Bedload transport equation: Ackers-White	106,000	299,000	251,000
Bedload transport equation: Bagnold 1980	151,000	349,000	649,000
Bedload transport equation: Meyer-Peter	220,000	452,000	1,269,000
Bedload transport equation: Meyer-Peter and Muller	180,000	587,000	876,000
Bedload as 5% of suspended load	83,600	n/a	45,500
Bedload as 10% of suspended load	167,000	n/a	91,000

4.3.2 Estimated sediment delivery

Various workers have brought together information about erosion processes and rates in the Mad River watershed with the goal of estimating sediment delivery to the channel network, a critical first step in understanding where and to what degree beneficial uses may be affected by sediment supply. Various approaches have been used to estimate sediment delivery in the Mad River watershed, each involving various methods of extrapolating sample data collected in or near the watershed. For example, an empirical model of sediment delivery was developed by Green Diamond Resource Company during analysis of their HCP. A more extensive sediment budget was developed to account for sediment sources during analysis of total maximum daily sediment load by the Environmental Protection Agency (EPA). During the TMDL process, a GIS modeling approach was also implemented for comparative analysis of sediment delivery at smaller spatial scales.

Green Diamond Resource Company constructed an empirical model to estimate long-term average annual sediment delivery from mass wasting (road-related and harvest-related) under different management scenarios in their Habitat Conservation Plan (Green Diamond Resource Company 2006). The model was not site specific, did not address all possible forms of management-related sediment (e.g., skid trail erosion, in-unit hillslope erosion, and stream bank erosion), and did not differentiate between fine and coarse-grained sediment. The two primary data sources used to parameterize sediment delivery rates in the model were landslide inventories and road erosion inventories conducted on Green Diamond Resource Company ownership outside of the Mad River watershed. Sediment delivery volumes from road-related landslides were calculated directly from road inventory data and used to extrapolate sediment delivery from roads. Sediment delivery from non-road-related landslides was estimated from interpretation of aerial photographs with a limited amount of field verification. Harvest-related sediment delivery for different silvicultural practices was estimated by applying a regional ratio between harvest-related sediment (HR) and background sediment. HR for clearcut silviculture was estimated using published and unpublished data from north coastal California and southwest Oregon. HR for other silvicultural treatments was based on overstory retention specified in the HCP. Estimates of sediment delivery under background, pre-Plan, and post-Plan conditions were reported by process (e.g., shallow and deep-seated landslides) for different management zones. Weighting factors were developed to express how much of the Plan area was similar to pilot areas where estimates were derived. Monte Carlo simulations were conducted to analyze the sensitivity to forecast variables. The benefits of the Plan in terms of change in annual sediment delivery rates were reported for different points in time (e.g., 0, 15, and 50 years). Results of the empirical modeling of long-term sediment delivery are reported in Green Diamond Resource Company's Habitat Conservation for the entire Plan Area and not for individual watersheds within the Plan Area (i.e., Mad River).

Graham Matthews & Associates evaluated sediment delivery in the Mad River watershed using a traditional sediment budget that combined sediment delivery from landslide analysis, modeling of road and harvest-related surface erosion, and estimates of bank erosion (Graham Matthews & Associates 2007)(Table 4-8). The traditional sediment budget indicated that the largest sediment producing sub-basins were Holm Creek, Showers Creek, Goodman Prairie Creek, Deer Creek, Bug Creek, Morgan Creek, Bear Creek 2, Graham Creek, Dry Creek, and Topkins Creek. Landslide related erosion accounted for the majority of the sediment delivery in these basins. Of these large sediment producing sub-basins, Showers Creek, Goodman Prairie Creek, and Bear Creek 2 were large sources of road-related and management related sediment. Fourteen of the top 15 sediment producing basins were in the middle Mad River (Ruth Lake downstream to Butler Valley), where Franciscan Melange is the dominant geologic terrane type.

In addition to the traditional sediment budget that was developed to characterize sediment loads at key points in the Mad River Watershed, Graham Matthews & Associates (2007) also developed a model-based sediment budget that estimates annual sediment delivery and load at smaller scales in the Mad River watershed using NetMap (Benda et al. 2007). NetMap is an integrated suite of numerical models and analysis tools created for regional scale watershed analysis.

To compare sediment delivery estimated from the empirical sediment budget, modeled sediment budget, and measured sediment loads; subwatersheds were aggregated into three areas defined at the downstream endpoint by sediment and turbidity monitoring sites: (1) the upper watershed upstream of the County Road 514 Bridge (monitoring site MRRTH), (2) the middle watershed between MRRTH and Butler Valley Bridge (monitoring site MRBVR), and (3) the lower watershed between MRBVR and the Hatchery Road Bridge (monitoring site MRHRB) (Figure A-6). Results from the measured suspended load, the traditional sediment budget, and the NetMap sediment budget indicate that the middle basin produces the majority of the total sediment output (Table 4-9). For subwatersheds that drain more than 50 mi^2, the NetMap model results were ±20% of the measured sediment load. For small subwatersheds, the error was as much as 125%. The highest sediment loads are in the middle and lower Mad River sub-basins. The North Fork Mad River had the highest estimated sediment load (factor of 8 more than measured load), with the majority of erosion originating from road surface and fluvial erosion in mélange terrane.

Table 4-8. Sediment delivery estimated using traditional sediment budget methods (Graham Matthews & Associates 2007).

Sub-watershed	Sub-basin	Landslides								Surface erosion				Bank erosion		Total	
		Background creep[1]		Background		Road-related		Timber harvest-related		Road-related		Timber harvest-related					
		tons/yr	% of sub-basin total	tons/yr	% of sub-basin total	tons/yr	% of sub-basin total	tons/yr	% of sub-basin total	tons/yr	% of sub-basin total	tons/yr	% of sub-basin total	tons/yr	%of sub-basin total	tons/yr	tons/ mi^2/yr
Upper Mad	Upper Mad River	4,528	45.2	1,357	13.5	0	0.0	103	1.0	1,667	16.6	43	0.4	2,328	23.2	10,026	153
	Ruth Lake	11,662	19.2	8,437	13.9	32,231	53.0	119	0.2	5,939	9.8	40	0.1	2,400	3.9	60,828	1,106
Middle Mad	Upper Middle Mad River	18,175	22.4	20,160	24.8	34,737	42.8	4,627	5.7	2,757	3.4	27	0.0	724	0.9	81,207	1,243
	Pilot Creek	11,910	14.8	64,949	80.6	0	0.0	80	0.1	2,938	3.6	40	0.0	675	0.8	80,592	1,230
	Lower Middle Mad River	41,561	8.6	99,505	20.6	322,095	66.6	1,130	0.2	17,212	3.6	190	0.0	1,613	0.3	483,306	5,945
Lower Mad	Boulder Creek	3,344	4.6	37,297	50.9	25,561	34.9	2,694	3.7	4,009	5.5	6	0.0	380	0.5	73,291	3,857
	Maple Creek	1,560	19.8	343	4.3	0	0.0	0	0.0	5,429	68.8	42	0.5	515	6.5	7,889	506
	Cañon Creek	4,608	28.5	16	0.1	0	0.0	0	0.0	11,201	69.3	82	0.5	262	1.6	16,169	992
	Lower Mad River	28,503	9.7	32,183	11.0	205,296	70.2	6,341	2.2	18,105	6.2	208	0.1	1,814	0.6	292,450	4,548
	North Fork Mad River	14,738	29.0	439	0.9	3,022	5.9	0	0.0	31,866	62.6	161	0.3	634	1.2	50,860	1,042
	Lindsay Creek	3,133	27.3	0	0.0	0	0.0	0	0.0	7,788	67.9	152	1.3	407	3.5	11,480	649
	Powers Creek	8,258	41.7	0	0.0	0	0.0	3,049	15.4	7,446	37.6	121	0.6	936	4.7	19,810	742

[1] Background creep from deep-seated landslides.

Note: Management-related sediment delivery estimates did not account for improved erosion control measures in the Forest Practice Rules or recently implemented or planned road improvements designed to reduce concentrated runoff, surface erosion, and the potential for failure of road drainage infrastructure.

Table 4-9. Comparison of measured sediment loads and estimated sediment delivery (modified from Graham Matthews & Associates 2007).

Monitoring site[1]		Source area (mi^2)	WA sub-basin	Measured suspended sediment load[2]		Estimated sediment delivery[3] (tons/yr)			
						Traditional sediment budget		NetMap sediment budget	
				tons/yr	% of total output	tons/yr	% of total output	tons/yr	% of total output
MRRTH	Mad River above Ruth Lake at County Road 514 Bridge	93.6	upper	114,250	10	19,628	1.6	124,769	7
MRBVR[4]	Mad River at Maple Creek below Butler Valley Bridge	352	upper and middle	735,000	67	990,908	81	959,200	55
NFMKB	North Fork Mad River at Korbel Bridge	44.5	North Fork	14,475	1.3	50,847	4.2	184,809	11
MRHRB	Mad River at Hatchery Road Bridge	446	upper, middle, and lower[5]	1,102,000	100	1,223,072	100	1,740,738	100

1 Refer to Figure A-6 for the location of monitoring sites.
2 Values for suspended load average measurements from water years 2006 and 2007. These values exclude bedload.
3 Values for sediment delivery are long-term averages. These values include suspended load and bedload.
4 Measured suspended sediment load at MRBVR are adjusted to account for 20% fine sediment trap efficiency in Ruth Lake. Traditional sediment budget values for sediment delivery at MRBVR are adjusted to account for 80% total trap efficiency in Ruth Lake.
5 Total sediment output, including North Fork Mad River.

4.4 Channel Sediment Storage and Channel Change

4.4.1 Tributaries

There is little existing information about channel changes and sediment storage in tributaries to the Mad River. Limited information is available for select areas where monitoring has been conducted on industrial timberlands and where the California Department of Fish and Game has inventoried aquatic habitat conditions. Refer to Section 5 for more information on the results of these aquatic habitat inventories.

4.4.2 Mainstem Mad River

The Mad River in the lower watershed is a low gradient meandering to braided channel bordered by floodplains and terraces of Late Pleistocene and Holocene age. The river channel in the lower watershed is controlled over long time scales by interactions between uplift and subsidence in the Cascadia subduction zone, deformation in the Mad River fault zone, sea level change, and a sediment mass balance tending toward equilibrium or transport limitation. Over shorter time scales, the lower Mad River has been influenced by a long history of human occupation and use, including settlement, road construction, timber harvest, aggregate extraction, grazing, and flood control.

Historic accounts suggest that prior to Anglo settlement and the onset of large-scale in-stream and watershed disturbance, the Mad River from Sweasey Dam to the Hammond Bridge was a single thread, meandering channel with deep pools, shallow riffles, point bars, and cut-banks (Tolhurst 1995). An extensive riparian zone bordered the river. Avulsions, aggradation, and channel widening were common in the reach from Blue Lake to the Annie and Mary Bridge following large floods (Tolhurst 1995). The lower mainstem Mad River from Sweasey Dam to the Hammond Bridge is commonly divided into five reaches: (1) Sweasey Dam to the Mad River Fish Hatchery, (2) the Mad River Fish Hatchery to the Blue Lake Bridge (3) the Blue Lake Bridge to the Annie and Mary Bridge, (4) Annie and Mary Bridge to Highway 299, and (5) Highway 299 to the Hammond Bridge (Figure A-7).

4.4.2.1 Sweasey Dam to Blue Lake Fish Hatchery

The reach from Sweasey Dam to the Mad River Fish Hatchery is a mixed bedrock-alluvial channel with alternating gravel bars. Construction of Sweasey Dam in 1938 trapped coarse sediment and reduced coarse sediment supply to downstream reaches, resulting in channel degradation immediately downstream of the dam. Tolhurst (1995) documented an initial decrease in channel width and vegetation encroachment onto bars, followed by widening and degradation from 1948 to 1966. Sweasey Dam filled completely by 1962 and was removed in 1970, releasing about 4.8 million cubic yards of stored sediment to the lower river and resulting in up to 10–12 feet of downstream channel aggradation. Clearcut logging in the late 1880s, and later tractor logging and road construction peaking in 1950s and 1960s increased sediment delivery to this reach. Riffle-pool morphology returned to the reach during the late 1980s and early 1990s.

4.4.2.2 Blue Lake Fish Hatchery to Blue Lake Bridge

The reach from the Blue Lake Fish Hatchery to the Blue Lake Bridge is an alluvial channel with alternating bars, point bars, and medial bars. The reach meanders within a broad floodplain bound by low alluvial terraces. Flood control levees extend approximately 2,500 feet upstream from Hatchery Road Bridge along North Fork Mad River. The reach has undergone cycles of aggradation and degradation since the late 1880s in response to flooding and drought, impoundment and release of sediment from Sweasey Dam, and gravel extraction. Tolhurst (1995) documented anecdotal accounts of channel widening, avulsion, and a change from a meandering to braided channel in response to land use changes and floods in 1861–1862, 1890, 1955, and 1965. Active channel area gradually decreased, confinement increased, and vegetation encroached into the channel after 1966. The reach rapidly changed to multi-thread channel morphology again in 1970–1974 in response to increased sediment input following removal of Sweasey Dam. Meanders grew and sinuosity increased after 1974. The channel experienced rapid lowering in the late 1980s and early 1990s, with approximately 3 feet of mean bed degradation between 1960 and 1992.

4.4.2.3 Blue Lake Bridge to Annie and Mary Bridge

The reach from the Blue Lake Bridge to the Annie and Mary Bridge is a meandering and braided alluvial channel formed within a broad floodplain bound by alluvial terraces of Pleistocene and Holocene age. The wide, low gradient channel promotes deposition in alternating bars, point bars, and medial bars. Flood control levees extend approximately 2,500 feet downstream from the Hatchery Road Bridge along the right bank and in the vicinity of the Blue Lake water treatment plan. Tolhurst (1995) documented anecdotal accounts of braiding following large floods in 1861–1862 and 1890. Channel width, area, and length increased in response to large floods in 1955 and 1964. The bed aggraded during 1960 to 1974, then degraded through 1992. The channel in this reach has become increasingly confined by bank protection and gravel extraction. Tolhurst (1995) estimated approximately 4.5 feet of mean bed degradation between 1962 and 1992.

4.4.2.4 Annie and Mary Bridge to Highway 299 Bridge

The reach from the Annie and Marie Bridge to the Highway 299 Bridge is a meandering alluvial and bedrock channel comprised of alternating bars and point bars. The relatively narrow floodplain is constrained by bedrock, narrow alluvial terraces, bank protection, and levees. Meanders are more stable than in upstream reaches. The reach was initially disturbed by rafting of logs in the 1870s. Although there have been few lateral changes in channel width and planform, large scale gravel extraction in 1950s likely initiated bed lowering. Bed degradation was greatest in the 1960s, averaging approximately 4.5–6.0 feet between 1960 and 1992. Bed degradation necessitated construction of a rock grade control structure in the vicinity of the Humboldt Bay Municipal Water District's Ranney collectors in 1991 to maintain the water-elevation necessary to operate the facility (HBMWD 2004).

4.4.2.5 Highway 299 Bridge to Hammond Bridge

The reach from the Highway 299 Bridge to the Hammond Bridge is a meandering and braided alluvial reach (constrained artificially in places) with alternating bars, point bars, and medial bars. The reach was disturbed by construction of a canal in 1854 for rafting logs from Mad River to Mad River Slough. The river was confined by artificial means during the 1900s. Large scale gravel extraction initiated bed lowering in the 1950s. Bed degradation was greatest in the 1960s, averaging approximately 5.2 feet between 1962 and 1992.

4.4.2.6 Gravel mining in the lower Mad River

Gravel mining is presently concentrated in a 7.5-mile-long section of the lower Mad River between about the Mad River Fish Hatchery and Highway 101. This gravel mining reach of Mad River is commonly divided into an upstream reach extending from the Mad River Fish Hatchery to the Annie and Mary Railroad Bridge, and a downstream reach extending from the Annie and Mary Railroad Bridge to about the Highway 101 Bridge (Figure A-7). In 1994, the Humboldt County Board of Supervisors prepared a Programmatic Environmental Impact Report (PEIR) for gravel extraction activities on the lower Mad River. The programmatic EIR was supported by technical analyses of historical mining and effects on river habitat, geomorphology, and infrastructure; including a coarse sediment budget and sustained yield estimate (Lehre 1993). The technical analysis determined that the long-term mean annual gravel recruitment rate in the mining reach was approximately 150,000 yd^3/yr, substantially less than the 425,000 yd^3/yr minimum average annual rate of gravel extraction between 1960 and 1992 (Lehre 1993). Refer to Section 1.3.1.3 above for a discussion of bedload transport and recruitment. The technical analysis concluded that the long-term and persistent imbalance between gravel recruitment and extraction between 1960 and 1992 resulted in bed degradation (lowering), which undermined the footings of bridges crossing the Mad River, threatened the functionality of HBMWD pump facilities, and limited salmonid habitat quantity and quality (Refer to Section 5.2.12 for a discussion of fisheries management issues in the gravel mining reach).

The 1994 PEIR formally established the County of Humboldt Extraction Review Team (CHERT) and adaptive management program for gravel mining on the lower Mad River. The CHERT program initiated a comprehensive monitoring program that includes, among other components, mapping of channel conditions on aerial photographs that are flown annually and annual survey of a network of cross sections. CHERT analyzed changes in channel geometry, estimated bedload recruitment, and assessed the effects of mining after the first five years of the CHERT program (1993–1997) (Klein et al. 1998). The 1998 CHERT report concluded that bed elevations in the lower Mad River had not changed appreciably over the five year period, a conclusion consistent with an updated sediment balance for the river presented in the report indicating that gravel inputs to the lower river (from upstream transport and within-reach bank erosion) were in approximate balance with commercial extraction.

Two additional studies were subsequently prepared to investigate the sediment budget in the gravel mining reach of the Mad River Valley; the first by Kondolf and Lutrick (2000) and the second by Knuuti and McComas (2003) (Table 4-10). The US Army Corps of Engineers applied terms and conditions to gravel mining operations in 2003 based in part on the results of Knuuti and McComas (2003) and a Biological Opinion by NOAA Fisheries. The terms and conditions limited annual volumes to 150,000 cubic yards and emphasized “alternative” methods rather than traditional bar skimming methods.

Table 4-10. Comparison of sediment budgets for lower Mad River from Blue Lake Fish Hatchery to Highway 299 Bridge (modified from Knuuti and McComas 2003).

	Average annual change in stored sediment volume (yd^3/yr)		
	Lehre (1993)[3] 1962–1992	Kondolf and Lutrick (2001)[4] 1970–1999	Knuuti and McComas (2003)[5] 1971–2000
Gain[1]	96,000–150,000	125,000	73,000–114,000
Loss[2]	144,000	67,000	100,000–133,000

1 Amount of bed material that would naturally accumulate in the channel without gravel mining.
2 Measured net change in channel sediment volume (bed and bank).
3 Low estimate of gain based on USGS bedload rating curves. High estimate of gain based on total rate of gravel transport into reach.
4 Estimate of gain obtained by subtracting CHERT data for average annual gravel mining volumes from Kondolf's calculated value for annual change in storage.
5 Low estimate of loss obtained using the volumetric polygon analysis method, high estimate of loss obtained using the average-end-area method.

To refine the average annual commercial gravel mining volume for the lower Mad, CHERT conducted an analysis of trends and conditions in the lower Mad River based on channel cross sections, air photos, and other information collected during the 1993–2003 period (Lehre et al. 2005). Lehre et al. (2005) found that there was a net loss of about 520,000 cubic yards for the entire mining reach during the 11-year period, and that while the largely unconfined upstream reach lost stored sediment, the semi-confined downstream reach significantly aggraded (Table 4-11). The upstream reach experienced an estimated net loss of approximately 945,000 cubic yards, resulting in channel widening, bank erosion, and decreased mean cross sectional and thalweg elevations (Table 4-11). Relations between volume of gravel extracted and geomorphic response suggested that an annual mean extraction rate of about 85,000 yd^3/yr from the upstream reach would have minimal effect on channel enlargement under current conditions. The downstream reach aggraded by about 425,000 cubic yards from 1993–2003, although Lehre et al. (2005) found no significant relations between volume of gravel extracted and change in any geomorphic variables. Lehre et al. (2005) concluded based on observations of mean yearly extraction volumes and mean yearly net deposition that an annual extraction rate of about 50,000–70,000 yd^3/year from the downstream reach would likely have minimal effect on channel enlargement under current conditions.

Table 4-11. Changes in stored sediment volume in the gravel mining reach of lower Mad River (modified from Lehre et al. 2005)

Reach	Change in sediment volume during period[3], yd^3		
	1993–1997	1997–2003	1993–2003
Upstream reach[1]	-15,000	960,000	945,000
Downstream reach[2]	-245,000	-180,000	-425,000
Total	**-260,000**	**780,000**	**520,000**

1 Upstream reach extends from the Mad River Fish Hatchery to the Annie and Mary Railroad Bridge.
2 Downstream reach extends from the Annie and Mary Railroad Bridge to about the Highway 101 Bridge.
3 Values reported by Lehre et al. (2005) are rounded to the nearest thousand. Negative values indicate filling.

Table 4-12. Summary of relations between increasing gravel extraction and geomorphic response at Mad River cross sections, 1993–2003 (modified from Lehre et al. 2005). Strength of the relation is shown in parentheses.

Channel parameter	Upstream reach: Fish Hatchery to Annie and Mary Bridge		Downstream reach: Annie and Mary Bridge to Highway 299 Bridge	
	1993–1997	1997–2003	1993–1997	1997–2003
Mean elevation	increase (weak)	decrease (strong)	increase (moderate)	no relation
Thalweg elevation	no relation	decrease (moderate)	increase (weak)	no relation
Confinement	no relation	no relation	no relation	no relation
Width	no relation	increase (strong)	increase (uncertain)	uncertain
Area	decrease (moderate)	increase (strong)	decrease (moderate)	no relation
Volume	decrease (moderate)	increase (strong)	decrease (uncertain)	no relation

4.4.3 Lower Mad River and estuary

Over long time periods (thousands of years), the location of the lower Mad River and estuary has been predominantly controlled by tectonics and eustatic sea level changes. The channel between the Highway 299 Bridge and the estuary meanders within a zone bound by the Mad River thrust fault to the north and the northwestern projection of the Fickle Hill anticline to the south. The right bank of the lower river near the estuary impinges on coastal bluffs exposing marine terrace deposits uplifted and deformed by the Mad River fault. The broad floodplains and salt marshes south of the river mouth and estuary, locally known as the Arcata Bottoms, have been downwarped by coseismic subsidence during subduction zone earthquakes.

Over shorter time intervals (decades to centuries), the dynamics and specific position of the channel in the lower river and estuary are controlled by stream discharge and sediment load during large storms, wave attack, tidal currents, and anthropogenic changes. The first survey maps of 1870 put the mouth of the Mad River at what is now known as Mad River County Park. The width of the estuary at this time ranged from about 400 to 1,200 ft. Two 12–14 acre ponds, referred to as the Mad River Lagoon, were located along the Mad River Bluffs north of the mouth. Slough channels located in the lower Mad River (McDaniel Slough, Liscom Slough, Denny Slough, Ousley's Slough, and Daily's Slough) historically conveyed floodwater from Mad River across the Arcata Bottoms to Humboldt Bay (HBMWD 2004). A canal was constructed in 1854 to float logs from the Mad River to Humboldt Bay. Widening of the canal encroached on agricultural land and resulted in deposition of sediment and debris from the Mad River in Humboldt Bay. Public pressure and economic considerations prompted closure of the canal in 1888. The natural slough channels were progressively blocked in the 1900s, and the mainstem river channel was straightened and channelized in an attempt to minimize overbank flooding.

Borgeld et al. (1993) divided migration of the Mad River mouth into three periods related to the major forcing that accompanied each time period: the oscillation period (1870–1969), the transition period (1969–1971), and the progressive migration period (1971–1992) (Figure A-8)

During the *oscillation period* (1870–1969), north-directed tidal currents were apparently of minor importance, and the approximate balance between wave power and river discharge led to migration of the mouth within only a 1.5 km length of coastline. When discharge was low, the inlet was wave-dominated and episodically closed. Upstream channelization and bank protection increased downstream discharges that impacted the inlet during floods, while bed lowering and incision increased the tidal prism in the estuary during low flows. These changes contributing to accelerated bank erosion. This period included the three record floods (1953, 1955, and 1964)

During the *transition period* (1969–1971), rapid migration of the mouth to the north was controlled by an apparent imbalance between wave power, discharge, and tidal currents. During these years, the mouth migrated farther north than it had during the preceding century, reflected a change from a relatively stable inlet controlled by the balance of waves and river discharge to one dominated by waves and tidal currents. The change was apparently initiated in 1969 by erosion driven by the longshore component of wave power and tidal currents when river discharge was low to moderate and the mouth inlet had a concave-southward configuration.

The period of *progressive migration* (1971–1992) was driven by tidal currents that increased in magnitude as the inlet migrated, reinforcing continued migration. The volume of tidal prism and tidal flushing increased, and the inlet became increasingly protected from northward waves as it migrated north into the wave shadow created by Trinidad Head. The northward migration continued until rock slope protection was installed by California Department of Transportation in 1992 to protect Highway 101 in the vicinity of the vista point overlooking Clam Beach.

The river inlet remained in the vicinity of the vista point until 1998, when storm discharge breached a new inlet approximately 1.5 miles to the south in the vicinity of the 1969 location. The river inlet has gradually migrated northward since 1998, reaching the vicinity of Murray Road in 2008.

As the river inlet moved northward and the channel lengthened, a sequence of alternating bars characteristic of low-gradient meandering rivers developed. Enlargement of the lateral bar on the left bank opposite School Road and an associated shift in the channel thalweg eastward resulted in significant erosion of the coastal bluff near the west end of School Road. The section of coastal bluff with the most severe erosion retreated 319 feet during the 64-year period from 1941 to 2005 (LACO Associates 2008). Average retreat rates varied from as high as 5.1 feet per year to less than 0.4 feet per year (LACO Associates 2008). Bluff erosion at the School Road site has likely been exacerbated by bank stabilization, riparian vegetation encroachment, and channel narrowing in the reach extending upstream to about the Hammond Bridge (Stillwater Sciences 2008). By 1983, the channel banks in this reach had been stabilized by the construction of gravel berms in the vicinity of Hammond Bridge, by rip rap revetment on the left bank near Tyee City and on the right bank at the stormwater outfall upstream of School Road, and by riparian vegetation planted along the right bank by the McKinleyville Community Services District following construction of the infiltration ponds in 1983. As a result, active channel area in the reach has declined by 32% since 1941 (Stillwater Sciences 2008). Major bank stabilization work incorporating biotechnical techniques and aquatic habitat structure was completed at the School Road site in 2008.

4.5 Summary of Erosion and Sedimentation in the Mad River Watershed

Mad River watershed drains about 500 mi^2 of the geologically complex northern Coast Ranges. The Franciscan Complex underlies most of the watershed, which is overlain by the Falor Formation and younger Quaternary and Holocene deposits in the western portions of the watershed. Mass wasting triggered by intense rainfall, rapid snowmelt, and earthquakes is an important natural process controlling long-term (thousands of years) denudation of the Mad River watershed. Most landslides occur in Franciscan melange and on steep slopes in other Franciscan rock types. Over shorter time scales, land use practices such as road construction and timber harvest have altered the size and frequency of mass wasting processes (most commonly shallow landslides, debris flows, and channel bank failures), dramatically increasing sediment delivery to stream channels during the historical time period.

Various approaches have been used to estimate background and management-related sediment delivery in the Mad River watershed. Estimates of sediment delivery from empirical and modeled sediment budgets generally agree with measured sediment loads, and indicate that the middle basin produces the majority of the total sediment output. The highest sediment loads occur in sub-basins where Franciscan Melange is the dominant geologic terrane type. The largest sediment producing areas are in the Lower Middle Mad River sub-basin (i.e., Holm Creek, Showers Creek, Deer Creek, Bug Creek, Morgan Creek, Bear Creek 2), the Lower Mad River sub-basin (Graham Creek, Goodman Prairie Creek, Dry Creek) and Ruth Lake sub-basins (i.e., Topkins Creek). Landslide related erosion accounts for the majority of the sediment delivery in these basins. Approximately 61% of the total annual landslide sediment delivery in the Mad River watershed is from management related sources, 59% from road related landslides, and 1.7% from harvest related landslides. The Lower Middle Mad River and Lower Mad River sub-basins have the largest estimated sediment delivery from background and management-related landslides, together accounting for about 70% of the total annual landslide sediment delivery in the basin.

While surface erosion associated with roads, timber harvest, and other disturbance likely constitutes a major source of sediment input to the Mad River, little data is available documenting surface erosion from different geologic terranes, land uses, and vegetation types in the watershed. Road densities vary from 0.8 to 8.4 miles/mi^2, and average 4.2 miles/mi^2 for the entire watershed. Extensive inventories have been conducted on roads within industrial timberlands, but available information on the type and condition of these and other roads is limited. The North Fork Mad River has the largest estimated sediment delivery from road-related surface erosion, followed by the lower Mad River and lower middle Mad River sub-basins. Of the large sediment producing sub-basins identified in the sediment budgets and measurement of sediment load, Showers Creek, Goodman Prairie Creek, and Bear Creek 2 are large sources of road-related and management-related sediment. Most of the surface erosion occurs on heavily traveled roads with native surfaces that dissect the Franciscan mélange. Roads underlain by the Falor Formation are also prone to rill and gully erosion from surface runoff and block topple of steep cutslopes.

Suspended sediment concentration and turbidity have been measured over various times at sites throughout the basin. Turbidity, SSC, and suspended sediment load generally increase in the downstream direction, with the highest values measured at Mad River near Arcata. Comparison of long-term turbidity, SSC, and discharge records at Mad River near Arcata for the 1958–1980 and 2006–2007 time periods suggests a reduction in suspended sediment concentration for a given discharge. Ruth Lake Reservoir reduces peak turbidity downstream of the dam but prolongs turbid conditions by slowly releasing turbid water. Estimates of long-term average annual bedload discharge for the Mad River near Arcata, derived from bedload rating curves, bedload equations, and as a percentage of suspended load are about 150,000 to 200,000 tons/yr.

The Mad River in the lower watershed is a low gradient meandering to braided channel bordered by floodplains and terraces of Late Pleistocene and Holocene age. Although the river channel in the lower watershed is controlled over long time scales by interactions between uplift, fault deformation, and sea level change; the channel has been influenced over shorter time scales by a long history of human occupation and use. Major events affecting channel morphology and associated aquatic habitat in the lower Mad River channel include construction of Sweasey Dam in 1938 and removal of the dam in 1970; legacy clearcut logging and associated rafting of logs in the 1870s and 1880s; tractor logging and road construction peaking in the 1950s; construction of Matthews dam and Ruth reservoir in 1961; channelization, bank protection, and construction of flood control levees; and large scale gravel extraction. The effect of these major events has been alternating aggradation and degradation resulting in net channel degradation and a reduction in overall aquatic habitat complexity. Gravel mining is presently concentrated in a 7.5-mile-long section of the lower Mad River between about the Mad River Fish Hatchery and Highway 101. The County of Humboldt Extraction Review Team (CHERT) and adaptive management program were established in 1994 to assess the effects of gravel extraction and assist in determining sustainable levels of commercial gravel extraction in the lower Mad River.

The mouth of the Mad River has shifted dynamically over the historical period due to the influences of stream discharge and sediment load during large storms, wave attack, tidal currents, and anthropogenic changes. From 1870 to 1969, a balance between ocean wave power and river discharge led to a relatively stable mouth that migrated within a narrow length of coastline. From 1969 to 1971, the mouth migrated rapidly to the north apparently due to the dominance of waves and tidal currents over relatively low river discharge. From 1971 to 1992, slower northward migration continued into the wave shadow created by Trinidad Head until the California Department of Transportation stabilized the channel with rock slope protection in 1992 to protect Highway 101 in vicinity of the vista point overlooking Clam Beach. Storm discharge in 1998 breached a new inlet approximately 1.5 miles to the south, and the river inlet has gradually migrated northward since 1998, reaching the vicinity of Murray Road in 2008.

5 SALMONID DISTRIBUTION AND ABUNDANCE

5.1 Salmonid Species Historic Use of the Watershed

The WAU contains Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), steelhead and resident rainbow trout (*O. mykiss*), coastal cutthroat trout (*O. clarki clarki*), and the occasional sockeye salmon (*O. nerka*) and chum salmon (*O. keta*). The Mad River watershed also contains several non-salmonid fish species. Native resident fish include the Pacific lamprey (*Lampetra tridentata*), prickly sculpin (*Cottus asper*), coast range sculpin (*C. aleuticus*), Sacramento sucker (*Catostomas occidentalis*), Humboldt sucker (*Catostomas occidentalis humboldtianus*), three-spine stickleback (*Gasterosteous aculeatus*), and estuarine species such as longfin smelt (*Spirinchus thaleichthy*), starry flounder (*Platichthys stellatus*), and eulachon (*Thaleichthys pacificus*). California roach (*Lavinia ssymmetricus*), brown bullhead (*Ictalurus nebulosus*), largemouth bass (*Micropterus salmoides*), and green sunfish (*Lepomis cyanellus*) represent non-native fish species introduced into the watershed.

Known distribution of salmonid fish species within the basin is based on various surveys conducted primarily by California Department of Fish and Game, Green Diamond Resource Company (formerly Simpson Timber Company), and the USDA Forest Service. Spawner/carcass surveys, limited depletion electrofishing surveys, and presence/absence surveys were conducted on many of the streams, with a few surveys dating back to the 1960s.

5.1.1 Chinook salmon

The Mad River contains fall-run Chinook salmon that are part of the California Coastal (CC) Chinook Evolutionarily Significant Unit (ESU). CC Chinook salmon were listed under the ESA as threatened on 16 September 1999 (64 FR 50394). Critical habitat was designated on 2 September 2005 (70 FR 52488). Designated critical habitat for CC Chinook salmon encompasses reaches of all rivers and tributaries south of the Klamath River (exclusive), and north of the Russian River (inclusive), not including those reaches excluded from critical habitat (70 FR 52488).

Chinook salmon are documented within the Mad River basin up to the boulder roughs reach located near Bug Creek (RM 50). Chinook salmon utilize both the mainstem Mad and several tributaries including Lindsey Creek, North Fork Mad River, Cañon Creek, Maple Creek, and Blue Slide Creek (a.k.a. Black Dog Creek) (Figure A-9).

There is relatively little information regarding Chinook salmon populations in the Mad River. During the late 1800s and early 1900s commercial quantities of Chinook salmon were caught in the lower Mad. However, by 1910 there was talk about changing laws to make the Mad River a sportsman stream and shutting down the seine and gillnet commercial fishery to allow for fish to reach their spawning grounds and replenish stocks (Arcata Union, 10 December 1910). By 1912, the first hatchery fish were released into the Mad River. These young fish were of the Quinnat (River) stock, which were raised at the Price Creek (Eel River) hatchery (Arcata Union, 16 March 1912).

The CDFG counted adult salmonids that passed over the old Sweasey Dam fish ladder from 1938 through 1964. During this period a range of 19 to 3,139 Chinook salmon were observed moving upstream to spawn (Figure 5). In 1952 and 1954, the CDFG conducted tagging and recovery programs to estimate the size of the Chinook salmon run. In 1952, the Chinook salmon run was estimated to be 6,321 fish of which 401 passed over the Sweasey Dam fish ladder, another 5,120 spawned downstream of the dam, and 800 were taken by anglers. In 1954, the run was estimated to be 3,907 Chinook salmon of which 403 passed over the Sweasey Dam fish ladder, another 3,266 spawned downstream of the dam, and 238 were taken by anglers. No adult Chinook salmon population abundance studies have been conducted in the Mad River since 1954.

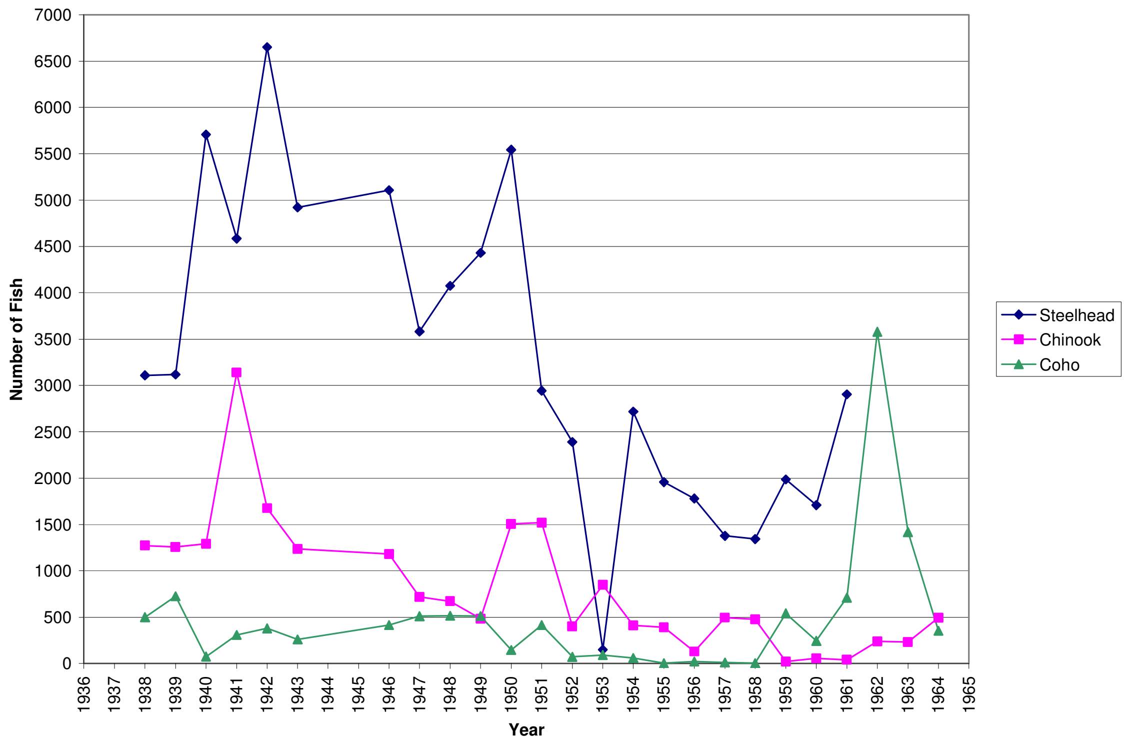


Figure 5. Sweasey Dam fish ladder adult salmonid counts 1938-1964.

More recently, Chinook salmon spawning surveys were conducted on Cañon Creek, North Fork Mad River, and mainstem Mad River from Devil Creek to the Annie and Mary Railroad Bridge on an intermittent basis (Table 5-1). The level of survey effort expended to collect these data varied widely and as such cannot be used to establish any population trend.

Table 5-1. Chinook salmon spawning survey data for Cañon Creek, the mainstem Mad River, and North Fork Mad River.

Stream/survey season	Live fish	Carcasses	Unknown carcasses	Redds	Unknown redds	Number of surveys
Cañon Creek						
1995/1996[1]	73	4	nd	27	3	1
1996/1997[1]	110	7	1	42	4	1
1997/1998[1]	30	22	nd	20	81	2
1998/1999[1]	66	6	nd	32	30	2
1999/2000[1]	202	66	2	73	65	9

Stream/survey season	Live fish	Carcasses	Unknown carcasses	Redds	Unknown redds	Number of surveys
2002/2003[2]	nd	nd	nd	57	39	3
2004/2005[2]	nd	nd	nd	22	nd	1
Mainstem Mad River						
2002/2003[2]	134	117		48	190	1
2003/2004[2]	669	91	34	408	1	1
2004/2005[2]	nd	nd	nd	437	nd	1
2005/2006[2]	nd	nd	nd	281	nd	1
North Fork Mad River (includes Sullivan Gulch)						
1996/1997[1]	296	395	38	321	7	3
1997/1998[1]	121	61	1	65	28	3
1998/1999[1]	54	28	5	22	63	4
1999/2000[1]	101	25	8	51	78	5
2002/2003[2]	nd	nd	nd	30	65	5
2004/2005[2]	nd	nd	nd	27	nd	1

[1] Source: Green Diamond Resource Company HCP (2006).
[2] Source: Unpublished data from Green Diamond Resource Company and instream gravel operators.

The CDFG conducted a downstream migrant trapping project between 30 March and 14 July, 2001 on the Mad River just downstream of the hatchery (Sparkman 2002). The population estimate for Age 0+ Chinook salmon over the course of the trapping period equaled 954,027 (95% C.I. of 854,178–1,053,876). This estimate does not include those juvenile fish that may have been produced in the tributaries (N.F. Mad River, Lindsey Creek) that enter the river below the hatchery.

5.1.2 Coho salmon

The Mad River contains coho salmon that are part of the Southern Oregon/Northern California Coast (SONCC) ESU. Coho salmon were listed under the ESA as threatened on 6 May 1997 (62 FR 24588). Critical habitat was designated critical habitat on 5 May 1999 (64 FR 24049). Designated critical habitat for SONCC coho salmon encompasses reaches of all rivers (including the Klamath River basin, estuarine areas, and tributaries) between the Mattole River in California and the Elk River in Oregon, inclusive. Coho salmon were listed as “threatened” under CESA on 30 March 2005.

Coho salmon are documented within the Mad River basin up to the boulder roughs reach located near Bug Creek (RM 50). This species utilizes both the mainstem Mad and lower gradient (<4%) reaches of several tributaries including, but not limited to, Lindsey Creek, Mill (Hall) Creek, Leggitt Creek, North Fork Mad River, Cañon Creek, and Maple Creek (Figure A-9).

There is relatively little information regarding coho salmon populations in the Mad River. The CDFG counted adult salmonids that passed over the old Sweasey Dam fish ladder from 1938 through 1964. During this period a range of 3 to 3,580 coho salmon were observed moving upstream to spawn (Figure 5). Lindsey Creek has been considered the primary coho salmon producing stream in the Mad River watershed. In 1956, the CDFG estimated between 200 and 250 adult coho salmon spawned on an annual basis in the creek. Spawning survey results for the years 1996–2000 in Cañon Creek and the North Fork Mad River recorded observing between 0 and 5 adult coho salmon on an annual basis (Green Diamond Resource Company 2006).

The CDFG conducted a downstream migrant trapping project between 30 March and 14 July, 2001 on the Mad River just downstream of the hatchery (Sparkman 2002). The trap captured 739 juvenile coho salmon, however, a population estimate was not developed. This estimate does not include those juvenile fish that may have been produced in the tributaries (N.F. Mad River, Lindsey Creek) that enter the river below the hatchery.

The CDFG Eureka has updated information on coho presence in the Mad River basin. Document production deadlines precluded inclusion of this information in this assessment.

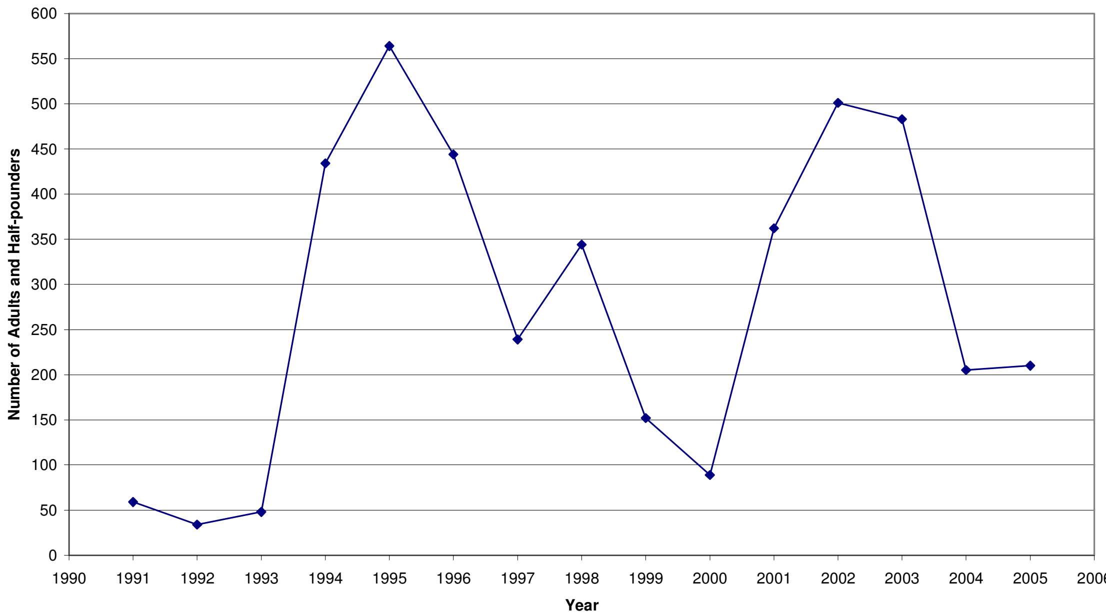
5.1.3 Steelhead

The Mad River contains winter-run and summer-run steelhead, which belong to the Northern California (NC) Distinct Population Segment (DPS). NC steelhead were listed under the ESA as threatened on 7 June 2000 (65 FR 36094). Critical habitat was designated on 2 September 2005 (70 FR 52488). Designated critical habitat for NC steelhead encompasses reaches of all rivers and tributaries between Redwood Creek (Humboldt County) and the Gualala River in Mendocino County, not including those reaches excluded from critical habitat (as described in 70 FR 52488).

Steelhead utilize smaller tributaries with steeper gradients than other anadromous salmonids, and can be found in the upper reaches of most large tributaries (unless barriers preclude their upstream migration). Historically, and at present, steelhead have been documented in all fish-bearing tributaries up to migration barriers (Figure A-9). A major barrier to migration exists near Deer Creek (RM 53), which restrict passage during all but the highest flows. However, some adult steelhead are occasionally found in Pilot Creek (RM 58).

There is relatively little information regarding populations of steelhead in the Mad River. The CDFG counted adult salmonids that passed over the old Sweasey Dam fish ladder from 1938 through 1964. During this period a range of 148 to 6,650 winter-run steelhead were observed moving upstream to spawn (Figure 5). The most recent information regarding winter-run steelhead populations in the Mad River was developed by the CDFG (Zuspan and Sparkman 2002). Zuspan and Sparkman (2002) conducted a mark and recapture study during the 2001–2002 season. They estimated 17,164 (95% C.I. of 11,478–26,077) adult winter-run steelhead migrated upstream of RM 13 during the 2000–2001 season. The summer-run steelhead population is much smaller than the winter-run fish. A range of 34 to 564 adult and half-pounders were observed during dive surveys conducted between 1992 and 2005 (Figure 6). Most of these fish were located downstream of the Bug Creek barrier.

Up until 2001 there were no data on the number of juvenile steelhead produced within the Mad River watershed. In 2001, the CDFG conducted downstream migrant trapping on the mainstem downstream of the Mad River Hatchery. The CDFG estimated naturally produced Age 1+ and 2+ steelhead populations at 11,455 (95% C.I. of 6,279–16,613) and 63,918 (95% C.I. of 29,038–98,798), respectively (Sparkman 2002).



Notes: 1991-1993 populations estimated from surveys of 25-49% of holding areas.
2000 population estimate from a survey of 50-69% of holding areas.

Figure 6. Underwater observation survey results of summer steelhead (adults and half-pounders) in the Mad River from 1991 through 2005 (from CDFG file data).

The Mad River Hatchery has been in operation since 1971. It was established as an enhancement hatchery to supplement ocean stocks to catchable levels and provide for sport fishing opportunities in the Mad River. Chinook and coho salmon are no longer reared at the hatchery and released into the Mad River. It is also used as a rearing facility for salmonids that originate from and will be released back into other basins. The hatchery also raises rainbow trout for local put-and-take fisheries. Between 1990 and 2000, the hatchery released between 134,000 and 1,440,460 Age 1+ juvenile steelhead in the Mad River (Zuspan and Sparkman 2002). The hatchery currently releases about 150,000 juvenile steelhead on an annual basis during the spring.

As mentioned in Sparkman (2003), one significant issue associated with maintaining a hatchery-reared population of steelhead in the Mad River is the potential reduction in viability of wild steelhead production in the basin. Chilcote (2001 and 2003) reported that wild steelhead populations can decrease as more hatchery steelhead intermix with wild fish. McLean et al. (2003) reported that hatchery steelhead that spawn in the wild have a much lower reproductive success rate than wild fish. They also showed that reproductive success may also decrease when the two groups interbreed. Chilcote (2001) estimated that if the proportion of hatchery fish in the wild exceeds 60% then the wild steelhead population may no longer be able to replace itself and would eventually become extinct.

The Zuspan and Sparkman (2002) mark and recapture study found that hatchery fish comprised 91.7% of the population with wild fish making up the remaining 8.3%. Zuspan and Sparkman (2002) also estimated that 88.5% of the hatchery-produced adult winter-run steelhead did not enter the hatchery. Gutierrez and Zuspan (2001) operated an upstream migrant trap for adult steelhead on Cañon Creek in 2000. They found that hatchery fish constituted nearly 63% of the steelhead captures at the weir while 21% were naturally-spawned and 16% were of unknown origin. Of the hatchery strays for which sex was determined, 86.4% were male and 13.5% were female. For the naturally-spawned adults 76.9% were female and the remaining 23% were male.

5.2 Barriers to Anadromous Salmonid Distribution

Anadromous salmonid distribution is restricted by natural and anthropogenic barriers within the Mad River basin. Barriers to fish migration can be natural and permanent or in the case of man-made obstructions, restorable. Natural and permanent barriers can include bedrock falls/steps, high gradient cascades, or bedrock sheets. Temporary natural barriers may also exist where stream channels become seasonally dry. Man-made barriers can include dams, road crossings, and temporary logging-related logjams. A thermal (high water temperature) barrier could also prevent seasonal movement by salmonids in a stream. Thermal barriers could be the result of natural conditions, land use practices, or some combination of each. A barrier may also limit upstream migration by salmon, but allow continued access by steelhead due to their different physical abilities.

A number of natural barriers exist in the Mad River basin that restrict upstream migration of anadromous salmonids. These include, but are not limited to:

- A boulder cascade is located in the North Fork Mad River about 3.8 miles upstream of its mouth. This barrier precludes coho and Chinook salmon and most steelhead from accessing upstream reaches.
- A series of boulder falls are located on the mainstem Mad River between Bug Creek and Deer Creek (RM 50–53). These barriers stop upstream anadromous migration for salmon and most steelhead.
- A boulder falls barrier exists on Cañon Creek approximately 2.25 miles upstream of its confluence with the Mad River.
- A boulder falls barrier reach on Maple Creek exists approximately 3 miles upstream of its mouth.
- A boulder cascade barrier exists on Boulder Creek approximately 2.1 miles upstream of its confluence with the Mad River.
- Noisy Creek falls that are located approximately 6,800 feet upstream of its confluence with Hall Creek.
- A boulder/bedrock cascade forms a barrier on Pilot Creek approximately 8.2 miles upstream of its mouth.

There are several man-made barriers within the Mad River basin. These include, but are not limited to:

- Matthews Dam (Ruth Lake) forms an impassable barrier for upstream anadromous steelhead and resident trout migration. This dam was not constructed with a fish passage structure and therefore blocks all resident fish passage as well as access to historic spawning and rearing grounds for those steelhead capable of surmounting the Bug to Deer creeks barriers.
- Culverts on the County Essex Road and Highway 299 block access by anadromous salmonids to approximately 6,000 linear feet of habitat in Essex Creek, a tributary to the lower Mad River (Lang 2005).

There are likely an unknown number of road crossing barriers on private lands within the Mad River basin. However, the Forest Practice Rules require any road used for timber operations that is a barrier to anadromous salmonids be removed, repaired, or replaced with a crossing that provides for unimpeded up- and downstream migration by fish at all times. This is required of new timber harvesting plans and non-industrial timber management plans.

6 FISH HABITAT

Most of the watersheds on the north coast have tracked a similar course from the late 1800s to present: Ranching occurred on the oak/grasslands, and timber harvesting began in the redwood zone in the mid- to late-1800s and then intensified in the late-1940s as mechanical developments and lumber demand expanded following WWII. Timber practices in those years were not regulated as they are today, and by the early 1960s many miles of stream zones were clearcut and heavily impacted by timber yarding. These watersheds were subject to the massive 1955 and 1964 storm events that raged through the tributaries and rivers of the county, which resulted in tremendous hillslope and streambank erosion and instream habitat degradation. This was likely the scenario for the Mad River basin.

6.1 Habitat Assessment Methods

The historical and current habitat conditions were determined by reviewing the available instream habitat survey information for each sub-basin. Instream habitat conditions in the major tributaries within the basin have been surveyed relatively sparsely by the CDFG and landowners. Most surveys began in the 1980s with a few in the early 1960s. These earlier surveys were mostly qualitative in nature, but still provided a general picture of stream conditions at that time. In other cases, the latest information was collected in the 1970s, which indicates a significant data gap and may misrepresent the current condition of the sub-basin. In some cases, the habitat information was collected on an annual basis for several years, as in the mainstem Mad River reach within the Powers Creek sub-basin.

6.2 Fish Habitat Conditions

The following fish habitat assessment is organized on a tiered basis beginning at the sub-watershed level and progressing to the sub-basin and individual creek levels as data are available. The descriptions contain information on subwatershed and sub-basin locations, instream habitat characteristics, water temperatures, and large woody debris where available.

6.2.1 Upper Mad River subwatershed

The Upper Mad River extends from the headwaters to Matthews Dam on Ruth Reservoir. The subwatershed encompasses approximately 120 square miles and makes up 24% of the Mad River basin. This subwatershed contains the Upper Mad River and Ruth Lake sub-basins.

6.2.1.1 Upper Mad River sub-basin

The upper Mad River sub-basin encompasses 41,920 acres, begins in the headwaters, and extends to about one-mile downstream of Barry Creek. Land use in the sub-basin is primarily ranching and non-industrial timber management. Six Rivers National Forest occupies a large percentage of the sub-basin.

Most of the upper Mad River mainstem channel is not incised and flows on a relatively flat floodplain without an inner gorge. While the main channel gradient is relatively flat, most of the tributaries have steep gradients, with inner gorges on the larger, steep gradient tributaries. Streamflow in the low gradient reaches of the main and tributary channels is often intermittent during the summer and fall due to excessive sedimentation.

There is very little information regarding the populations of rainbow trout within the project area. The last fisheries surveys in the upper Mad River tributaries were done in the late 1970s. In 2003, a two person USDA Forest Service team walked those tributaries historically identified as containing resident trout habitat to assess current conditions (USDA Forest Service 2005b). The 2003 surveys indicated habitat condition has changed very little since the 1970s. Surveys done in the summer of 2003 indicated that rainbow trout were present in many of the tributaries to the Upper Mad River. Most of the streams were intermittent with rainbow trout being found in isolated pools in various age classes, primarily young-of-year and 1+ rainbow trout. Few adult trout were seen during these surveys.

Barry Creek was considered to be possibly the best resident trout stream upstream of Ruth Lake (USDA Forest Service 1972). The USDA Forest Service conducted a 2.5-mile long survey of Barry Creek in 1983. The surveyors reported the stream was contained in a channel that had gradients ranging from 5–75% and a pool:riffle:flatwater ratio of 1:1:0. Pool depth ranged from 0.3 to 3.5 feet deep with an average of 1.0 feet. Shade canopy averaged 65% and instream shelter was low. Flow was considered the main limiting factor to fish production.

Trout Creek, Lost Creek and South Fork Mad River appeared to have mostly perennial flows in the upper sections surveyed with rainbow trout found in various age classes. The lower more aggraded sections, as well as other tributaries in the project area had isolated pools containing rainbow trout. With the exception on Barry Creek, none of the trout populations in these streams are sufficient to support a recreational trout fishery. The amount of angling on these streams is unknown, but is assumed to occur primarily in Barry Creek because of the easy access.

The USDA Forest Service (2005b) reported that riparian vegetation was not abundant in the upper Mad River tributaries, with few areas of true riparian plant communities. There were narrow strings of willows along most channels, however the condition was not evaluated. Upland vegetation types often dominated sections of the intermittent and ephemeral channels. Shading associated with smaller intermittent and ephemeral channels did not contribute directly to downstream habitat, since these channels were not flowing during the summer season when water temperatures would be of concern. Water temperatures in the upper perennial reaches ranged from 15°C to 17°C, which was adequate for rainbow trout.

6.2.1.2 Ruth Lake sub-basin

The Ruth Lake sub-basin encompasses 35,230 acres, begins at Matthews Dam (RM 84) and extends upstream to about two miles above Armstrong Creek; a distance of approximately 15.5 miles. Ruth Lake extends about 6.9 miles upstream of the dam. The watershed vegetation is primarily conifer forest intermixed with a lesser amount of oak woodland and grasslands on the lower slopes and valley floor. Land use in the sub-basin is primarily ranching and non-industrial timber management along with recreation on the lake. Six Rivers National Forest occupies a large percentage of the mid- to upper slopes in the sub-basin.

Mad River mainstem channel upstream of Ruth Lake is not incised and flows on a relatively flat floodplain without an inner gorge. While the main channel gradient is relatively flat, most of the tributaries have steep gradients, with inner gorges on the larger, steep gradient tributaries. Streamflow in the low gradient reaches of the main and tributary channels is often intermittent during the summer and fall due to excessive sedimentation.

The river upstream of Ruth Reservoir has a pool:riffle morphology that experiences intermittent flow during the dry months of the year. The 13-mile reach of the Mad River between the reservoir and Three Forks supports few, if any, trout during the summer and fall due to the lack of shade canopy, high water temperatures, and intermittent flow conditions.

The Upper Mad River Watershed Analysis (USDA Forest Service 1998) reported that only Armstrong, Hetten, Lost creeks contained populations of native rainbow trout. However, the populations were very low and limited to reaches that had adequate perennial flow and suitable temperatures. None of the trout populations in these streams were sufficient to support a recreational trout fishery.

6.2.2 Middle Mad River subwatershed

6.2.2.1 Upper Middle Mad River sub-basin

The Upper Middle Mad River sub-basin begins about a mile downstream of County Line Creek and continues upstream for about 23 miles before ending at Matthews Dam at approximately RM 84. The sub-basin encompasses approximately 23,183 acres. This sub-basin is relatively narrow and contains many short and steep gradient creeks, most of which are non fish-bearing. The watershed vegetation is primarily oak/grassland intermixed with conifers on the east side of the valley changing to conifer-dominated forest on the western slopes. Land use in the sub-basin is primarily ranching along with non-industrial timber management and recreation in the valley bottom and lower hillslopes. Six Rivers National Forest occupies a large percentage of the mid- to upper slopes in the sub-basin.

The mainstem Mad River within this sub-basin meanders through a moderately confined and entrenched channel with infrequent narrow floodplains and small gravel bars. The channel exhibits a riffle:pool to plane bed morphology. This reach contains relatively large substrate and may have been subject to bed elevation degradation as a result of Ruth Reservoir trapping sediment. Pools in this reach typically form due to scour around bedrock or boulders. Canopy closure over the river is about 20% and mostly provided by deciduous vegetation. Streambank landslides and earthflows are present on aerial photographs that are primarily associated with the outside of meander bends or destabilized toes of slopes.

County Line Creek is located at the downstream end of the sub-basin and was the only creek within this sub-basin with a known stream survey, which was conducted in 1977. The creek typically experienced intermittent flow during the summer months with isolated pools supporting fish species until surface flow commences with the fall rains. Riparian shade canopy was 30% in the lower reaches increasing to 65% in the upper reach. Topographic shading was estimated at being 30%. The survey reported the stream being moderately aggraded with would-be pools being filled with silt, sand and gravel. Spawning habitat was in poor condition and contained a significant amount of sand and fine sediment.

6.2.2.2 Pilot Creek sub-basin

Pilot Creek is located at about RM 58, the approximate midpoint of the Mad River basin. The sub-basin encompasses approximately 25,430 acres and is mostly contained within the Six Rivers National Forest with less than 5% privately owned. This sub-basin is upstream of the upper limit of salmon distribution and supports steelhead and resident rainbow trout. It has three major tributaries including: East Creek (and its tributary Rattlesnake Creek), Owl Creek, and Dan East Creek. The watershed vegetation is predominately (81%) fir (Douglas, white, red) forests with the remainder composed of oak woodland (15%) and grassland (3%) (USDA Forest Service 1996).

Most of the following discussion was taken from USDA Forest Service (1996).

Pilot Creek was designated as a "Tier 1 Key Watershed" by the Forest Ecosystem Management and Assessment Team (FEMAT 1993). This designation emphasizes the Aquatic Conservation Strategy, which contributes directly to the conservation of at-risk anadromous salmonids (USDA Forest Service and USDI Bureau of Land Management 1994). Land use in the sub-basin consists of commercial timber harvesting and activities to maintain and restore the aquatic ecosystem as per the Aquatic Conservation Strategy (USDA Forest Service and USDI Bureau of Land Management 1994).

Pilot Creek and its tributaries have been impacted by land-use activities and natural disturbance events, which have left portions of the aquatic ecosystem in a degraded state (USDA Forest Service 1996). The channel has reaches that are filled with sediment where water flows subsurface during the summer. Large logjams were observed in several places and were associated with the aggraded reaches. Sediment deposition in the aggraded reaches has resulted in wider and more open stream channel and decrease in the frequency and depth of pools. Although Pilot Creek has been impacted by an over-supply of sediment it still provides some relatively good trout habitat.

Winter steelhead and resident rainbow trout comprise most of the fish population in Pilot Creek, with summer steelhead being a minor component. Pilot Creek may be the only tributary with substantial reaches suitable for steelhead spawning and rearing for the 40 miles downstream of Ruth Reservoir. Steelhead are able to use 8.2 miles of Pilot Creek before being stopped by a boulder/bedrock cascade barrier.

In 1996, the USDA Forest Service conducted instream habitat assessments along 40,380 feet of Pilot Creek. The assessment reported pools made up 23% of the length of the survey reach with riffles, and flatwaters made up 30%, and 47% respectively. The dry channel tended to exist in the subreach just upstream of mouth. Riparian shade canopy ranged from 20–42% with the most exposed reach from the mouth of Pilot Creek to East Creek, a distance of approximately 13,000 feet. Wood was lacking as an instream habitat element even though large volumes were found in isolated logjams.

The USDA Forest Service also conducted a stream inventory of the lower 2,300 meters of East Creek in 1994. The survey found 18% of the reach was composed of pool habitat, 38% was riffle and the remaining 44% was flatwater. There were 14 pools identified as being greater than 3 feet deep. The stream had near optimum shade canopy; large logs and logjams provided good quality summer and winter habitat; and was a cold water source for Pilot Creek. Sedimentation in East Creek appeared to be low. A 10-foot high waterfall was located about 3,350 feet from the mouth and formed a barrier to steelhead migration. Resident rainbow trout were present upstream of the barrier.

Although the amount of shade canopy was low and the stream channel was aggraded, the water temperatures in Pilot Creek were not considered to be limiting production of salmonids (USDA Forest Service 1996). The highest maximum temperature in Pilot Creek in the summer of 1991, a drought year, was 19ºC (67ºF). The temperature regime was maintained by cool inflow from perennial tributaries. The well-shaded reach upstream of Owl Creek provided 14ºC (57ºF) water during the summer of 1991. East Creek contributed water that ranged from 8–11ºC (47–52ºF).

6.2.2.3 Lower Middle Mad River sub-basin

The Lower Middle Mad River sub-basin begins at Cowan Creek and continues upstream for about 19 miles before ending a couple miles upstream of Pilot Creek at approximately RM 61. The sub-basin encompasses approximately 52,005 acres. This sub-basin contains many short and steep gradient creeks, most of which are non fish-bearing. The watershed vegetation is primarily oak/grassland with a minor component of hardwood and conifer forest in the lower sub-basin changing to mixed hardwood/conifer forest in the upper reach. Land use in the sub-basin is primarily ranching along with non-industrial timber management. Six Rivers National Forest occupies a small percentage of the sub-basin.

The mainstem Mad River within this sub-basin meanders through a highly confined channel with infrequent narrow floodplains and small gravel bars. The lower three or four miles of the channel exhibits a step pool to cascade morphology. This reach contains numerous boulder roughs and cascades that form anadromous barriers to nearly all salmonids, except the most athletic steelhead. These barriers are located around Wilson and Bug Creeks. Pools in this reach typically form due to scour around bedrock or boulders. Further upstream the gradient lessens to some degree and the number of boulder roughs decreases. Canopy closure over the river is less than 10%. Streambank landslides and earthflows are present on aerial photographs that are primarily associated with the outside of meander bends or destabilized toes of slopes.

The Pilot Creek sub-basin drains into this reach of river. Two fish-bearing tributaries within the sub-basin are Wilson Creek (near the downstream end) and Wildcat Creek (near the upstream end). There may be other small tributaries within this sub-basin that have short sections of anadromy near their confluences with the Mad River. Both Wilson and Wildcat creeks have had only a single instream habitat survey conducted. The Wilson Creek survey was conducted by the CDFG in 1975 and Wildcat Creek was surveyed in 1982.

The 1975 Wilson Creek survey reported that the channel existed in a steep-sided gulch with highly eroded and unstable banks. This instability was considered natural since no evidence of logging was observed. The watershed vegetation was composed of alder, maple, oak, and buckeye trees with assorted dry grasses and brush. Pools in the survey reach comprised 20–40% of the stream length. Pool depths ranged from one to four feet deep. Instream shelter was provided by boulders and overhanging vegetation. Spawning gravels were clean enough to support spawning. Many juvenile steelhead, and possibly coho salmon, were observed.

The 1982 Wildcat Creek survey reported the fish-bearing reach was only 0.25 miles long. Within this reach, the pool:riffle ratio was 1:3 and pools averaged one to two feet deep. Pools were boulder-formed. Instream shelter was dominated by bedrock and woody debris. Bank vegetation was composed of 10% conifers, 30% deciduous trees, and 60% shrubs. Total shade canopy was 60%.

6.2.3 Lower Mad River subwatershed

6.2.3.1 Boulder Creek sub-basin

Boulder Creek enters the Mad River at about RM 30 and is contained in the lower Mad River subwatershed. It is known to support Chinook salmon, steelhead, and resident rainbow trout. A single coho salmon carcass was observed by CDFG in 1980. The sub-basin encompasses approximately 12,169 acres and has one major tributary, Little Boulder Creek. The watershed vegetation is mixed conifer/hardwood forest with a hardwood dominated riparian zone. Land use in the sub-basin is primarily commercial timber production and ranching. Homesteads and ranches are located primarily in the lower one-mile of the watershed.

No recent information was found regarding instream habitat conditions within this sub-basin. The only two stream reports available were written by the Bureau of Land Management (BLM) in 1977 and the CDFG in 1987. The BLM (1977) found that pools made up 50% of the stream with depths up to five feet (Table 6-1). The BLM also recorded shade canopy of 20–30% and water temperature of 21ºC on 22 June 1977. No survey reach length was recorded by the BLM although there was mention of habitat conditions within 2 miles from the mouth. The CDFG (1987) reported a pool:riffle ratio of 1:4 with average depths of four feet and a maximum depth of 15 feet within a 3 mile-long survey reach.

Table 6-1. Boulder Creek instream habitat parameters (CDFG 1987; BLM 1977).

Subwatershed	Sub-basin	Survey year	% of habitat type by length			Pool depths	Canopy closure (%)
			Pools	Riffles	Flatwaters		
Lower	Boulder Creek	1977	50	50	nd	Up to 5 feet deep	20–30
		1987	20	80	nd	0.5–4 ft lower reach, 4-foot average in upper reach	nd

A review of recent aerial photographs showed the creek channel has riparian canopy closure of 0 to 50%. Green Diamond Resource Company (and formerly Simpson Timber Company) collected summer time water temperature data within Boulder Creek between 1994 and 2007 (Table 6-2). The temperature data are reported as the highest 7-day moving average of all recorded temperatures, highest 7-day moving average of the maximum daily temperatures, the highest daily maximum recorded temperature, and the minimum temperature after the highest daily maximum temperature. The temperature data indicate suitable to stressful conditions for salmonids exist within Boulder Creek.

Table 6-2. Boulder Creek water temperatures for the years 1994-2007 (Green Diamond Resource Company 2008, unpubl. data).

Stream	Year	7-day moving average(ºC)	7-day moving maximum (ºC)	Maximum (ºC)	Minimum after maximum (ºC)
Boulder tributary	1996	13.2	13.8	14.7	12.7
Boulder	1994	16.6	19.6	20.1	14.0
	1995	16.7	18.3	18.8	15.2
	1997	18.1	20.8	21.6	15.8
	1998	17.7	20.1	21.2	16.4
	1999	17.2	19.6	20.6	14.4

Stream	Year	7-day moving average(ºC)	7-day moving maximum (ºC)	Maximum (ºC)	Minimum after maximum (ºC)
Boulder (below forks)	2001	15.7	16.9	17.8	14.5
	2002	16.6	17.6	18.0	16.2
	2003	17.2	18.6	19.4	16.2
	2004	17.1	18.4	18.7	15.9
	2005	17.3	18.8	19.1	16.0
	2007	16.0	17.4	18.5	15.2

Note: Conversion from degrees Celsius to Fahrenheit is F = (Cx9/5) +32

A barrier to anadromous migration exists about two miles upstream of the mouth of the creek. The barrier is a boulder roughs section with gradients exceeding 30% (CDFG 1987).

6.2.3.2 Maple Creek sub-basin

Maple Creek enters the Mad River at about RM 28 and is contained in the lower Mad River subwatershed. It supports coho and Chinook salmon, steelhead, and resident rainbow trout. The sub-basin encompasses approximately 10,013 acres and has one major tributary, Davis Creek. The watershed vegetation is predominately Douglas fir forests along with hardwood trees and grasslands. Land use in the sub-basin is primarily commercial timber production and ranching.

Two instream habitat surveys have been conducted on Maple Creek: a 31,000-foot long survey in 1984 by CDFG and a 23,280-foot long survey in 1988 by RCAA. The CDFG survey reported streamside vegetation composed of bay laurel, willows, alders, and maple trees. This would indicate a relative lack of conifers and potentially large woody debris recruitment potential. The CDFG also recorded only one logjam in the lower three miles of stream, which may also be an indication of low amounts of instream wood. The RCAA survey indicated a lack of large woody debris in the stream and proposed prescriptions to increase the number of pieces and improve pool habitat. Although their methods differed, both of these surveys collected quantitative data on instream habitat parameters that are presented in Table 6-3.

The CDFG conducted a stream survey along 3,120 feet of Davis Creek in 1981 to assess its value to anadromous fishes. The CDFG (1981) reported a pool:riffle ratio of 1:2 for most of the survey reach that changed to 1:1 near the upstream end (Table 6-3). Pools averaged one-foot deep for most of the reach and two feet deep near the end of the survey. Shade canopy averaged 90% and was composed primarily of deciduous trees with a lesser amount of conifers.

Table 6-3. Maple Creek sub-basin instream habitat parameters (CDFG 1981 and 1984, RCAA 1988).

Subwatershed	Sub-basin	Stream	Survey year	% of habitat type by length			Pool depths (ft)	Canopy closure (%)
				Pools	Riffles	Flatwaters		
Lower	Maple Creek	Maple	1984	43	57	nd	3–4 ave.	75
			1988	32	39	29	2.6 ave. max.	nd
		Davis	1981	40 ave.	60 ave.	nd	1–2 ave.	90

Simpson Timber Company collected summer time water temperature data within Maple Creek between 1994 and 1999 (Table 6-4). The temperature data indicate suitable conditions for salmonids existed within Maple Creek. The RCAA (1988) reported an average of 0.21 and 0.14 coho salmon per square meter in pool and flatwater habitats, respectively.

Table 6-4. Maple Creek water temperatures for the years 1994–1999 (Green Diamond Resource Company 2006).

Stream	Year	7-day moving average (ºC)	7-day moving max. (ºC)	Maximum (ºC)	Min. after max. (ºC)
Maple	1994	14.1	15.5	15.9	12.0
	1996	16.5	20.4	21.1	14.5
	1997	16.4	19.0	19.6	14.6
	1999	15.7	17.6	18.4	14.1

Note: Conversion from degrees Celsius to Fahrenheit is F = (Cx9/5) +32

A barrier to anadromous migration exists in Maple Creek approximately 3.2 miles upstream of the mouth. The barrier is composed of a series of cascading boulder falls 4–12 feet high followed by a single falls 15–20 feet high (CDFG 1984).

The CDFG (1981) reported a complete barrier to anadromous migration in Davis Creek was formed by a double box culvert at the Maple Creek Road crossing, which was 300 feet upstream of the creek's mouth.

6.2.3.3 Cañon Creek sub-basin

Cañon Creek enters the Mad River at about RM 20 and is contained in the lower Mad River subwatershed. It supports coho and Chinook salmon, steelhead, coastal cutthroat trout, and resident rainbow trout . The sub-basin encompasses approximately 10,484 acres and has one major tributary, Knutz Creek. The watershed vegetation is predominately redwood and Douglas fir forests on the hillslopes and riparian woodland on the valley floor where it joins the Mad River. Land use in the sub-basin is primarily commercial timber production.

Three instream habitat inventories have been conducted on Cañon Creek: a 17,277-foot long survey in 1988 by RCAA, a 24,862-foot long survey in 1994 by Simpson Timber Company, and a 23,656-foot long survey in 2005 by Green Diamond Resource Company. The RCAA survey utilized the Bisson et al. (1981) method and the 1994 and 2005 used the CDFG protocol (Flosi and Reynolds 1994, Flosi et al. 1998). All of these surveys collected quantitative pool, riffle, and flatwater that are presented in Table 6-5. Although there is likely variability between surveyors and methods, the quantitative measurements could give a gross idea of how instream habitat may have changed over the years. The reader should understand that observer variation could inject a substantial amount of error into the datasets and that these comparisons need to be taken with that in mind. With that in mind, the data appear to show that there has been some improvement in instream habitat quality between 1988 and 2005.

Table 6-5. Cañon Creek instream habitat parameters (RCAA 1990; Simpson Timber Company 1994; Green Diamond Resource Company 2008, unpubl. data).

Subwatershed	Sub-basin	Survey year	% of habitat type by length				% of pools by depth			Number of pool tails <25% embedded	Canopy closure (%)
			Pools	Riffles	Flatwaters	Dry	2–3 feet	3–4 feet	>4 feet		
Lower	Cañon Creek	1988	31	25	43	0	15	3	0	nd	61
		1994	47	26	27	0	39	23	18	nd	81
		2005	51	48	1	0	38	21	16	14	74

Green Diamond Resource Company conducted large woody debris surveys in Cañon Creek during 1994 and 2005. The LWD survey data are presented in Table 6-6.

Table 6-6. Cañon Creek instream LWD size distribution (Green Diamond Resource Company 2006; 2008, unpubl. data).

Stream (Year)	Average piece LWD per 100 feet by size class									
	Length surveyed (ft)	1–1.9 ft dia.; ≤20 ft	1–1.9 ft dia.; >20 ft	2–2.9 ft dia.; ≤20 ft	2–2.9 ft dia.; >20 ft	3–3.9 ft dia.; ≤20 ft	3–3.9 ft dia.; >20 ft	≥4 ft dia.; ≤20 ft	≥4 ft dia.; >20 ft	All size classes
Cañon Creek (2005)	23,656	0.49	0.28	0.14	0.07	0.05	0.02	0.15	0.01	1.21
Cañon Creek (1994/1995)†	4,800	0.6	0.6	0.2	0.1	0.1	0.0	0.2	0.0	1.8

† Survey composed of 24–200-foot long reaches.

Green Diamond Resource Company and its predecessor, Simpson Timber Company, collected summer time water temperature data at a number of stations in the Cañon Creek sub-basin between 1994 and 2007 (Green Diamond Resource Company 2008, unpubl. data). From these data, the seven-day moving average temperatures, seven-day moving maximum temperatures, maximum temperature, and minimum temperature after the maximum were determined (Table 6-7). In general, the temperature information showed that Cañon Creek warmed in a downstream direction.

Table 6-7. Water temperatures in Class I reaches of Cañon Creek for the years 1994–2000 (Green Diamond Resource Company 2008, unpubl. data).

Stream (location)	Year	7-day moving average (ºC)	7-day moving maximum (ºC)	Maximum (ºC)	Minimum after maximum (ºC)
Canon Creek (4093)	1999	17.6	18.9	20.0	14.7
	2000	18.2	20.0	21.1	16.1
	2001	17.4	19.4	20.0	16.3
	2004	18.4	20.7	21.3	15.0
	2005	17.6	19.8	20.2	16.2
	2006	18.4	20.2	21.1	17.6
	2007	17.7	18.8	19.9	18.0
Canon Creek (4300)	1994	15.8	18.0	18.4	13.1
	1999	16.8	17.4	18.1	14.5
	2000	17.9	19.6	20.3	16.6
	2001	17.4	20.0	20.9	16.0
	2002	17.5	20.0	21.1	16.6
	2003	17.5	20.2	21.1	15.6
	2004	17.8	19.7	20.1	16.5
	2005	17.2	19.5	20.1	15.6
	2007	17.3	18.7	20.2	17.4
Canon Creek (Maple Creek Road)	1994	14.9	15.9	16.2	14.0
	1999	16.0	17.1	17.8	15.2
	2001	16.8	18.3	19.0	15.5
	2002	16.6	18.8	19.5	15.4
	2003	16.9	18.2	19.1	16.1
	2004	17.7	19.4	19.7	16.8
	2005	16.8	18.2	18.7	15.4
	2007	16.5	17.8	19.0	16.7

Note: Conversion from degrees Celsius to Fahrenheit is F = (Cx9/5) +32

The CDFG conducted downstream migrant trapping during the late spring of 1995 on Cañon Creek. As part of the data collection procedure, the CDFG crew recorded water and air temperatures. The data appear to show the rise and fall of water temperatures fairly correlated with increases and decreases in air temperatures (Figure 7). Interestingly, the CDFG also recorded the greatest number of steelhead outmigrants during the warmest period (6–9 July) of the project, which may indicate instream conditions became marginal for those fish exposed to the higher temperatures.

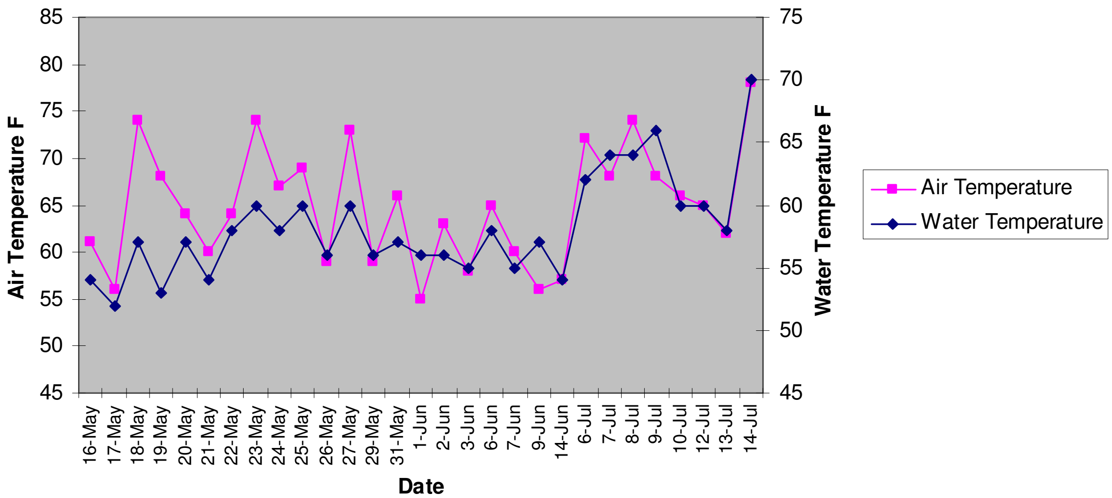


Figure 7. Cañon Creek air and water temperatures during the spring and summer of 1995.

The various data sets show Cañon Creek water temperatures fairly frequently reach stressful levels for juvenile salmonids during the summer months. However, coho salmon are consistently observed within Cañon Creek during these warmer periods. This may indicate there are locations within the creek that have cooler water temperatures such as seeps, tributary inflow, and stratified water locations.

6.2.3.4 Lower Mad River sub-basin

The Lower Mad River sub-basin extends upstream from the Mad River Hatchery (RM 17) to Graham Creek, a distance of 27 miles. The sub-basin encompasses approximately 41,167 acres. Much of this sub-basin lies along the west side of the river with the upstream end including Graham and Goodman Prairie creeks along the east slope. Main tributaries include Black Creek and Dry Creek. The Cañon, Maple, and Boulder creeks sub-basins also drain into this sub-basin. The watershed vegetation is primarily conifer forest with a lesser component of hardwoods. Land use in the sub-basin is primarily commercial timber production and ranching. Homesteads and ranches are located primarily in the lower one-mile of the watershed.

The mainstem Mad River within this sub-basin meanders through a moderately confined channel with narrow floodplains and gravel bars. The channel exhibits a pool:riffle morphology with an occasional small step. Pools typically form at meander bends and bedrock exposures. Canopy closure over the river is less than 10%. Streambank landslides are present on aerial photographs that are primarily associated with the outside of meander bends. The reach contains many suitable spawning areas and experiences significant Chinook salmon spawning activity. Coho salmon and steelhead, although primarily tributary spawners, also likely spawn in this reach during low flow years when tributaries are unavailable.

Dry Creek is a relatively small watershed of 1,492 acres that is located at the downstream end of the sub-basin at approximately RM 20. Instream habitat data for this stream were collected by Simpson Timber Company in 1994 and Green Diamond Resource Company in 2005. The data show Dry Creek containing relatively few and shallow pools, fair to good spawning habitat quality, and a closed canopy (Table 6-8).

Black Creek (a.k.a. Black Dog Creek) is located along the west side of the Mad River, just upstream of Maple Creek, at approximately RM 28.3. It has been known to support Chinook salmon, steelhead, and resident rainbow trout. The CDFG conducted stream surveys in 1985 and 2000 along 3.1 and 2.4 mile long reaches, respectively (Table 6-8). The CDFG surveys reported streamside vegetation was dominated by deciduous trees with a lesser amount of conifers. Spawning habitat quality was reported as being suitable for salmonids. The CDFG (2000) reported 35% of the pool tail-outs were less that 25% embedded and 32% were between 25 and 50% embedded. Both surveys identified a relatively low level of LWD and recommended installation of wood structures to improve pool habitat and instream cover.

Table 6-8. Black Dog Creek (CDFG 1985, 2000) and Dry Creek (Green Diamond Resource Company 2006; 2008, unpubl. data) instream habitat parameters.

Subwatershed	Sub-basin	Stream	Survey year	% of habitat type by length			Pool depths (ft)	Canopy closure (%)
				Pools	Riffles	Flatwaters		
Lower	Lower Mad	Dry	1994	16	67	14	79% 1–2 ft, 15% >2 ft	92
			2005	6	88	7	62% 1–2 ft, 38% >2 ft	100
		Black	1985	7	93	nd	1–2 ft. ave., 6 ft max.	80
			2000	25	6	69	57% >2 ft	83

Green Diamond Resource Company conducted large woody debris surveys in Dry Creek during 1994 and 2005 (Table 6-9).

Table 6-9. Dry Creek instream LWD size distribution (Green Diamond Resource Company 2006; 2008, unpubl. data).

Stream	Average piece LWD per 100 feet by size class									
	Length surveyed (ft)	1–1.9 ft dia.; ≤20 ft	1–1.9 ft dia.; >20 ft	2–2.9 ft dia.; ≤20 ft	2–2.9 ft dia.; >20 ft	3–3.9 ft dia.; ≤20 ft	3–3.9 ft dia.; >20 ft	≥4 ft dia.; ≤20 ft	≥4 ft dia.; >20 ft	All size classes
Dry Creek 1994/1995	1,200	0.9	0.1	0.3	0.1	0.0	0.0	0.0	0.0	1.4
Dry Creek 2005	3,877	2.2	0.4	0.6	0.2	0.1	0.1	0.1	0.0	3.7

Simpson Timber Company collected summer time water temperature data within Dry and Black Creeks between 1994 and 1999 (Table 6-10). The temperature data indicated suitable conditions for salmonids existed within these creeks. Factors that influence water temperatures within these creeks include east-facing aspect and a high degree of canopy closure.

Table 6-10. Dry and Black Dog Creek water temperatures for the years 1994–1999 (Green Diamond Resource Company 2006).

Stream	Year	7-day moving average (ºC)	7-day moving maximum (ºC)	Maximum (ºC)	Minimum after maximum (ºC)
Dry	1994	12.1	13.1	13.4	10.2
	1999	13.2	14.2	15.2	11.3
Black Dog	1996	13.0	13.5	13.7	12.8
	1997	14.2	14.4	14.6	14.0
	1998	13.3	13.8	14.0	12.8
	1999	13.3	13.6	13.9	13.4

Note: Conversion from degrees Celsius to Fahrenheit is F = (Cx9/5) +32

6.2.3.5 North Fork Mad River sub-basin

The North Fork Mad River enters the Mad River at the town of Blue Lake. This sub-basin supports coho and Chinook salmon, steelhead, coastal cutthroat trout, and resident rainbow trout. The sub-basin encompasses approximately 31,246 acres, contains the communities of Blue Lake and Korbel. It has five major tributaries including: Long Prairie Creek, Sullivan Gulch, Mill Creek, Hatchery Creek, and Canyon Creek. The watershed vegetation is predominately redwood and Douglas fir forests on the hillslopes and pastureland, wetland, and riparian woodland on the valley floor. Land use in the sub-basin consists of industrial timber production on the hillslopes, along with agriculture, rural and residential communities, and infrastructure and industrial development on the valley floor.

In 1995, Simpson Timber Company conducted instream habitat assessments along 80,278 feet of the North Fork Mad River and 14,928 feet of Long Prairie Creek utilizing the CDFG habitat inventory protocol (Table 6-11) (Green Diamond Resource Company 2006). The assessment reported pools in the North Fork made up 42% of the length of the survey reach with riffles, flatwaters, and dry channel making up 11%, 38%, and 10% respectively. The dry channel was present in the subreach just upstream of mouth. Nearly 55% of the North Fork pools were greater than three feet deep. About 18% of pool tailouts were less than 25% embedded with fine sediment. The mean riparian canopy density was 73%, but was dominated by deciduous trees (95%) with conifers making up the remaining 5%.

Green Diamond Resource Company (formerly Simpson) conducted an instream habitat inventory along 90,698 feet of the North Fork in 2007 using the CDFG habitat inventory protocol (Green Diamond Resource Company 2008, unpubl. data). They found the percentage of the survey length made up of pools remained the same between 1994 and 2007 (Table 6-11). The reader should understand that observer variation could inject a substantial amount of error into the datasets and that these comparisons need to be taken with that in mind. However, the percentage of pools greater than two feet deep decreased by about 35%. Within the same period, the pooltail embeddedness values improved with 30% of the tailouts being less than 25% embedded. The mean riparian canopy density was 69%, but was dominated by deciduous trees (83%) with conifers making up the remaining 17%.

In 1994, pools in Long Prairie Creek made up 30% of the length of the 14,928-foot long survey reach with riffles and flatwaters making up 47% and 23%, respectively (Table 6-11) (Green Diamond Resource Company 2006). Nearly 55% of the Long Prairie Creek pools were greater than two feet deep and 15% were greater than three feet deep. About 6% of pool tailouts were less than 25% embedded with fine sediment. The mean riparian canopy density was 95%, but was dominated by hardwoods (95%) with conifers making up the remaining 5%.

Green Diamond Resource Company conducted an instream habitat inventory along 15,074 feet of Long Prairie Creek in 2007 (Green Diamond Resource Company 2008, unpubl. data). They found the percentage of the survey length made up of pools remained the same between 1994 and 2007 (Table 6-11). However, the percentage of pools greater than two feet deep decreased by about 40%. Within the same period, the pooltail embeddedness values improved with 19% of the tailouts being less than 25% embedded. The reader should understand that observer variation could inject a substantial amount of error into the datasets and that these comparisons need to be taken with that in mind. The mean riparian canopy density was 89%, but was dominated by deciduous trees (91%) with conifers making up the remaining 9%.

Green Diamond Resource Company conducted an instream habitat inventory along 3,526 feet of Sullivan Gulch in 2005 (Green Diamond Resource Company 2008, unpubl. data). The assessment reported pools in the Sullivan Gulch made up 35% of the length of the survey reach with riffles, flatwaters, and dry channel making up 62%, and 3%, respectively. Seven percent of pools were greater than two feet deep. About 3% of pool tailouts were less than 25% embedded with fine sediment. The mean riparian canopy density was 83%, but was dominated by deciduous trees (79%) with conifers making up the remaining 21%.

Table 6-11. North Fork Mad River sub-basin instream habitat parameters (Green Diamond Resource Company 2006; 2008, unpubl. data).

Subwatershed	**Sub-basin**	**Stream**	**Survey year**	**Percentage habitat type by length (ft)**				**Percentage of pools by depth**			**Pooltails <25% embedded**	**Canopy closure**
				Pools	**Riffles**	**Flatwaters**	**Dry**	**2–3 feet**	**3–4 feet**	**>4 feet**		
Lower	North Fork Mad River	NF Mad	1995	42	11	38	10	34	27	28	18	73
			2007	42	28	30	<1	29	16	13	30	69
		Long Prairie Creek	1994	30	47	23	0	40	13	2	6	95
			2007	31	42	27	0	21	11	2	19	89
		Sullivan Gulch	2005	35	62	3	0	5	2	0	3	83

Green Diamond Resource Company conducted large woody debris surveys in the N.F. Mad River and Long Prairie Creek during 1994 and 2007 (Table 6-12).

Table 6-12. North Fork Mad River instream LWD size distribution (Green Diamond Resource Company 2006; 2008, unpubl. data).

Stream	Average piece LWD per 100 feet by size class									
	Length surveyed (ft)	1–1.9 ft dia.; ≤20 ft	1–1.9 ft dia.; >20 ft	2–2.9 ft dia.; ≤20 ft	2–2.9 ft dia.; >20 ft	3–3.9 ft dia.; ≤20 ft	3–3.9 ft dia.; >20 ft	≥4 ft dia.; ≤20 ft	≥4 ft dia.; >20 ft	All size classes
NF Mad 1994/1995†	16,800	0.2	0.3	0.1	0.1	0.1	0.0	0.2	0.0	1.0
NF Mad River 2007	86,331	1.0	0.4	0.3	0.2	0.2	0.1	0.2	0.1	2.6
Long Prairie 1994/1995†	3,400	1.0	0.5	0.1	0.4	0.0	0.2	0.0	0.0	2.2
Long Prairie 2007 (inc. SF)	16,149	1.4	1.0	0.4	0.5	0.1	0.2	0.1	0.0	3.8

† indicates the survey was composed of 200-foot long reaches.

Simpson Timber Company/Green Diamond Resource Company collected summer time water temperature data at a number of stations in the North Fork sub-basin between 1994 and 2007 (Green Diamond Resource Company 2006; 2008, unpubl. data). From these data, the seven-day moving average temperatures, seven-day moving maximum temperatures, maximum temperature, and minimum temperature after the maximum were determined (Table 6-13). A heat wave occurred during the week of 21–28 July 2006 that led to a spike in maximum water temperatures. In general, the temperature information showed that the tributaries tended to be cold and suitable for coho salmon while the North Fork was warmer even with the cool water accretion.

Table 6-13. Selected North Fork Mad River sub-basin stream temperatures (Green Diamond Resource Company 2006; 2008, unpubl. data).

Stream	Year	Stream class	7-day moving average (ºC)	7-day moving maximum (ºC)	Maximum (ºC)	Minimum after maximum (ºC)
N.F. Mad	2001	I	16.3	17.4	17.8	15.5
	2002		17.5	19.2	20.2	16.8
	2003		18.0	19.8	20.8	15.9
	2004		18.5	20.2	20.7	17.5
	2005		17.3	19.4	19.7	15.4
	2006		18.5	20.1	21.0	17.8
	2007		17.4	18.8	20.6	17.9
Long Prairie	1994	I	14.2	15.4	15.5	12.8
	1998		14.9	16.0	16.6	14.4
	1999		14.8	15.6	16.1	13.4
	2001		14.5	15.5	16.2	13.8
	2002		14.7	15.7	16.5	14.1
	2003		15.1	16.1	16.8	13.9
	2004		15.5	16.7	17.1	14.8
	2005		15.4	16.4	16.8	14.2
	2006		16.4	17.8	18.5	16.0
	2007		15.4	16.2	17.2	15.8
Sullivan Gulch	1997	I	15.2	15.9	16.3	13.9
	1999		14.6	15.1	15.9	12.5
	2000		14.9	15.6	16.2	13.5

Stream	Year	Stream class	7-day moving average (ºC)	7-day moving maximum (ºC)	Maximum (ºC)	Minimum after maximum (ºC)
	2001		14.2	14.9	15.7	12.3
	2002		14.5	15.2	16.0	13.7
	2003		14.8	15.1	15.4	13.8
	2004		15.3	15.9	16.3	15.0
	2005		15.4	17.2	17.5	13.8
	2006		15.1	16.1	16.6	14.7
	2007		15.6	16.2	17.0	15.9
Pollock Creek	1997	II	14.5	14.9	15.1	13.7
	1998		13.9	14.6	15.2	13.4
	1999		13.6	13.8	13.9	13.3
	2002		13.6	14.4	15.2	13.3
	2003		14.3	15.1	15.6	14.0
	2004		14.6	15.5	15.8	14.1
	2006		15.1	16.0	16.5	15.0
	2007		14.6	15.2	16.0	15.0

Note: Conversion from degrees Celsius to Fahrenheit is F = (Cx9/5) +32

6.2.3.6 Lindsay Creek sub-basin

Lindsay Creek enters the lower reach of the Mad River near the community of Glendale. Lindsay Creek supports coho and Chinook salmon, steelhead, and coastal cutthroat trout. It is considered to be the most productive coho salmon stream in the Mad River watershed. The sub-basin encompasses approximately 11,331 acres, contains the community of Fieldbrook, and has five major tributaries including: Squaw Creek, Grassy Creek, Anker Creek, Van Eck Creek, and Mather Creek. The watershed vegetation is predominately redwood and Douglas fir forests on the hillslopes and pastureland, wetland and riparian woodland on the valley floor.

The Lindsay Creek watershed, like much of the north coast, has been subject to intensive land uses for the past 150 years, which have significantly altered the aquatic system. These land use practices began in the mid- to late 1800s with intensive unregulated harvesting to the old growth timber followed by broadcast burning of the cutover landscape. Currently land uses include rural residential and infrastructure development, agriculture, and sustainable timber harvesting.

In 1995, Simpson Timber Company conducted an instream habitat assessment along 30,227 feet of Lindsay Creek. The assessment reported pools made up 50% of the length of the survey reach with riffles and flatwaters making up 9% and 41% respectively (Table 6-14). Over 48% of the pools were greater than three feet deep and the mean canopy density was 79%. The survey also found that only 3% of the spawning areas were less than 25% embedded.

Table 6-14. Salmonid habitat parameters in the Lindsay Creek sub-basin.

Subwatershed	Sub-basin	Stream	Survey year	Percentage habitat type by length (ft)				Percentage of pools by depth			Pooltails <25% embedded	Canopy closure (%)
				Pools	Riffles	Flatwaters	Dry	2–3 feet	3–4 feet	>4 feet		
Lower	Lindsay Creek	Lindsay Creek	1995	50	9	41	0	38	33	16	3	79
			2006	37	15	49	0	38	21	6	61	92
		Grassy Creek	1961	40	60	nd	0	nd	nd	nd	nd	nd
			1972	20	80	nd	nd	nd	nd	nd	nd	nd
			2005	28	13	25	33	18	6	0	39	91
		Squaw Creek	1961	50	50	nd	nd	nd	nd	nd	nd	nd
			1972	14	86	nd	nd	nd	nd	nd	nd	nd
		Anker Creek	1981	11 ave.	89 ave.	nd	nd	nd	nd	nd	nd	70

The CDFG conducted an instream habitat inventory along approximately 35,600 linear feet of Lindsay Creek during the summer of 2006. The inventory reported pools made up 37% of the length of the survey reach with riffles and flatwaters making up 15% and 49% respectively (Table 6-14). Twenty seven percent of the pools were greater than three feet deep and the mean canopy density was 92%. The CDFG also found that 60% of the spawning areas were less than 25% embedded.

Simpson Timber Company (now Green Diamond Resource Company) conducted summer time water temperature monitoring at a single station in Lindsay Creek from 1994 through 2007 (Green Diamond Resource Company 2006; 2008, unpubl. data). The monitoring station was located upstream of Timmon’s bridge and had an upstream drainage area of 8,811 acres. During this period, the seven-day moving average temperatures ranged from 15.3 to 16.4ºC (Table 6-15). The seven-day moving maximum temperatures ranged from 16.0 to 17.1ºC. These water temperatures were within the range that would support juvenile coho salmon, which are present in Lindsay Creek in significant numbers.

Table 6-15. Lindsay Creek water temperatures (Green Diamond Resource Company 2008, unpubl. data).

Year	7-day moving average (ºC)	7-day moving maximum (ºC)	Maximum (ºC)	Minimum after maximum (ºC)
1994	15.9	16.8	17.1	15.2
1995	15.9	17.1	17.8	15.2
1996	15.9	16.6	17.2	15.0
1997	16.1	16.9	17.3	14.8
1998	15.8	16.8	17.4	14.5
1999	15.3	16.2	17.1	14.9
2000	15.4	16.0	16.3	15.0
2001	15.8	16.7	17.0	15.1
2002	15.6	16.4	17.4	14.9
2003	16.1	17.0	17.6	15.6
2004	16.4	16.9	17.1	16.3
2005	16.0	16.9	17.3	14.8
2006	15.7	16.5	17.2	15.3
2007	16.2	16.9	17.7	16.7

Note: Conversion from degrees Celsius to Fahrenheit is F = (Cx9/5) +32

A comparison of the 14-year period of record showed the seven day maximum average water temperatures varied within a 1ºC range (Figure 8). In general, water temperatures in Lindsay Creek appear to be suitable for coho salmon rearing.

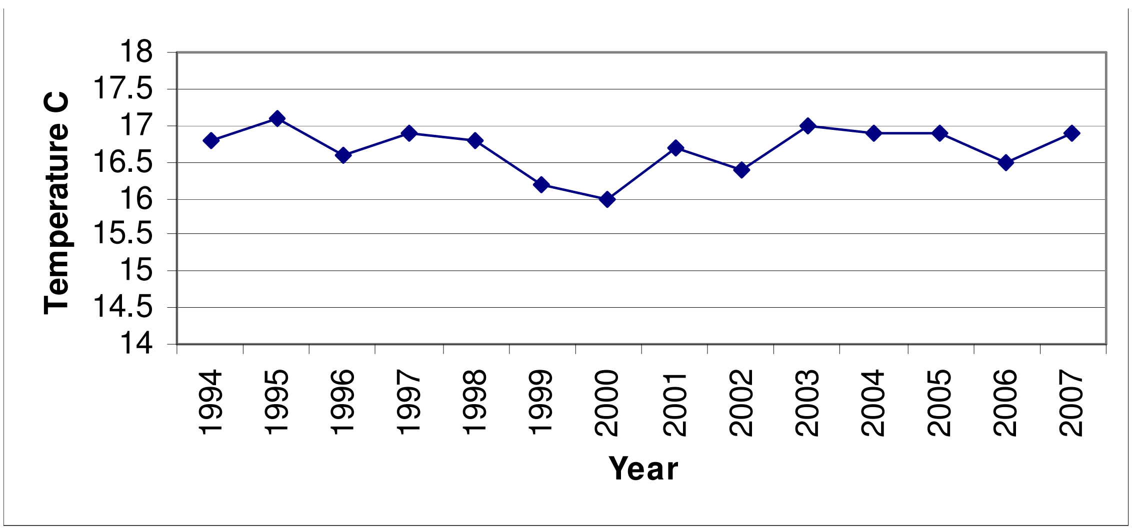


Figure 8. Lindsay Creek seven-day maximum average summertime water temperatures, 1994-2007 (Green Diamond Resource Company 2008, unpubl. data).

A number of fish passage and restoration projects have been conducted in the Lindsay Creek sub-basin. Culvert replacements on Mather and South Fork Anker creeks have allowed access by anadromous salmonids to approximately 30,000 linear feet of spawning and rearing habitat. The Grassy Creek/Fieldbrook Road crossing was upgraded with baffles and backflood weirs to improve passage. The Lindsay Creek crossings at Fieldbrook and Railroad Crossing roads were also upgraded to improve passage. Bank stabilization and riparian planting projects were also implemented on Lindsay Creek.

6.2.3.7 Powers Creek sub-basin

The Powers Creek sub-basin is located between RMs 4 and 17 and extends from approximately the Mad River Hatchery to the Highway 101 Bridge. The sub-basin encompasses approximately 17,093 acres. Communities within this sub-basin include Blue Lake, Glendale, and the northern portion of Arcata. This sub-basin, like much of the north coast, has been subject to intensive land uses for the past 150 years, which have significantly altered the aquatic system. These land use practices began in the mid- to late 1800s with intensive unregulated harvesting to the old growth timber followed by broadcast burning of the cutover landscape. Currently land uses include rural residential and infrastructure development, agriculture, gravel extraction, and sustainable timber harvesting on industrial and non-industrial timberlands.

Instream gravel extraction has been the primary land use directly affecting the mainstem river channel for several decades. In the early 1990s it was recognized that over-extraction (±425,000 cubic yards per year from 1960–1992) was resulting in significant streambed lowering and potentially threatening the stability of the Highway 101 and 299 bridges. It was estimated that maximum bed lowering resulting from over-harvesting ranged from 4 to 18 feet at some locations (Lehre 1993). The Mad River programmatic EIR and other regulatory initiatives (Clean Water Act section 404 permits, NMFS biological opinions) introduced since 1992 have resulted in a reduction of harvest volumes to a sustainable level (155,000 cubic yard per year) and partial recovery of the river bed elevation.

This sub-basin contains a number of tributary streams and two distinct mainstem river reaches: lower (Highway 101 to Annie and Mary Railroad bridge) and upper (Annie and Mary Railroad Bridge to the Mad River Hatchery). Tributary streams include Warren, Hall, Mill, Noisy, Powers, Kelly, Leggit, Palmer, and Quarry creeks. In addition, the Lindsay Creek and North Fork Mad River sub-basins drain into this reach of the river. The following mainstem reach descriptions are taken in part from Lehre et al. (2005) and annual instream gravel extraction monitoring reports (Halligan 2007, Stillwater Sciences 2008).

Lower reach

The upper portion of the lower reach lies between the Annie and Mary Railroad Bridge and Highway 299. In this reach, floodplain width is severely limited and narrow alluvial terraces are discontinuously present along the banks. Bedrock outcroppings in the bed and banks are common. Channel migration is limited to a narrow zone and meanders are relatively stable. Downstream of the Highway 299 Bridge the gorge widens somewhat and a wider floodplain is present. Gravel covered terraces are present fairly high (10–40 feet) above the channel on both banks. Bedrock outcrops are present in and along the banks. The Humboldt Bay Municipal Water District (HBMWD) has a series of Ranney wells and a surface collection station in this reach with the capacity to divert up to 90,000,000 gallons per day.

The sub-reach between Highways 299 and 101 is of a low gradient (<0.2%) alluvial nature with moderately -sized meanders and alternate bars. The channel has a relatively small width to depth ratio and is shaded with less than 5% canopy. Stream temperatures reach stressful levels for salmonids, but are highly influenced by the coastal marine layer. The channel bed has been increasing in elevation in recent years and contains significant sand and gravel deposits. Very little LWD is present in this reach due to the magnitude of winter flows and lack of very large riparian trees. This reach contains a fair amount of summer rearing habitat for juvenile steelhead and very limited salmonid spawning opportunities.

Upper reach

The upper reach of this sub-basin lies between the Annie and Mary Railroad Bridge and the Mad River Hatchery. This reach is of a highly depositional nature and contains a number of instream gravel extraction operations. Stream gradient in this reach ranges from 0.1 to 0.3%. The channel is relatively unconfined with large meanders and extensive alluvial deposits. Pool development is primarily the result of hydraulic scour action along the outside edges of bars. The substrate is dominated by small cobble and gravel. LWD quantity is limited in this reach due to the high winter water velocities and transport capacity. The stream side canopy closure is very low due to the channel width. Summer time water temperature reach stressful levels for juvenile salmonids, but thousands of juvenile steelhead and lesser numbers of juvenile Chinook and coho salmon can be observed rearing during the summer months. Adult summer steelhead also occupy this reach during the summer and fall months.

Instream habitat in the upper reach is composed of the full range of conditions required by anadromous salmonids. High quality winter rearing habitat is present within secondary and tertiary channels on gravel bars, in alcoves, as well as on vegetated floodplains. Chinook salmon spawn in the reach between Hall Creek and the Hatchery. Juvenile Chinook salmon habitat can be found in the upper water column of pools. Juvenile coho salmon habitat is present along banks that contain overhanging and submerged riparian vegetation. Age 2+ steelhead habitat is provided by turbulent flow at the head of pools and within cobble-dominated flatwaters. Abundant edgewater habitat is available for post-emergent fry.

Mainstem instream salmonid and riparian habitat

Instream habitat

Trush (2008a) conducted an analysis of instream salmonid habitat quantity from 11 sets of aerial photographs that spanned the years 1948 to 2007. Trush (2008a) analyzed changes to adult salmon and steelhead holding, juvenile coho salmon, Age 2+ steelhead, and spawning habitat within a reach extending from the mouth of the North Fork Mad River down to the Highway 101 Bridge. Trush (2008a) determined that instream habitat quantity decreased from the 1948 baseline during the 1950's through the early 1970s and then improved to, or close to, baseline levels in later years (Figures 9–11).

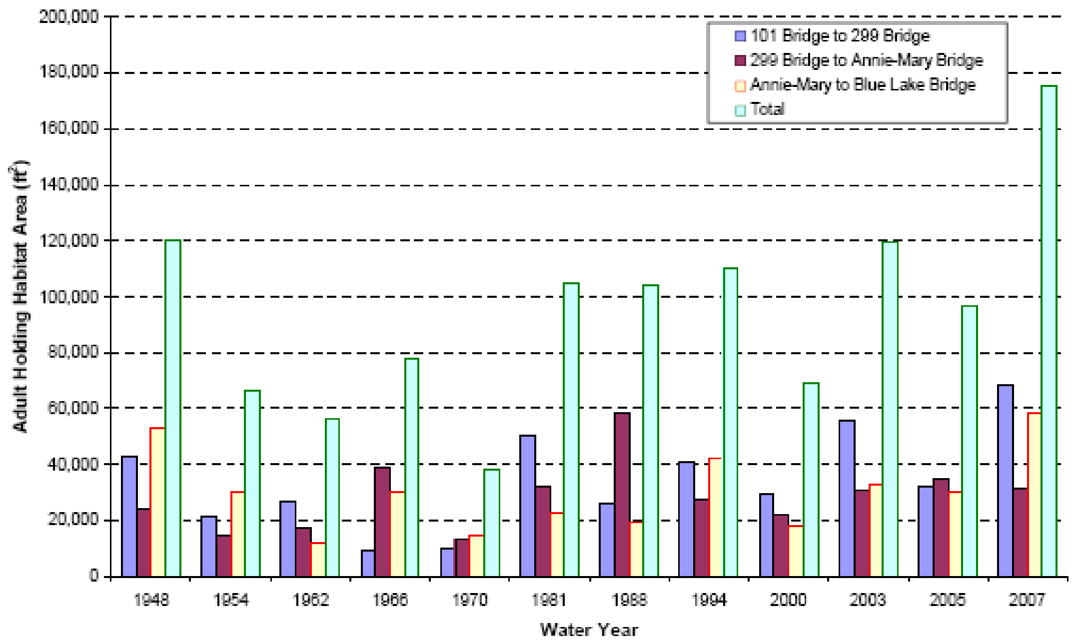


Figure 9. Adult salmon and steelhead holding habitat (ft²) in the lower Mad River from 1948 to 2007 (Trush 2008a).

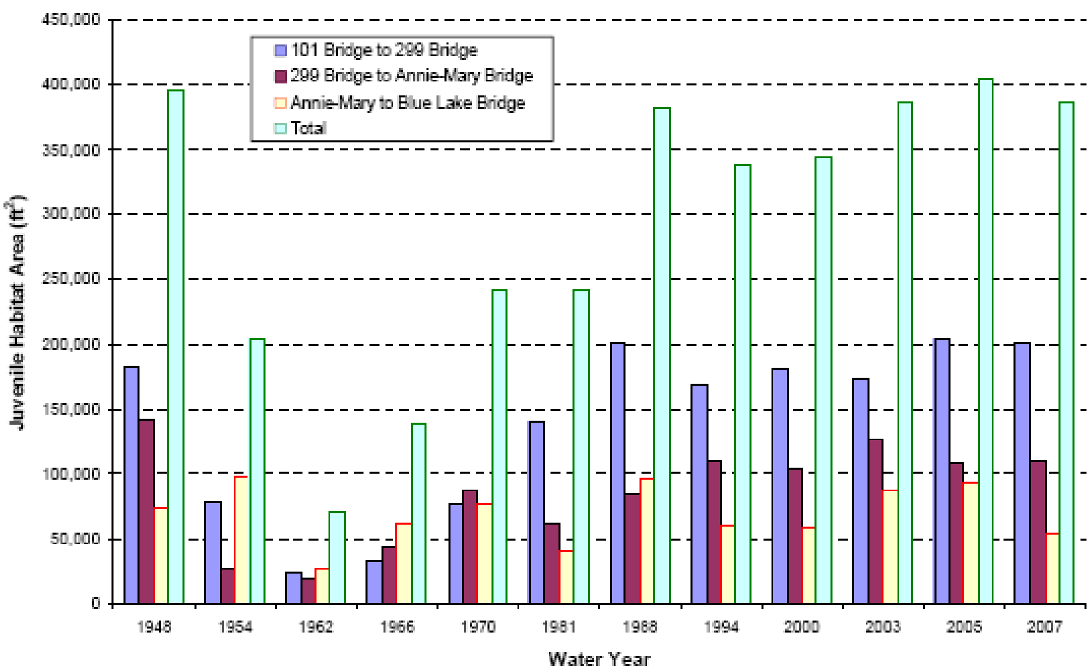


Figure 10. Juvenile Age 1+ coho salmon rearing habitat (ft²) in the lower Mad River from 1948 to 2007 (Trush 2008a).

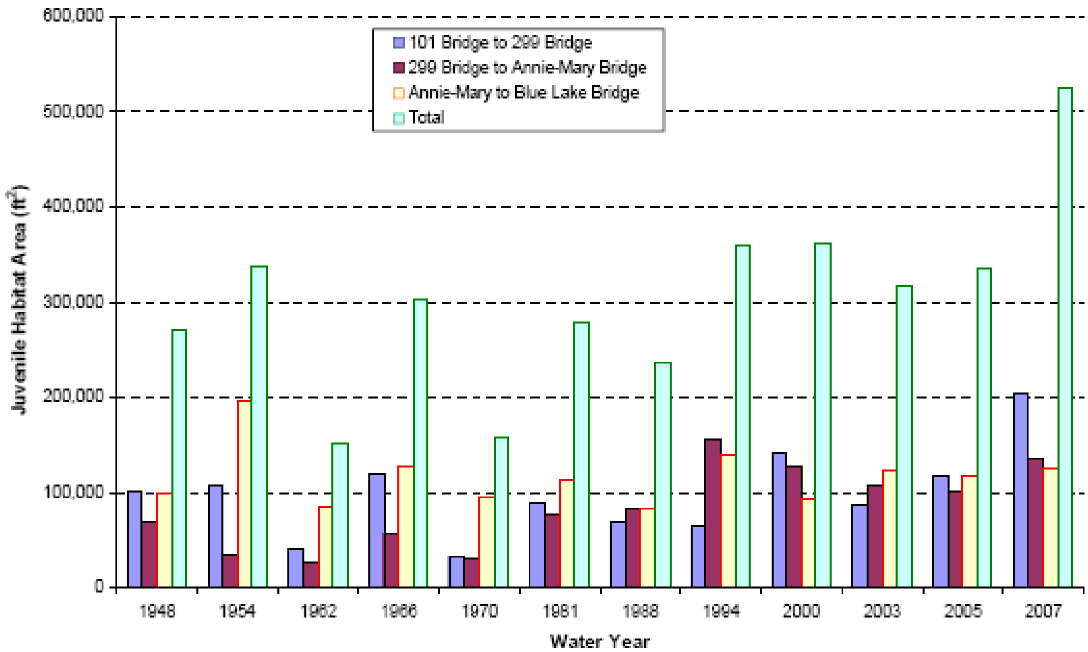


Figure 11. Juvenile Age 2+ steelhead rearing habitat (ft²) in the lower Mad River from 1948 to 2007 (Trush 2008a).

The instream gravel extraction companies (Mad River Sand and Gravel, Granite Construction, Eureka Ready Mix, and Mercer-Fraser) have been conducting instream habitat typing and mapping activities as part of their biological monitoring program since 1996. Table 6-16 and Table 6-17 summarize instream habitat parameters within the mainstem Mad River.

Table 6-16. Salmonid habitat parameters in the reach extending from the Mad River Hatchery to Guintoli Lane, Arcata (Halligan 2007, Stillwater Sciences 2008).

Year	Adult holding		Spawning		0+ Coho		2+ Steelhead		Alcove	
	# units	ft²	# units	ft²	# units	ft²	# units	ft²	# units	ft²
2004	13	213,387	35	387,082	11	55,871	21	127,147	7	115,261
2005	21	192,629	33	301,532	22	51,056	28	143,493	8	89,990
2006	31	241,602	39	265,860	22	45,921	53	182,896	11	90,891
2007	40	242,708	34	249,256	27	72,987	75	165,000	12	118,178
2008	nd	93,134	nd	159,034	nd	98,165	nd	210,271	nd	217,899
2009	nd	167,993	nd	233,887	nd	49,388	nd	180,163	nd	nd

Note: The survey reach length in 2006 through 2009 was longer than in 2004 and 2005. This increase in survey length was due to the inclusion of secondary channel habitats in the data collection effort.

Table 6-17. Pool:Riffle:Flatwater percentages by length in the reach extending from the Mad River Hatchery to Guintoli Lane, Arcata (Halligan 1997, 2000, 2007; Stillwater Sciences 2008, 2009, and 2009, unpubl. data).

Year	Pool:riffle:flatwater % by length	Maximum depth range (ft)	Residual pool depths range (ft)
1996	nd	3.5–10.0	2.7–9.2
1999	18:33:49	4.5–9.0	2.9–8.2
2005	17:17:66	4.1–10.0	3.6–9.7
2006	27:18:55	4.0–11.6	2.9–10.8
2007	23:19:58	2.7–10.4	2.1–9.6
2008	17:15:68	3.2–10.3	2.5–9.8
2009	22:15:64	3.8–11.2	3.2–10.6

Riparian vegetation

Trush (2008b) conducted a historical aerial photograph analysis of riparian vegetation trends within three reaches of the Mad River. The three reaches included: (1) from the Highway 101 Bridge to Highway 299, (2) Highway 299 to the AMRRB, and (3) the AMRRB to the Mad River Fish Hatchery. Trush (2008b) mapped riparian vegetation polygons on sequential aerial photographs (1994, 1997, and 2007) according to their associations with the five following basic channel bed types.

- Open channel bed surfaces that are highly mobile. These surfaces typically do not support vegetation, but are capable of supporting annual herbs and seedlings of red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera*), and arroyo willow (*Salix lasiolepis*).
- Active channel bed surfaces that are frequently inundated and scoured by common flood events through the winter. These surfaces may be completely devoid of plants, partially or entirely covered in annual herbs such as white sweet clover (*Melilotus alba*) and mustard (*Brassica* spp.), have up to 20% coverage of willow shrub and coyote brush (*Baccharis pilularis*), and/or have occasional red alder and black cottonwood seedlings. These pioneer plants generally have a poor chance of long-term survival unless a series of dry years eliminates scour or if channel re-orientation sharply reduces scour risk.
- Floodplain channel bed surfaces are inundated by a bankfull flow (with a 1.5-year annual maximum flood exceedance) and greater. In drier years, therefore, these surfaces may not be inundated. Most floodplain channel bed surfaces develop as active channel bed surfaces aggrade. Coarse and fine sediment is deposited when the plants grow to a sufficient height and density that reduces water velocities and induces sediment deposition. This widespread deposition of fine sediment, within the emerging floodplain, creates a uniform surface for seed germination and higher seedling survival. Coyote bush soon begins to be out-competed as several willow species, red alders, and black cottonwoods mature. The floodplain channel bed still has multiple openings within the tree canopy and internal scour lanes capable of delivering finer sediment during peak floods.
- Woodland channel bed surfaces are generally floodplains that have been aggraded significantly (1–3 ft deep) with silts. Woody riparian vegetation has matured to create a closed canopy and diverse understory. The three prevalent vegetation species are red alder, black cottonwood, and narrowleaf willow (*Salix lasiandra* ssp. *licuda*).
- Terrace channel bed surfaces are coarse mainstem channel features initially deposited by large flood events and therefore are inundated and/or scoured by relatively large and

infrequent floods. Their dry, cobble surfaces make successful germination and seedling establishment of red alders, willow species, and black cottonwoods risky, resulting in fewer, scattered trees and an open canopy compared with the floodplain channel bed surfaces. Coyote bush is common and competes with alders, willows, and cottonwoods. Grasses and a variety of annuals eventually blanket the original cobble surface.

Trush's (2008b) results showed that overall, net woody riparian vegetation abundance and diversity for the lower Mad River (Highway 101 Bridge to Mad River Fish Hatchery) between 1994 and 2007 have remained about the same. There were, however, differences in acreage observed within the three mainstem reaches.

The reach from the Highway 101 Bridge to the Highway 299 Bridge experienced an increase in woodland channel bed and a corresponding decrease in floodplain channel bed (Table 6-18). This could be expected as floodplain channel bed evolves into woodland channel bed as the floodplain aggrades and vegetation matures. This reach of the river was heavily extracted prior to CHERT being instituted. A review of historical photographs (1958 Schuster photos) showed extensive historical removal of riparian vegetation in this reach. What was highly disturbed open channel bed in 1958 is now woodland channel bed containing a mature cottonwood forest.

Very little change in channel bed types was observed in the Highway 299 to AMRRB reach (Table 6-18). Trush (2008b) attributed the relative lack of change to the valley confinement, intact depositional features, and bedload being mostly transported through the reach to downstream location.

Table 6-18. Comparison of acreages for the five channel bed types within the two survey reaches downstream of the AMRRB, 1994 to 2007 (Trush 2008b).

Channel bed type	Hwy 101 to Hwy 299 (ac)		Hwy 299 to AMRRB (ac)	
	1994	2007	1994	2007
Open	72	62	52	52
Active	17	16	29	27
Floodplain	12	4	8	8
Woodland	59	73	11	9
Terrace	0	0	0	0
Total	**160**	**155**	**100**	**96**

The mainstem channel from the AMRRB upstream to the Mad River Fish Hatchery lost terrace and open channel bed (Trush 2008b). This reach also gained modestly in woodland and considerably in active channel bed (Table 6-19). The increase in active channel bed was attributed to the high floods experienced in 1995 and 1997. The active channel bed went from 110 acres in 1994 to 231 acres in 1997 as the floods scoured the terraces and floodplains (Trush 2008b). By 2007, the active channel bed acreage decreased to 190 acres. Woodland channel bed acreage dropped from 95 acres in 1994 to 72 acres in 1997 in response to the floods and then increased to 106 acres by 2007.

Table 6-19. Comparison of acreages for the five channel bed types within the AMRRB to Mad River Fish Hatchery reach for 1994, 1997, and 2007 (Trush 2008b).

Channel bed type	AMRRB to Mad River Fish Hatchery (ac)		
	1994	1997	2007
Open	175	124	162
Active	110	231	190
Floodplain	120	82	103
Woodland	95	72	106
Terrace	397	389	348
Total	**897**	**898**	**909**

Water temperatures

The Powers Creek sub-basin is located within the coastal marine fog-belt, which significantly influences water temperatures between the Mad River Hatchery and Highway 101. Water temperature data collected within the mainstem river reach in 1997 and 1998 showed a general decrease between the Hatchery and downstream monitoring locations (Table 6-20). However, in general summer water temperatures in the mainstem remained stressful for salmonids.

Table 6-20. Maximum weekly average temperatures (MWAT) recorded in the Powers Creek sub-basin. MWAT is the average temperature during the warmest 7-day period.

Location	MWAT °C		
	1995	1997	1998
Hall Creek	15.7	nd	nd
Quarry Creek	14.2	nd	nd
Mad River			
Hatchery	nd	22.2	21.8
Blue Lake Bar	nd	21.4	21.3
Christie Bar	nd	21.0	20.4
O'Neill Bar	nd	nd	20.1

Note: Conversion from degrees Celsius to Fahrenheit is F = (Cx9/5) +32

Tributary drainages

The Powers Creek sub-basin tributary streams flow through non-industrial timberland, rural residential developments, and farms. The watershed vegetation is predominately redwood and Douglas fir forests on the hillslopes and pastureland, wetland and riparian woodland on the valley floor. The watercourses within the sub-basin are affected by the associated land uses. Impacts to the tributary streams include reduced salmonid spawning and rearing habitat quality due to sediment delivery from roads, tilled fields, and silviculture operations. Livestock grazing along the creeks decreases riparian vegetation and cover components (overhanging vegetation, large woody debris inputs, undercut banks) and also reduces water quality through introduction of manure and sediment into the channels.

The creeks in this sub-basin support coho and Chinook salmon, steelhead, and coastal cutthroat trout. Table 6-21 summarizes the instream habitat parameters within several of the sub-basin's creeks. In general, significant portions of these streams become intermittent during the summer, which results in summer salmonids rearing occurring in isolated pools. Canopy closure is typically very high.

Table 6-21. Salmonid habitat parameters in the Powers Creek sub-basin (CDFG field notes, CDFG 2007a, 2007b, 2007c; NRM unpubl. data).

Subwatershed	Sub-basin	Stream	Survey year	Percentage habitat type by length (ft)				Percentage of pools by depth			Pooltails <25% embedded	Canopy closure (%)
				Pools	Riffles	Flatwaters	Dry	2–3 feet	3–4 feet	>4 feet		
Lower	Powers Creek	Kelly Creek	1961	25	75	nd	nd	nd	nd	nd	nd	Dense
			2003	40	60	nd	nd	nd	nd	nd	nd	50–80
		Noisy Creek	1961	85	15	nd	nd	nd	nd	nd	nd	nd
			1995	50	50	nd	nd	nd	nd	nd	nd	70
			2007	12	32	9	47	30	0	0	0	95
		Hall Creek	1984	5	95	nd	nd	nd	nd	nd	nd	<50
			1995	5	95	nd	nd	nd	nd	nd	nd	25–60
			2007	19	39	29	12	15	3	0	10	96
		Mill Creek	1961	50	50	nd	nd	nd	nd	nd	nd	nd
			1970	50	50	nd	nd	nd	nd	nd	nd	nd
			1995	nd	nd	nd	nd	nd	nd	nd	nd	30–60
			2007	5	27	9	58	12	0	0	0	93

A variety of erosion control and restoration projects have been implemented within the Powers Creek sub-basin. Culvert replacement projects on Kelly and Leggit creeks have allowed access by anadromous salmonids to over 1 mile of spawning and rearing habitat. Riparian planting projects have been completed along Hall and Noisy creeks. Cattle have been excluded from lower Hall, Mill, and mid-Noisy creeks as well as upper Leggit, Kelly, Palmer, Warren, and Quarry creeks. Road improvements, which include culvert upgrades and erosion control activities, have been developed and implemented on the non-industrial timberlands surrounding these same creeks. The Hall Creek culvert downstream of Glendale Road has been replaced. It was acting as a grade control and causing upstream sediment deposition and habitat degradation.

In summary, the mainstem Mad River does appear to have experienced improving instream habitat conditions for the past 25 to 30 years. Trush (2008a) quantified historical instream salmonid habitat abundance from aerial photography dating back to 1948 between the Highway 101 Bridge and the Mad River Hatchery. This study reach includes intensive commercial gravel mining operations. His analysis focused on instream habitat abundance for adult salmonids, Age 2+ steelhead, and Age 1+ coho. The analysis concluded that habitat abundance for these species and life stages have recovered from the 1953, 1955, and 1964 floods (Figures 9–11). There appeared to be relatively little change in pool habitats between 1999 and 2009 (Table 6-17). The acreage of mature woodland vegetation appears to have increased within the mainstem between 1994 and 2007 (Table 6-18 and Table 6-19) (Trush 2008b). Mainstem pool percentages (by stream length) have ranged from 18% in 1999 to 27 % in 2006 to 17% in 2008 and back to 22% in 2009, while depths have remained about the same. However, it must be noted that instream gravel extraction activities likely play a significant role in habitat quantity and quality in the lower mainstem Mad River.

The tributary creeks within the Powers Creek sub-basin typically drain non-industrial timber and ranch lands. During some years these creeks experience intermittent flow conditions, which make it difficult to assess aquatic habitat trends. However, it does appear as if Kelly Creek increased pool habitats between 1961 and 2003 (Table 6-21). It also appears that the percentage of pool habitats within Hall Creek improved between 1995 and 2007 despite of intermittent flow conditions. Mill and Noisy creeks, in spite of having a significant portion of the survey reaches being dry, appear to have experienced a decrease in pool habitats, much of which occurred in 1996 during an intense storm event that scoured and destabilized streambanks (D. Halligan, Stillwater Sciences, Fisheries Biologist, pers. comm., 2010). It appears that canopy closure has improved significantly over these creeks within the past 12 years (Table 6-21). This should be reflected in improved water temperature conditions for salmonids.

6.2.3.8 Mouth of the Mad River

The Mouth of the Mad River sub-basin is located between the Highway 101 Bridge to the Pacific Ocean. This sub-basin encompasses 10,954 acres. Communities within this sub-basin include the northern portion of Arcata, McKinleyville, and Tyee City. Widow White Creek and Mill Creek are the two largest tributaries that drain into this reach. This sub-basin has been significantly altered in the last 150 years due to a variety of land uses. These land use practices began in the mid- to late-1800s with clearing of conifer-dominated floodplains and terraces for agricultural and timber production purposes. Subsequent land uses included infrastructure and residential development. The propensity of the Mad River to flood led to the straightening of the channel and armoring of streambanks.

This sub-basin is subject to tidal influences and supports a variety of fish species including coho and Chinook salmon, steelhead, coastal cutthroat trout, green sturgeon, and a variety of marine species including, but not limited to, starry flounder, eulachon, Dungeness crab, California sea lions, and harbor seals. The watershed vegetation is pastureland with isolated spruce and redwood forest on the hillslopes and willows and alders next to the river.

There is very little information regarding the instream habitat within this reach. Instream habitat changes with the tide. At low tide a pool:riffle morphology is present, while at high tide the river backwaters nearly to the Highway 101 Bridge. The intertidal nature of the river precludes salmonids from utilizing the reach for spawning. This area is primarily used by adult salmonids to gather prior to proceeding upstream to spawn. The estuary is also a critical nursery ground that is utilized by juvenile salmonids prior to their entry into the Pacific Ocean.

Widow White Creek enters the Mad River near its confluence with the Pacific Ocean. Coho salmon, cutthroat trout, and steelhead are known to utilize this stream. The only instream habitat data for this creek dates back to a CDFG stream survey from 1982.

In 1982, the CDFG reported Widow White Creek had a pool:riffle ratio of 1:3 with pool ranging from 0.5 to 1.5 feet deep. Shade canopy ranged from 40 to 80%. There were suitable spawning locations for steelhead and coho salmon, but rearing habitat was of marginal quality.

RCAA (2007) reported "In January 2002, Michael Love of Michael Love & Associates observed a female coho salmon (*Oncorhynchus* kisutch) defending a redd located in the North Fork of Widow White Creek just upstream of the confluence with Widow White Creek. Juvenile coho salmon were captured and relocated during a biotechnical bank stabilization project in lower Widow White Creek in September 2002. In September 2003, a coho was identified near the culvert crossing at McKinleyville Avenue during an electrofishing survey conducted by California Department of Fish and Game (CDFG)."

Fish passage improvement projects have been completed in the Widow White Creek drainage. A culvert replacement project in 2001 on the North Fork opened up approximately a half-mile of anadromous habitat. In 2003, a box culvert under Highway 101 was retrofitted with baffles to allow anadromous access to approximately 1.5 miles of stream.

7 SYNTHESIS

This synthesis qualitatively integrates existing information for the Mad River by identifying hazards related to sediment delivery and the sensitivity of aquatic habitat to sediment impairment. The synthesis then ranks and categorizes sub-basins according to the risk of future sediment impairment to fish habitat. The synthesis also includes a brief summary of overall aquatic habitat trends in each sub-basin, and to the extent possible, addresses the critical questions outlined in Section 1.1.

7.1 Hazards Related to Sediment Delivery

Hazards leading to sediment delivery typically exist where there is a coincidence of inherently unstable geology, steep and potentially unstable slopes, and management activities (e.g., timber harvest, ranching, mining, and roads) that accelerate mass wasting and/or surface erosion. Land use activities in areas with greater hazards are more likely to increase sediment delivery and therefore negatively impact aquatic habitat in responsive reaches by prolonging and/or worsening sediment impaired channel conditions. With these processes in mind, a simple analysis was conducted using existing and available information discussed earlier in this document to rank sub-basins with the most erosive terrane, historically high sediment delivery rates, and therefore the greatest potential for future sediment delivery.

The analysis involved assigning scores to various factors related to sediment delivery in each sub-basin, including erosive geology, steep slopes, road density and surface type, and background and management-related sediment delivery. Scores were objectively assigned by dividing the range of values for each factor into quartiles (i.e., values that fell within the first quartile were assigned a low score of zero and values that fell within the fourth quartile were assigned a high score of 3). Scores for each individual factor were then summed to determine a cumulative score from which a percent rank was calculated. Cumulative scores from the assessment of sediment delivery hazard were used in combination with cumulative scores from an assessment of aquatic habitat sensitivity to rank sub-basins according to the risk of sediment impairment. Sub-basins with the highest risk of sediment impairment have greater sediment delivery hazards and more sensitive aquatic resources.

Franciscan mélange is the most inherently erosive geology in the Mad River watershed. Franciscan mélange has large debris flow, debris slide, earthflow, and rock fall areas relative to other geologic units; and sub-basins where Franciscan mélange is a large percentage of the total watershed area typically delivery more sediment. The percentage of the total sub-basin area in Franciscan mélange was therefore used as the first parameter in scoring sediment delivery hazard. Canon Creek, the North Fork Mad River, Maple Creek, Boulder Creek, Lindsay Creek, the Lower Mad River, and the Lower Middle Mad River all have 50% or more of their watershed area in Franciscan Melange and received the highest scores for this factor. The Lower Middle Mad River has the largest area of Franciscan Melange (40.4 mi^2).

In addition to the presence of Franciscan melange, hillslope gradient is another important factor controlling sediment delivery in the Mad River. Shallow landslides, debris flows, and inner gorge landslides are a common occurrence on steep slopes within the Franciscan complex and other non-melange geologic units (Table 4-2). The incidence of shallow landsliding typically increases at slopes greater than 35%, and inner gorges that are particularly prone to shallow landsliding are typically defined as having slopes greater than 65%. These two values for hillslope gradient are mandated in regulation and used as practical thresholds for avoiding mass wasting on potentially unstable slopes in coastal watersheds similar to the Mad River. The percentage of the total watershed area within these two hillslope gradient classes (35–65% and >65%) were therefore used as factors in scoring sediment delivery hazard. All of the sub-basins in the upper watershed (including the Upper Mad River, Ruth Lake, Upper Middle Mad River, and Pilot Creek) had more than 40 % of their area in slopes with 35–65% gradient and received the highest scores for this factor. The Upper Mad River and Ruth Lake sub-basins also had large portions of their area in slopes >65% and received high scores for this factor, as did Lower Middle Mad River and Lower Mad River.

The type and intensity of management activities that have occurred in an area over time are important factors controlling management-related sediment delivery. Management activities are spatially and temporally complex, however, and the data necessary to adequately characterize management activities relative to their effect on sediment delivery over time is not currently available throughout the Mad River watershed. Data on roads in the Mad River watershed is available (refer to Section 3.2), and the potential hazards posed by roads were accounted for in this assessment by applying scores to the average road density in each sub-basin and the length of roads with native surfacing. While larger paved and rocked roads typically have more cutbank erosion, road surface erosion tends to be higher on native roads. Areas with higher road densities and unsurfaced roads without storm-proofing tend to produce more sediment and therefore received higher scores. Lindsay Creek, the North Fork Mad River, Canon Creek, and Powers Creek all have road densities of 6.9 mi/mi^2 or greater and received the highest scores for this factor. Mouth of Mad River also had a high road density, but the majority of the roads in this sub-basin are paved streets that traverse low gradient topography and pose far less of a risk compared to forest and ranch roads in steep topography. Maple Creek and Lower Mad River also scored relatively high, with road densities from 4 to 5 mi/mi^{-2}. North Fork Mad River and Lower Mad River had the longest lengths of unsurfaced roads and received the highest scores for this factor, as did Lower Middle Mad River. These basins are predominantly in private industrial timber management and contain dense networks of unsurfaced and graveled roads used for that purpose.

Background and management-related sediment delivery rates developed for the Mad River sediment TMDL (refer to Section 3.3), which directly reflect the effects of land use on erosion processes, were included as the last two factors in assessing the risk of sediment delivery. Boulder Creek, Pilot Creek, Upper Middle Mad River, and Lower Middle River had the highest background sediment delivery rates, and with the exception of Pilot Creek, also had the highest management-related sediment delivery rates. Road-related landslides represented large percentages of the management-related sediment delivery in these sub-basins. These basins also received high scores for factors related to Franciscan mélange geology, steep slopes, and roads.

The cumulative scores from all sediment delivery factors illuminate the sediment delivery hazards in the central portion of the Mad River Watershed between Pilot Creek and the North Fork Mad River. Basins in this area received high scores due to a combination of Franciscan mélange geology, steep and potentially unstable slopes, dense networks of unsurfaced roads, and historically high management-related sediment delivery rates (Table 7-1, Figure A-10). The basins with the highest cumulative scores for risk of sediment delivery included Lower Mad River, Lower Middle Mad River, North Fork Mad River, Boulder Creek, and Canon Creek. The Ruth Lake sub-basin also scored high but is less of a potential risk because sediment produced from the sub-basin is trapped in Ruth Lake and has little effect on downstream reaches. Of these basins with greater sediment delivery hazard, the lower Mad River, Lower Middle Mad River, and North Fork Mad River ranked above the 80^{th} percentile.

Table 7-1. Sediment delivery hazard.

Sub-basin	Total area, (mi^2)	Franciscan Melange			Hillslope gradient						Roads				Sediment delivery (tons mi^{-2} yr^{-1})				Cumulative score	Percent rank
					35–65%			>65%			Density		Native surface							
		mi^2	% of area	score	mi^2	% of area	score	mi^2	% of area	score	mi/mi^2	score	mi	score	Back.	score	Manag.	score		
Boulder	19.0	11.7	61	3	6.7	35	2	1.0	5.0	2	3.0	0	55	0	2,159	3	1,698	3	13	58
Cañon	16.3	13.3	81	3	4.0	25	1	0.2	1.2	1	7.0	3	103	2	300	1	692	2	13	58
Lindsay	17.7	9.3	52	2	1.2	7	0	0.0	0.1	0	7.6	3	97	2	200	1	449	1	9	16
Lower Mad	64.3	33.6	52	2	21.0	33	2	8.9	13.9	3	4.5	2	226	3	972	2	3,576	3	17	100
Lower Middle Mad	81.3	40.4	50	2	28.1	35	2	4.8	5.9	3	3.0	0	242	3	1,755	3	4,190	3	16	83
Maple	15.6	11.5	74	3	3.9	25	1	0.2	1.0	0	4.7	2	70	1	155	0	351	1	8	8
Mouth of Mad	17.1	0.2	1	0	0.4	3	0	0.0	0.1	0	6.9	3	32	0	0	0	0	0	3	0
North Fork Mad	48.8	37.0	76	3	16.2	33	2	1.6	3.3	2	7.4	3	273	3	324	1	718	2	16	83
Pilot	39.7	2.6	7	0	18.1	45	3	1.3	3.3	2	2.6	0	80	1	1,953	3	77	0	9	16
Powers	26.7	9.8	37	1	4.2	16	0	0.6	2.1	1	6.9	3	125	3	344	2	398	1	11	41
Ruth Lake	55.0	12.9	23	1	24.0	44	3	3.0	5.4	3	3.3	1	96	1	409	2	697	2	13	58
Upper Mad	65.5	0.1	0	0	34.5	53	3	5.5	8.4	3	3.1	1	99	2	125	0	28	0	9	16
Upper Middle Mad	36.2	3.6	10	1	14.8	41	3	0.9	2.4	1	3.4	1	65	0	1,079	3	1,164	3	12	50

7.2 Aquatic Habitat Sensitivity

The assumption was made for this analysis that potential salmonid fisheries utilization within a landscape with varied geologic terrains and land uses tends to be governed primarily by stream gradient and the presence of barriers. For example, the length of stream with <10% gradient roughly corresponds to the amount of fish habitat that would be present and in the absence of barriers, could be inhabited by coho and Chinook salmon, steelhead, coastal cutthroat trout, and resident rainbow trout. Streams with gradients <1.5% typically have meandering alluvial channels with off-channel habitats (oxbows, secondary channels, alcoves) that are more heavily used by coho and Chinook salmon and offer more winter rearing habitat. The presence of barriers to anadromous migration severely restricts upstream fish species diversity. For example, the anadromous barriers within the vicinity of Bug and Wilson creeks effectively stop all coho and Chinook salmon from entering the upper two thirds of the Mad River basin. These barriers also preclude steelhead from moving upstream during most flow events. However, a small number of individual summer-run steelhead (and likely winter-run steelhead) are able to pass these barriers. Matthews Dam is a total barrier to migration and therefore, only resident rainbow trout occupy the Ruth Lake and Upper Mad River sub-basins.

The aquatic habitat sensitivity analysis involved assigning scores to various factors related to the amount of fish bearing channel length (as broken down by slopes of <1.5% and <10%), number of salmonid species present, and the degree of anadromous salmonids access within each sub-basin (Table 7-2). Scores for fish bearing length of stream broken down by gradient class were objectively assigned by dividing the range of values for each factor into quartiles (i.e., values that fell within the first quartile were assigned a low score of zero and values that fell within the fourth quartile were assigned a high score of 3). Scores relating to the number of salmonid fish species present were assigned simply by enumerating the number of species. The anadromy score was determined by using a "0" for upstream of a dam, "1" for unknown (of which there weren't any), "2" for partial barrier downstream, and "3" for no barriers to fish access into the sub-basin. The scores for each individual factor were then summed to determine a cumulative score from which a percent rank was calculated. Cumulative scores from the assessment of aquatic habitat sensitivity were used in combination with the cumulative scores from the assessment of sediment delivery hazard (Table 7-1) to rank sub-basins according to the risk of sediment impairment.

Channels with gradients of <1.5% could arguably provide a greater amount of low and high flow habitat for a greater number of fish species than higher gradient streams. Therefore, streams with a relatively high percentage of <1.5% gradient channels scored higher in Table 7-2 than those with lower percentages. Sub-basins with a greater percentage of <1.5% channels include Lindsay Creek, Mouth of Mad River, Powers Creek, and the Upper Mad River. The Upper Mad River sub-basin, which is upstream of Matthews Dam, contains a low gradient valley that allowed it to score high in this category. Sub-basins with a higher percentage of channel length that is <10% gradient have a greater amount of overall fish use than those with lower percentages. Once again the high scoring Sub-basins in this category are Lindsay Creek, Mouth of Mad River, Powers Creek, and the Upper Mad River.

Not surprisingly, the sub-basins with the greatest number of salmonid species were clustered downstream of the anadromous barriers near Bug and Wilson creeks. The sub-basins for which at least 4 salmonid species were reported being present included Cañon Creek, Lindsay Creek, Lower Mad River, Maple Creek, Mouth of the Mad River, North Fork Mad River, and Powers Creek. Sub-basins upstream of the Bug and Wilson creeks barriers that contain steelhead on at least an intermittent basis include the Lower Middle Mad River, Upper Middle Mad River, and Pilot Creek.

The basins with the highest cumulative scores for aquatic habitat sensitivity included Cañon Creek, Lindsay Creek, Lower Mad River, Mouth of the Mad River, North Fork Mad River, and Powers Creek (Table 7-2). The Ruth Lake and Upper Mad River sub-basins scored low due to being upstream of Matthews Dam. The Lower Middle Mad sub-basin also scored low, but due primarily to no channel with less than 1.5% gradient and having relatively few salmonids species.

7.3 Risk of Impairment

The cumulative scores from assessment of sediment delivery hazard and assessment of aquatic habitat sensitivity were combined to rank sub-basins according to the risk of sediment impairment (Table 7-3, Figure A-10). Sub-basins with the highest risk of sediment impairment (Risk Category 1) have a coincidence of greater sediment delivery hazards and more sensitive aquatic habitat. Increased sediment delivery from high risk sub-basins is more likely to negatively impact aquatic habitat, and measures to reduce sediment delivery in these basins will have the greatest overall benefit to aquatic habitat. Conversely, sub-basins with a low risk of sediment impairment (Risk Category 4) have a relatively low sediment delivery hazard and/or relatively insensitive aquatic habitat.

7.3.1 Upper watershed

The upper watershed includes the Upper Mad River and Ruth Lake Sub-basins, both of which are located upstream of Matthews Dam and Ruth Reservoir. Both basins contain steep slopes but relatively low total sediment delivery rates, and the majority of the sediment delivered from these basin areas (including all coarse sediment) is trapped in Ruth Lake. Although the Ruth Lake sub-basin contains a large amount of low gradient, response-type channel potentially suitable for salmonid spawning and rearing, Matthews dam is a barrier to all anadromous fish migration and summer low flow water depths (and high water temperatures) likely limit aquatic habitat value in these reaches. These factors result in a relatively low overall risk of sediment impairment in these basins; Risk Category 4 for Upper Mad River and Risk Category 3 for Ruth Lake (Table 7-3, Figure A-10). Over half of the sediment delivery in the Ruth Lake sub-basin, however, is produced by road-related landslides and road improvements in this basin would likely improve habitat conditions for resident salmonids in the low gradient channel reaches upstream of Ruth Lake.

Table 7-2. Aquatic habitat sensitivity.

Sub-basin	Total channel length (mi)	Fish bearing channel length (% of total)				Fish species present[1]						Anadromy		Cumulative score	Percent rank
		<1.5%	score	<10%	score	Coho	CHN	SH	CT	Res	score	barrier	score		
Boulder	254	0.3	0	19.2	1	✓	✓	✓		✓	4	no	3	8	42
Cañon	65	4.1	2	26.3	2	✓	✓	✓	✓	✓	5	no	3	12	67
Lindsay	67	22.7	3	64.1	3	✓	✓	✓	✓		4	no	3	13	75
Lower Mad	67	3.1	1	18.9	1	✓	✓	✓	✓	✓	5	no	3	10	58
Lower Middle Mad	355	0.0	0	10.4	0		✓	✓			2	partial natural	2	4	0
Maple	86	0.7	0	20.7	1	✓	✓	✓		✓	4	no	3	8	42
Mouth of Mad	49	35.0	3	95.1	3	✓	✓	✓	✓		4	no	3	13	75
North Fork Mad	189	7.6	3	26.3	2	✓	✓	✓	✓	✓	5	no	3	13	75
Pilot	170	3.4	2	15.0	0			✓		✓	2	partial natural	2	6	33
Powers	81	15.6	3	58.3	3	✓	✓	✓	✓		4	no	3	13	75
Ruth Lake	225	6.7	2	28.0	2					✓	0	dam	0	4	0
Upper Mad	226	2.1	1	35.7	3					✓	0	dam	0	4	0
Upper Middle Mad	143	1.7	1	12.2	0			✓		✓	2	partial natural	2	5	25

[1] Coho salmon (Coho), Chinook salmon (CHN), steelhead (SH), coastal cutthroat trout (CT), resident trout (Res). The species presence was based on a review of survey data contained in public and private databases. The score given to the factor is the number of species present.

Table 7-3. Risk of sediment impairment based on sediment delivery hazard and aquatic habitat sensitivity.

Sub-basin	Area (mi²)	Cumulative score		Sum	Risk of sediment impairment
		Sediment delivery hazard	Aquatic habitat sensitivity		
North Fork Mad River	48.8	16	13	29	1
Lower Mad River	64.3	17	10	27	
Cañon Creek	16.3	13	12	25	
Powers Creek	26.7	11	13	24	
Lindsay Creek	17.7	9	13	22	2
Boulder Creek	19.0	13	8	21	
Lower Middle Mad River	81.3	16	4	20	
Upper Middle Mad River	36.2	12	5	17	3
Ruth Lake	55.0	13	4	17	
Maple Creek	15.6	8	8	16	
Mouth of Mad River	17.1	3	13	16	
Pilot Creek	39.7	9	6	15	4
Upper Mad River	65.5	9	4	13	

7.3.2 Middle watershed

The middle watershed includes the Upper Middle Mad River, Pilot Creek, and Lower Middle Mad River sub-basins. The area is split roughly in half by the north-northwest trending Grogan-Red Mountain fault zone; geology east of the fault is of the more competent Eastern belt of the Franciscan Complex, and geology west of the fault is of the more erosive mélange matrix characteristic of the Central belt of the Franciscan Complex. The large areas of Franciscan melange and steep slopes in the Lower Middle Mad River result in much larger sediment delivery from landslides than any other sub-basin. Although road density is not particularly high in the middle watershed area, the extensive length of unsurfaced roads across Franciscan mélange geology contributes to high sediment yields, particularly in the Lower Middle Mad River. A series of three natural barriers between Wilson Creek and Bug Creek in the Lower Middle Mad River block coho and Chinook salmon and limit steelhead migration to upstream reaches. For these reasons, the Lower Middle Mad River ranked as one of the sub-basins with high sediment delivery hazard but relatively low aquatic habitat sensitivity, resulting in a moderate risk of sediment impairment (Risk Category 2)(Table 7-3, Figure A-10). The Pilot Creek and Upper Middle Mad River sub-basins have a lower risk of sediment impairment (Risk Category 4) because most anadromous salmonids are blocked from migrating into these areas and the channel network is relatively steep.

7.3.3 Lower watershed

The lower watershed encompasses the largest portion of the Mad River, the largest number of sub-basins, and most of the responsive channel length with low gradient and high habitat value for anadromous salmonids. Boulder Creek, Lower Mad River, Canon Creek, and the North Fork Mad River had a high risk of sediment delivery due to mélange geology, moderate to steep slopes, moderate to high densities of predominantly unsurfaced roads, and high sediment delivery rates. Lindsay Creek, Mouth of Mad River, North Fork Mad River, and Powers Creek received high scores for aquatic habitat sensitivity primarily due to the extensive length of low gradient channel with high value spawning and rearing habitat for anadromous salmonids. These factors resulted in a relatively high overall risk of sediment impairment in many of the sub-basins in the lower watershed (Table 7-3, Figure A-10). Cañon Creek, Lower Mad River, Powers Creek, and North Fork Mad River fell into Risk Category 1; Boulder Creek and Lindsay Creek fell into Risk Category 2, and Maple Creek and Mouth of Mad River fell into Risk Category 3.

7.4 Key Questions

How have the stream channels been affected by sediment delivery in the watershed?

The landslide inventory and sediment budget work conducted for the sediment source assessment (Graham Matthews and Associates 2007) resulted in estimates of total sediment delivery in Mad River sub-basins and annual suspended sediment load at 15 monitoring sites located throughout the watershed. The largest sediment producing areas are in the Lower Middle Mad River (i.e., Holm Creek, Showers Creek, Deer Creek, Bug Creek, Morgan Creek, Bear Creek 2), the Lower Mad River (Graham Creek, Goodman Prairie Creek, Dry Creek) and Ruth Lake (i.e., Topkins Creek) sub-basins. There is very little response type channel in Lower Middle Mad River (0.1 mi or <0.03% of total length) and Lower Mad River (0.8 mi or <0.3% of total length). Therefore, most of the sediment delivered in these sub-basins in transported to downstream reaches rather than being stored, and there is little opportunity to detect changes in channel conditions related to sediment delivery in the short length of response-type channel with storage potential. There is also little information regarding past or present channel conditions needed to establish a link between rates of sediment delivery and aquatic habitat conditions in response type channels in these sub-basins.

Do instream habitat conditions (pool:riffle:run lengths; residual pool depths) follow sediment delivery trends?

Implementation of forest practice rules beginning in 1973 and various other programs subsequently implemented to improve land management practices (including erosion control plans, inventory and treatment of road-related erosion sites, and Green Diamond Resource Company's Habitat Conservation Plan) have likely decreased sediment delivery from management-related sources. Existing and available information on sediment delivery, however, is not divided into multiple time periods and therefore, does not allow for analysis of trends in sediment delivery over time.

Comparison of long-term turbidity, SSC, and discharge records at Mad River near Arcata for the 1958–1980 and 2006–2007 time periods suggests a reduction in suspended sediment concentration for a given discharge. Other more detailed time series data do not currently exist, however, to support the conclusion that implementation of improved land use practices has reduced sediment delivery from management-related sources in any sub-basin or the watershed as a whole. However, trends in instream habitat conditions may provide an indication about whether or not sediment delivery has been reduced.

The availability of aquatic habitat information for many of the sub-basins within the Mad River is relatively sparse. This lack of historical to current information has made it difficult to ascertain any trends in aquatic habitat quality, especially in the upper 2/3 of the basin. Therefore, the following trend assessment is only for those sub-basins for which there are sufficient and recent data. These include the Cañon Creek, Lower Mad River, North Fork Mad River, Lindsay Creek, and Powers Creek sub-basins.

The reader should understand that the trend assessment below is based on instream habitat inventories that were conducted by different observers and separated by several years of no *data collection. The use of different observers during the various surveys could inject an unknown amount of error into the habitat inventory datasets. Therefore, the trend assessment could also contain an unknown range of error.*

Instream habitat quality in Cañon Creek appears to have been generally improving since 1988. The length of the creek made up of pools increased from 31% in 1988 to 51% in 2005 (Table 6-5). Similarly, in 1988 only 18% of the pools were greater than two feet deep, but 75% were deeper than two feet in 2005.

The Lower Mad River sub-basin contains Dry and Black creeks. The instream habitat quality within Dry Creek has decreased to some degree, as reflected in the reduction in the length of stream in pool habitat, from 16% in 1992 to 6% in 2005 (Table 6-8). The percentage of pools greater than two feet deep increased from 15% in 1994 to 38% in 2005. Contrary to what was observed in Dry Creek, pool percentages in Black Creek increased from 7% in 1985 to 25% in 2000 (Table 6-8). Pool depth does appear to have increased to some degree between 1985 and 2000.

Instream habitat quality in the North Fork Mad River appears to have remained fairly stable since 1995. The length of the creek made up of pools remained at about 42% between the 1995 and 2007 surveys (Table 6-11). However, there appeared to be a loss of pool depth with 89% of pools being greater than two feet deep in 1995 and 57% in 2007. Pooltail embeddedness improved from 18% to 30% of the pooltails being less than 25% embedded with fine sediment between 1995 and 2007, respectively. Instream habitat quality in Long Prairie Creek followed the same trend as the North Fork. Pool percentages stayed the same between 1995 and 2007, but showed a loss of depth. The number of pooltails that were less than 25% embedded tripled between 1995 and 2007.

Instream habitat quality in Lindsay Creek appears to have decreased to some degree between 1995 and 2007. The length of the creek made up of pools decreased by about 26% between the two surveys (Table 6-14). Likewise, there appeared to be a loss of pool depth with 87% of pools being greater than 2 feet deep in 1995 and 65% in 2007. Pooltail embeddedness improved dramatically from 3% to 61% of the pooltails being less than 25% embedded with fine sediment between 1995 and 2007, respectively.

Instream habitat quality in Grassy Creek, a tributary to Lindsay Creek, appears to have decreased to some degree between 1961 and 1972, but then improved by 2005. The length of the creek made up of pools decreased from 40% to 20% between 1961 and 1972, but then bounced back to a small degree to 28% by 2005 (Table 6-14). Given the lack of data, it is unknown as to whether there was a loss of pool depth associated with the loss of pool length and if pooltail embeddedness has improved or degraded.

The mainstem Mad River does appear to have experienced improving instream habitat conditions for the past 25 to 30 years. Trush (2008a) quantified historical instream salmonid habitat abundance from aerial photography dating back to 1948 between the Highway 101 Bridge and the Mad River Hatchery. This study reach includes intensive commercial gravel mining operations. His analysis focused on instream habitat abundance for adult salmonids, Age 2+ steelhead, and Age 1+ coho. The analysis concluded that habitat abundance for these species and life stages have recovered from the 1953, 1955, and 1964 floods and achieved the condition seen in the early 1940's (Figures 9–11). Mainstem pool percentages (by stream length) have ranged from 18% in 1999 to 27 % in 2006 to 22% in 2009 while depths have remained about the same. However, it must be noted that instream gravel extraction activities likely play a significant role in habitat quantity and quality in the lower mainstem Mad River.

The tributary creeks within the Powers Creek sub-basin typically drain non-industrial timber and ranch lands. During some years these creeks experience intermittent flow conditions, which make it difficult to assess aquatic habitat trends. However, it does appear as if Kelly Creek increased pool habitats between 1961 and 2003 (Table 6-21). It also appears that the percentage of pool habitats within Hall Creek improved between 1995 and 2007 despite of intermittent flow conditions. Mill and Noisy creeks, in spite of having a significant portion of the survey reaches being dry, appear to have experienced a decrease in pool habitats, much of which occurred in 1996 during an intense storm event that scoured and destabilized streambanks (D. Halligan, pers. comm., 2010).

The above summaries indicate that for at least some sub-basins specific aquatic habitat parameters may have improved. For example, Lindsay Creek, N.F. Mad River, and Long Prairie Creek have experienced a significant improvement in embeddedness values. The improvement in embeddedness values, although qualitative, could indicate a lower fraction of fine sediment in the bed and less fine sediment delivery in these sub-basins. Cañon Creek has seen a steady improvement in habitat quality to the point where it has achieved the CDFG (Flosi et al. 1998) target level of 50% of the stream length in pools. Cañon Creek also experience a large increase in the number of pools greater than 2 ft deep. However, not all sub-basins have shown improvement in some habitat parameters. The Lindsay and Powers creeks sub-basins experience a decrease in the length of stream made up of pools. Dry Creek experience a loss of pools, while Black Dog Creek in the same sub-basin showed an improvement.

What are the natural and human-caused changes in the historical and current channel condition?

Natural causes for historical and current channel conditions include sediment delivery from mass wasting triggered by intense rainfall, rapid snowmelt, and earthquakes. Background sources of sediment delivery (i.e., landslides and soil creep) account for about 35% of the total watershed sediment delivery. Earthflows in Franciscan mélange and other rocks of the Franciscan complex occupy the largest area of any mass wasting type. The majority of mapped active landslides that were classified as background were debris flows, followed by debris slides and earthflows. Large storm events that trigger mass wasting and large flood events that mobilize coarse sediment stored in channels are also important natural processes controlling historical and current channel conditions. Large flood events occurred in the Mad River watershed in December 1861, 1890, 1902, 1903, 1906, 1907, 1914, 1938, 1955, 1964, 1986, and 2006. The two largest floods on record were in January 1955 and December 1964. Both floods caused significant changes in channel characteristics, resulting in aggradation in some portions of the channel network and degradation in others. The headward portion of many drainages aggraded, while channels in mid-basin positions were scoured by debris flows. The gravel mining reach likely aggraded during these floods, while the lower-most reaches of the Mad River degraded and widened.

Background erosion, sediment delivery, and sediment transport processes that exert the dominant control over channel conditions have been altered by land use activities such as timber harvest and road construction, impoundment of the mainstem Mad River behind Matthews Dam and Sweasey Dam, gravel mining in the reach between the Mad River Fish Hatchery and Highway 101, and by flood control projects and bank protection in the lower watershed. Timber harvest and road construction on steep slopes, as well as legacy yarding practices on slopes and in channels have increased sediment delivery from debris slides, debris flows, and surface erosion. Increased sediment delivery often severely aggraded first and second order channels. This resulted in increased embeddedness and higher concentrations of fine sediment in spawning gravels, less complex channel morphology with fewer and shallower pools, and in some cases, warmer water temperatures. Impoundment of the Mad River by Matthews Dam trapped sediment and reduced the coarse sediment supply to downstream reaches. The dam's effect on peak flow was likely small due to the relatively small storage area leading to an impoundment that fills relatively early in the winter period and then spill all inflow once full. The summer releases (70 to 90 cfs) have resulted in increased usable habitat area in the Mad River channel downstream of the dam. Dam releases have lowered water temperatures for an unknown distance downstream, thus improving salmonids habitat conditions. Impoundment of the Mad River by Sweasey Dam also trapped coarse sediment, resulting in channel degradation immediately downstream until the dam was removed in 1970, after which time the downstream reach aggraded. Gravel mining in the Mad River from the Fish Hatchery to Highway 101 resulted in net degradation up until about 1994, after which time adaptive management of gravel extraction in the reach has resulted slower degradation from the Fish Hatchery to the Annie and Marie Bridge and aggradation from Annie and Marie Bridge to Highway 101. Flood control and bank protection projects in the lower river have simplified the channel, reduced the amount of riparian vegetation, and decreased the amount of high flow off-channel fish habitat.

What are the potential effects of suspended sediment and turbidity on salmonids in the Mad River watershed?

Excess fine sediment can embed channel substrate, limiting water flow through salmon redds and preventing spawning and emergence. Excess sediment supply relative to transport can also reduce the quality of salmonid habitat by reducing the frequency, volume, and depth of pools. Stream temperatures can increase as a result of stream widening and pool filling. Invertebrate food sources for salmonids can be reduced by excessive sedimentation. High levels of turbidity or suspended sediment can impair growth by reducing the availability or visibility of food sources, and suspended sediment can cause direct damage to gills.

Newcombe and Jensen created a quantitative index, the Severity of Ill Effects (SEV) scale, by which to define the response of fish to increasing concentration and duration of suspended sediment. The index groups responses into four major classes: nil effect, behavioral effects, sublethal effects and lethal effects. The range of effects is categorized using a 15-point SEV scale arranged in a matrix of duration versus concentration. The SEV scores are often used to estimate the minimum concentrations and durations that may trigger sublethal and lethal effects in fish.

Graham Matthews & Associates (2007) conducted an analysis of turbidity, suspended sediment concentration, and SEV score at four monitoring sites in the Mad River (MRRTH, MRBVR, NFMKB, and MRHRB) where continuous SSC records were collected for WY2006 and WY2007, and compared the results at the Mad River sites to the EPA's estimates of "background" rates from reference streams in north coastal California (Klein 2006, unpubl. data). The results indicated that the Mad River routinely exceeded SEV scores of 5 (e.g., minor to major physiological stress, increased rate of coughing, increased respiratory rate, habitat degradation, impaired homing, long-term reduction in feeding) in both wet and dry water years. Although the Mad River basin is much larger than the basins where "background" rates were estimated (i.e., 2–8 mi^2), turbidity values for the Mad River sites were orders of magnitude greater than the background rates and well above the Regional Board's standard (i.e., no greater than 20% over background levels). Refer to Graham Matthews & Associates (2007) and (Klein 2006, unpubl. data) or more detailed information.

Are there reaches where stream temperatures exceed preferred and stressful thresholds? What may be the reasons for the observed water temperatures?

Optimal growth temperatures of 19ºC with continued feeding up to 23 ºC have been demonstrated for some species in response to an unlimited food supply, but food conversion efficiencies were maximized at approximately19.6 ºC (e.g., Chinook salmon, Brett et al. 1982). When food is limited however, optimal growth rates are reduced to lower temperatures to compensate for elevated respiration/growth ratios (Elliott 1981 cited in McCullough 1999). Temperature extremes as high as 22 to 26ºC and as low as 0 ºC are considered life-threatening for salmon species (Bjornn and Reiser 1991). A rise in the metabolic rate of fish occurs when optimum temperatures are exceeded, which in turn, increases their energy requirements.

The majority of juvenile salmonids experience optimum growth between 10 and 15 ºC while positive growth is maintained from about 4 to 19 ºC (Armour 1991). Bjornn and Reiser (1991) reported that juvenile coho salmon preferred water temperatures between 12 and 14 ºC. Bjornn and Reiser (1991) reported that juvenile steelhead preferred water temperatures between 10 and 13 ºC. The EPA (2002) determined that good summer water temperature conditions for juvenile steelhead were less than 15 ºC. Only Black dog Creek meets the preferred 12 to 14ºC water temperature range for coho salmon and none meet the steelhead preference. However, what are preferred temperatures (as determined in a laboratory) and highly functional temperatures, based on actual fish production in streams are two different things and should not be confused.

An increase in water temperatures results in a rise in the metabolic rate of fish, which in turn, increases their energy requirements. However, this may not necessarily result in stressful conditions. Optimal growth temperatures of 19ºC with continued feeding up to 23ºC have been demonstrated for some species in response to an unlimited food supply, but food conversion efficiencies were maximized at approximately 19.6 ºC (e.g., Chinook salmon, Brett et al. 1982). When food is limited however, optimal growth rates are reduced to lower temperatures to compensate for elevated respiration/growth ratios (Elliott 1981 cited in McCullough 1999). Lindsay Creek, a known producer of coho salmon has summer water temperatures that tend to vary between 15.5 and 16.5ºC (Figure 12). Welsh et al. (2001) found juvenile coho salmon were absent in streams in the Mattole River basin when the maximum weekly average temperature (MWAT) exceeded 16.8ºC. Adequate steelhead rearing conditions were when water temperatures were between 15 and 17ºC (EPA 2002). Marginal, inadequate, and lethal conditions resulted when MWATs were 17 to 19, 19 to 24, and greater than 24ºC, respectively (EPA 2002).

Due to the difficulty in determining a stressful temperature threshold , this watershed analysis will use the 16ºC mark as the stressful threshold for coho salmon and 18 degrees for steelhead. During most years, based on these somewhat arbitrary targets, Sullivan Gulch (Table 6-13), Long Prairie Creek, and Lindsay Creek are below stressful limits for coho salmon. Nearly all the creeks are below the stressful threshold for steelhead. The mainstem Mad River consistently exceeds stressful temperatures for both coho salmon and steelhead (Table 5-20).

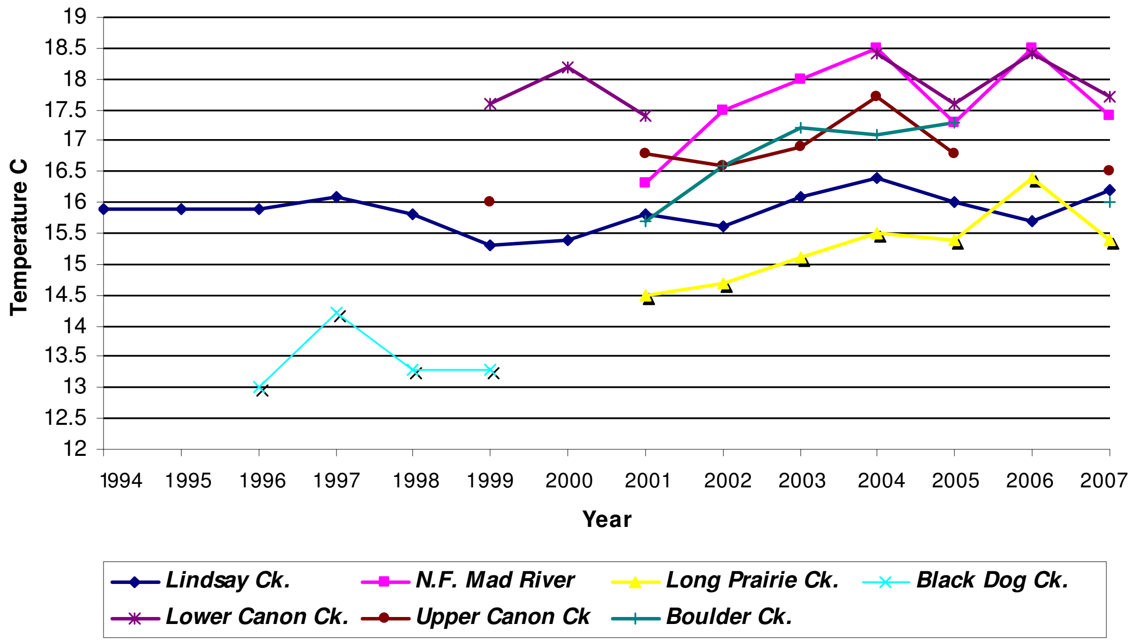


Figure 12. Maximum weekly average temperatures for selected streams within the Mad River basin.

7.5 Data Gaps

Several key pieces of data were not available during development of this watershed assessment. These data are critical for identifying trends in sediment delivery and aquatic habitat conditions over time, the relative influence of natural events and land use activities on these trends, and the benefits that may have been achieved by improved land management practices.

Linkages between land use, sediment delivery, and channel condition are difficult to make without a detailed and spatially explicit database of land use and land management activities. A comprehensive database of historical and current land use would ideally include information about parcel boundaries and zoning; silviculture, yarding, and site preparation on industrial and non-industrial timber harvest plans; history of other resource-based land uses such as grazing and mining; and burn history.

A more comprehensive and integrated database describing the full extent, type, and condition of roads in the watershed would help provide a better means of estimating past and potential future sediment delivery from road-related surface erosion, mass wasting, and failure of road drainage infrastructure. The existing road database is incomplete for smaller roads and skid trails and does not reflect the type and current condition of many forest and ranch roads. The database does not include, for example, road improvement and road removal projects implemented on private and public land in the watershed.

Existing data on sediment delivery from landsliding does not provide necessary information about how landslide rates and sediment delivery from landsliding has changed over time. An analysis of landslide sediment delivery for a time series of historical aerial photographs divided into multiple periods defined by significant storm events would provide the resolution necessary to identify the timing and magnitude of significant storm triggered landslide sediment input and the effect that changing forest and road management practices may have had on sediment delivery from landsliding.

Fine scale topography obtained from Light Detection and Ranging (LiDAR) would be very useful at identifying potentially unstable slope forms that may currently delivery sediment or have a high potential to delivery sediment to a watercourse. LiDAR would also be very useful for identifying low-gradient channel reaches that provide high-value aquatic habitat and are most responsive to changes in sediment supply.

With a comprehensive management history and roads database, time series of landslide sediment delivery, and fine scale topography for characterizing hillslope forms and channel gradient; responsive reaches could then be identified for continuous long-term monitoring of water and sediment discharge. Long-term monitoring of water and sediment discharge, sediment storage, bed material grain size, and habitat conditions in these select reaches would help to determine the effects of increased sediment delivery on channel characteristics and the trajectory of recovery following sediment input. These types of assessment and monitoring of physical processes are necessary to better understand linkages between land management practices, erosion processes and sediment delivery, and stream channel condition in the watershed.

Current instream habitat inventories are lacking in the upper 2/3 of the Mad River basin. This lack of information precludes any assessment of changes in habitat quality over the last couple of decades.

Other than the CDFG downstream migrant trapping from the early 2000s, there is currently very little information regarding production of juvenile salmonids in the basin. The same can be said regarding enumeration of adult returns. A relatively long-term record of juvenile salmonid productivity and adult returns in the basin will be needed to determine whether or not listed salmonids are recovering.

8 REFERENCES

Armour, C. L. 1991. Guidance for evaluating and recommending temperature regimes to protect fish. USFWS Biological Report 90:

Bagnold, R. A. 1980. An empirical correlation of bedload transport rates in flumes and natural rivers. Proceedings of the Royal Society 372A: 453–473.

Berry, M. 1981. Geomorphology and relative dating analysis of Quaternary fluvial terraces on the Mad River near Blue Lake, California. Master's thesis. Humboldt State University, Arcata California.

Bisson, P. A., J. L. Nielsen, R. A. Palmason, and L. E. Grove. 1981. A system of naming habitat in small streams, with examples of habitat utilization by salmonids during low streamflow. Pages 62–73 *in* N. B. Armantrout, editor. Acquisition and utilization of aquatic habitat inventory information. Proceedings of a symposium, 28-30 October 1981, Portland, Oregon. Hagen Publishing Company, Billings, Montana.

Bjornn, T. C., and D. W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83–138 *in* W. R. Meehan, editor. Influences of forest and rangeland management on salmonid fishes and their habitats. Special Publication No. 19. American Fisheries Society, Bethesda, Maryland.

Blake, M. C., W. P. Irwin, and R. G. Coleman. 1967. Upside-down metamorphic zonation, blueschist facies, along a regional thrust fault in California and Oregon. U.S. Geological Survey Professional Paper 575-C:

Borgeld, J. C., M. J. Scalici, M. Lorang, P. D. Komar, and F. G. Alden Burrows. 1993. Mad River mouth migration. Final project evaluation report. Prepared for the California Department of Transportation, District 1, Eureka, California.

Brett, J. R., W. C. Clarke, and J. E. Shelbourn. 1982. Experiments on thermal requirements for growth and food conversion efficiency of juvenile Chinook salmon *Oncorhynchus tshawytscha.* Canadian Technical Report of Fisheries and Aquatic Sciences 1127. Department of Fisheries and Oceans, Fisheries Research Branch, Pacific Biological Station, Nanaimo, British Columbia.

Brown, W. M., III. 1973a. Streamflow, sediment, and turbidity in the Mad River basin, Humboldt and Trinity Counties, California. Water-Resources Investigations 36-73. Prepared by U.S. Geological Survey, Water Resources Division, Menlo Park, California in cooperation with U.S. Army Engineer District, San Francisco, California.

Brown, W. M., III. 1973b. Sediment transport, turbidity, channel configuration, and possible effects of the impoundment of the Mad River, Humboldt and Trinity Counties, California. Water-Resources Investigations 26-75. Prepared by U.S. Geological Survey, Water Resources Division, Menlo Park, California in cooperation with U.S. Army Engineer District, San Francisco, California.

Burke, R. M., G. A. Carver, and S. C. Lundstrom. 1986. Soil development as a relative dating and correlation tool on marine terraces of northern California (abstract). Geological Society of America Abstract Programs 18: 91.

Carver, G. A., and R. M. Burke. 1992. Late Cenozoic deformation on the Cascadia subduction zone in the region of the Mendocino triple junction. Pages 31–63 *in* Guidebook for the field trip to northern coastal California, 5-7 June 1992. Friends of the Pleistocene, Pacific Cell.

CDFG (California Department of Fish and Game). 1981. Stream survey, Davis Creek. Department of Fish and Game, Eureka, California.

CDFG. 1984. Stream survey, Maple Creek. California Department of Fish and Game, Eureka, California.

CDFG. 1985. Stream survey, Black Creek. California Department of Fish and Game, Eureka, California.

CDFG. 1987. Stream survey, Boulder Creek. California Department of Fish and Game, Eureka, California.

CDFG. 2000. Draft stream inventory report, Black Creek. California Department of Fish and Game, Eureka, California.

CDFG. 2007a. Noisy Creek stream inventory report. California Department of Fish and Game, Fortuna, California.

CDFG. 2007b. Hall Creek stream inventory report. California Department of Fish and Game, Fortuna, California.

CDFG. 2007c. Mill Creek stream inventory report. California Department of Fish and Game, Fortuna, California.

CDMG (California Division of Mines and Geology). 1997. Factors affecting landslides in forested terrain. California Division of Mines and Geology Note 50: 1–5.

CDWR (California Department of Water Resources). 1965. Land and water use in Mad River-Redwood Creek hydrographic unit. CDWR Bulletin No. 94-7:

CDWR. 1982. Mad River watershed erosion investigation. Prepared by CDWR, Northern District, The Resources Agency, California.

Chilcote, M. W. 2001. Conservation assessment of steelhead populations in Oregon.

Chilcote, M. W. 2003. Relationship between natural productivity and the frequency of wild fish in mixed spawning populations of wild and hatchery steelhead (*Oncorhynchus mykiss*). Canadian Journal of Fisheries and Aquatic Sciences 60: 1,057–1,067.

Clarke, S. H., Jr., and G. A. Carver. 1992. Late Holocene tectonics and paleoseismicity, southern Cascadia subduction zone. Science 255: 188–192.

Cruden, D. M., and D. J. Varnes. 1996. Landslide types and processes. Pages 36–75 *in* Landslides investigation and mitigation. Special Report 247. Transportation Research Board, Washington, D. C.

Elliott, J. M. 1981. Some aspects of thermal stress on freshwater teleosts. Pages 209–245 *in* A. D. Pickering, editor. Stress and fish. Academic Press, London.

EPA (U. S. Environmental Protection Agency). 2002. North Fork Eel River total maximum daily loads for sediment and temperature. U. S. Environmental Protection Agency, Region IX.

EPA. 2007. Mad River total maximum daily loads for sediment and turbidity. Final report. U.S. Environmental Protection Agency, Region IX.

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic, and social assessment. USDA Forest Service, U. S. Fish and Wildlife Service, National Marine Fisheries Service, National Park Service, Bureau of Land Management, and Environmental Protection Agency.

Flosi, G., S. Downie, J. Hopelain, M. Bird, R. Coey, and B. Collins. 1998. California salmonid stream habitat restoration manual. Third edition. California Department of Fish and Game, Sacramento.

Flosi, G., and F. Reynolds. 1994. California salmonid stream habitat and restoration manual. Second edition. California Department of Fish and Game.

Fox, L., III, G. L. Bonser, G. H. Trehey, R. M. Buntz, C. E. Jacoby, A. P. Barston, and D. M. La Brie. 1997. A wildlife habitat map and database for The Orca (Oregon-California) Klamath derived from landsat imagery, Version 1.0a.

Graham Matthews & Associates. 2007. Mad River sediment source analysis. Final report. Prepared by Graham Matthews & Associates, Weaverville, California for Tetra Tech, Inc., Fairfax, Virginia.

Green Diamond Resource Company. 2006. Aquatic habitat conservation plan and candidate conservation agreement with assurances. Volume 1, Final report. Prepared by Green Diamond Resource Company for National Marine Fisheries Service and U.S. Fish and Wildlife Service.

Halligan, D. 1997. Final report on the results of the 1996 fisheries monitoring program on the Trinity and lower Mad, Eel, and Van Duzen rivers. Natural Resources Management Corporation, Eureka, California.

Halligan, D. H. 2000. Final report - 2000 fisheries monitoring program for gravel extraction operations on the Mad, Eel, Van Duzen, and Trinity rivers. Natural Resources Management Corporation, Eureka, California.

Halligan, D. H. 2007. Final report, 2005–2006 fisheries monitoring program for gravel extraction operations on the Mad, Eel, Van Duzen, and Trinity Rivers,. Natural Resources Management Corporation, Eureka, California.

Harden, D. R., H. M. Kelsey, S. D. Morrison, and T. A. Stephens. 1982. Geologic map of the Redwood Creek drainage basin, Humboldt County, California. Open-File Report 81-496. U.S. Geological Survey. Scale 1:62,500.

Haynes, C. S. n.d. (no date). The Mad River Canal. Student paper. Humboldt State Univeristy, Arcata, California.

HBMWD (Humboldt Bay Municipal Water District) and Trinity Associates. 2004. Habitat conservation plan for Mad River Operations. Humboldt Bay Municipal Water District, Eureka, California and Trinity Associates.

Irwin, W. P. 1960. Geologic reconnaissance of the northern Coast Ranges and Klamath Mountains, California. California Division of Mines and Geology Bulletin 179: 80.

Kelley, F. R. 1984. Geology and geomorphic features related to landsliding, Arcata North 7.5-minute quadrangle, Humboldt County, California. Open-File Report 84-38. California Division of Mines and Geology, San Francisco. Watersheds Mapping Program. Scale 1:24,000.

Keter, T. S. 1993. Environmental history and cultural ecology of the North Fork of the Eel River. Draft Report. USDA Forest Service.

Kilbourne, R. T. 1985a. Geology and geomorphic features related to landsliding, Blue Lake 7.5-minute quadrangle, Humboldt County, California. Open-File Report 85-06. California Division of Mines and Geology, San Francisco. Watersheds Mapping Program. Scale 1:24,000.

Kilbourne, R. T. 1985b. Geology and geomorphic features related to landsliding, Korbel 7.5-minute quadrangle, Humboldt County, California. Open-File Report 85-05. California Division of Mines and Geology, San Francisco. Watersheds Mapping Program. Scale 1:24,000.

Klein, R. D., A. K. Lehre, D. Jager, and B. Trush. 1998. Post-extraction report with historical analysis for the Mad River. Unpublished report. Prepared by County of Humboldt Extraction Review Team (CHERT) for the Humboldt County Board of Supervisors.

Knuuti, K., and D. McComas. 2003. Assessment of changes in channel morphology and bed elevation in Mad River, California, 1971–2000. ERDC/CHL TR-03-16. Coastal and Hydraulics Laboratory, U.S. Army Corps of Engineers, Engineer Research and Development Center.

Kondolf, G. M., and E. Litrick. 2000. Changes in bed elevation and sediment storage in the Mad River, 1970–1999. Prepared for Eureka Ready Mix, California.

LACO Associates. 1994. Geology and geomorphology of the Mad River basin, Humboldt and Trinity Counties, California. Project No. 4120. Prepared by LACO Associates, Consulting Engineers, Eureka, California for USDA Forest Service, Six Rivers National Forest, Eureka, California.

LACO Associates. 2008. Subject: Mad River Bluffs, geologic investigation and assessment. LACO Project No. 6869.00. Letter to Mr. H. Seemann, Environmental Services Manager, County of Humboldt County, Department of Public Works, Eureka, California from D. N. Lindberg, Certified Engineering Geologist, LACO Associates, Eureka, California. 11 April.

Lang, M. 2005. California Department of Transportation District 1 Pilot fish passage assessment study. Volume 1: overall results. Report #FHWA/CA/EN-2005/02. Prepared for CalTrans.

Lehre, A. 1993. Appendix F: River Institute consultants report. Section 3: estimation of Mad River gravel recruitment and analysis of channel degradation. Mad River EIR technical supplement. Department of Geology and Institute for River Ecosystems, Humboldt State University, Arcata, California.

Lehre, A., B. Trush, R. Klein, and D. Jager. 2005. Historical analysis of the Mad River: 1993–2003. Review Draft No. 1. Prepared by County of Humboldt Extraction Review Team (CHERT) for the Humboldt County Board of Supervisors.

Manning, G. A., and B. A. Ogle. 1950. Geology of the Blue Lake quadrangle, California. California Division of Mines and Geology Bulletin 148: 36.

Mayer, K. E., and Jr. W. F. Laudenslayer, editors. 1988. A guide to wildlife habitats of California. State of California, Resources Agency, CDFG, Sacramento, California.

McCullough, D. A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. EPA 910-R-99-010. Prepared for U. S. Environmental Protection Agency Region 10, Seattle, Washington. www.critfc.org/tech/EPAreport.htm.

McLaughlin, J. W., S. D. Ellen, Jr. M. C. Blake, A. S. Jayko, W. P. Irwin, K. R. Aalto, G. A. Carver, and Jr. S. H. Clarke. 2000. Geology of the Cape Mendocino, Eureka, Garberville, and southwestern part of the Hayfork 30 X 60 minute quadrangles and adjacent offshore area, Northern California. Pamphlet to accompany Miscellaneous Field Studies MF-2336, Version 1.0. U.S. Department of the Interior and U.S. Geological Survey.

McLean, J. E., P. Bentzen, and T. P. Quinn. 2003. Differential reproductive success of sympatric naturally spawning hatchery and wild steelhead trout through the adult stage. Canadian Journal of Fisheries and Aquatic Sciences 60: 433–440.

Raines, M. 1998. South Fork Trinity River sediment source analysis. Prepared for Tetra Tech, Fairfax, Virginia.

RCAA (Redwood Community Action Agency). 1988. Maple Creek anadromous fish habitat improvement project. Prepared for Humboldt Bay Municipal Water District.

RCAA 1990. Canon Creek anadromous fish habitat improvement project. Contract #FG 8449. Prepared for the California Department of Fish and Game.

RCAA. 2007. Inital study- biotechnical bank stabilization and stream enhancement project, Widow White Creek, McKinleyville, California. Prepared by County of Humboldt Public Works Department, Eureka, California.

Scalici, M. J. 1993. Mad River mouth monitoring report. Prepared for the California Department of Highways, Hydraulics Division.

Simpson Timber Company. 1994. Canon Creek habitat typing data. Korbel, California.

Sparkman, M. 2002. Juvenile steelhead downstream migration study in the Mad River, Humboldt County, California. CDFG, Steelhead Research and Monitoring Program.

Sparkman, M. 2003. Recreational angler use and catch in the Mad River, Humboldt County, California. November 2002–March 2003. 2002–2003 Annual report. Project 1g2. CDFG, Anadromous Fisheries Resource Assessment and Monitoring Program.

Stillwater Sciences. 2008. Mad River streambank stabilization project geomorphic evaluation. Prepared by Stillwater Sciences, Arcata, California for County of Humboldt, Department of Public Works, Eureka, California.

Stillwater Sciences. 2009. Batched biological assessment for aggregate extraction operations in the lower Mad River, Humboldt County, California. Final Report. Prepared by Stillwater Sciences, Arcata, California for Mad River Sand and Gravel, Granite Construction, Eureka Ready Mix, Mercer-Fraser Company, and D&R Miller.

Tolhurst, J. W. 1995. Historical analysis of geomorphic channel changes, lower Mad River, Humboldt County, California. Master's thesis. Department of Geology, Humboldt State University, Arcata, California.

Trush, B. 2008a. Lower Mad River anadromous salmonid habitat trends between WY1994 and WY2007. Prepared by McBain and Trush, Arcata, California.

Trush, B. 2008b. Lower Mad River woody riparian vegetation trend between WY 1994 and WY 2007. Appendix A-Mad River supplemental programmatic environmental impact report. Prepared by McBain and Trush, Arcata, California for County of Humboldt, Eureka, California.

USDA Forest Service. 1972. Fisheries resource assessment for the Horse timber sale. Six Rivers National Forest, Mad River District, California.

USDA Forest Service. 1994. Pilot Creek watershed analysis: an analysis of ecosystems at the watershed scale. USDA Forest Service, Six Rivers National Forest, Mad River District, California.

USDA Forest Service. 1996. Final environmental impact statement, Pilot Creek. USDA Forest Service, Six Rivers National Forest, Mad River District, California.

USDA Forest Service. 1998. Upper Mad River watershed analysis, Version 1.0. Pacific Southwest Region, Six Rivers National Forest.

USDA Forest Service. 2005a. Six Rivers National Forest, geomorphology GIS coverage.

USDA Forest Service. 2005b. Draft environmental impact statement for the North Fork Eel grazing allotment management. USDA Forest Service, Six Rivers National Forest, Eureka, California.

USDA Forest Service and USDI Bureau of Land Management. 1994. Record of decision (ROD) for the amendments to Forest Service and Bureau of Land Management Planning documents within the range of the northern spotted owl. USDA Forest Service and BLM, Washington, D.C.

USDI Bureau of Land Management. 1977. Physical and biological stream survey report for Boulder Creek. USDI Bureau of Land Management, Ukiah, California.

Welsh, H. H., Jr., G. R. Hodgson, B. C. Harvey, and M. E. Roche. 2001. Distribution of juvenile coho salmon in relation to water temperatures in tributaries of the Mattole River, California. North American Journal of Fisheries Management 21: 464-470.

Zuspan, M. G., and M. D. Sparkman. Mad River winter-run adult steelhead run-size estimate, 2000–2001 season. Annual report, Project 1a3. CDFG, Anadroumous Fisheries Resource Assessment and Monitoring Program.

Appendix A

Maps/ Additional Figures.

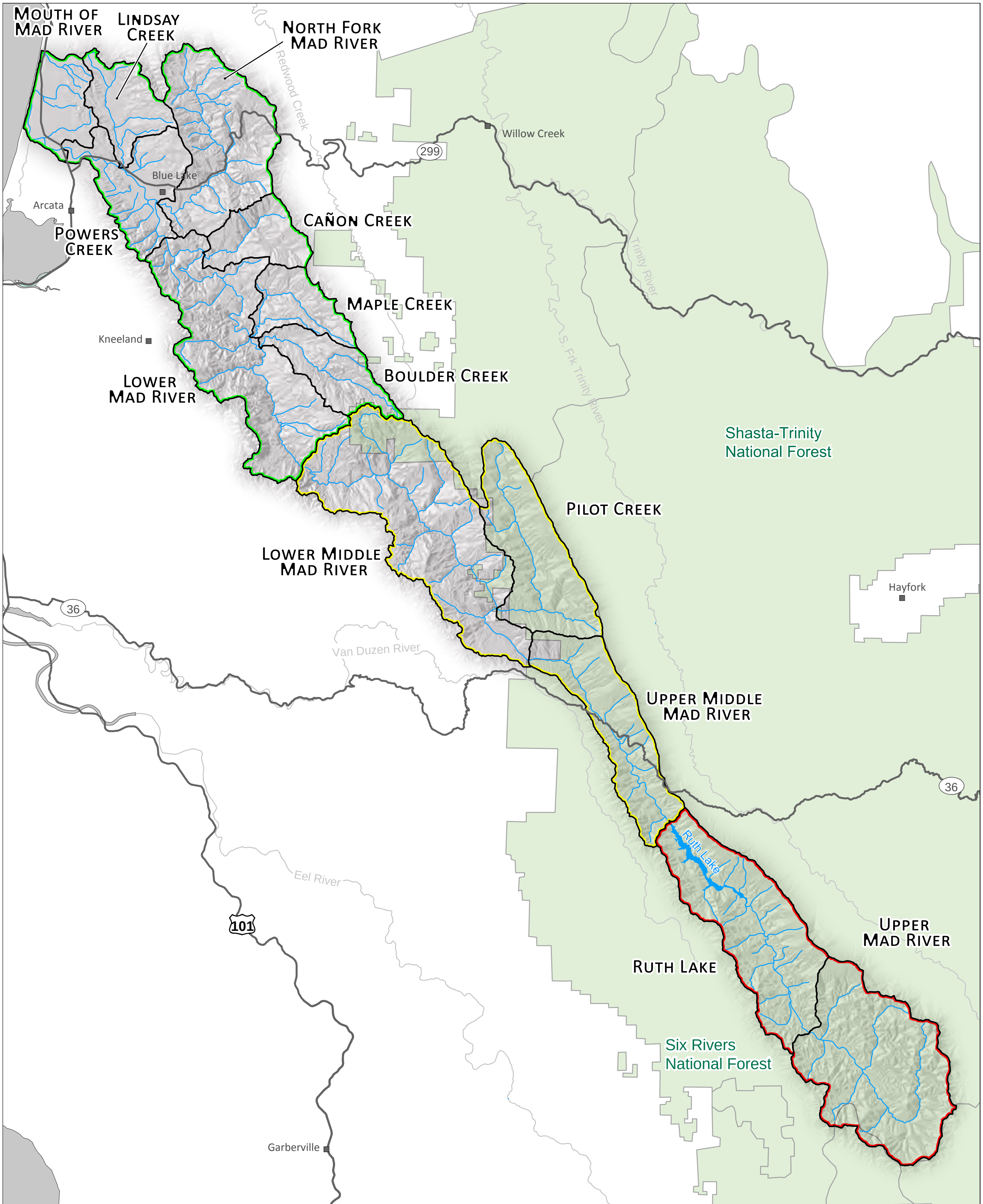
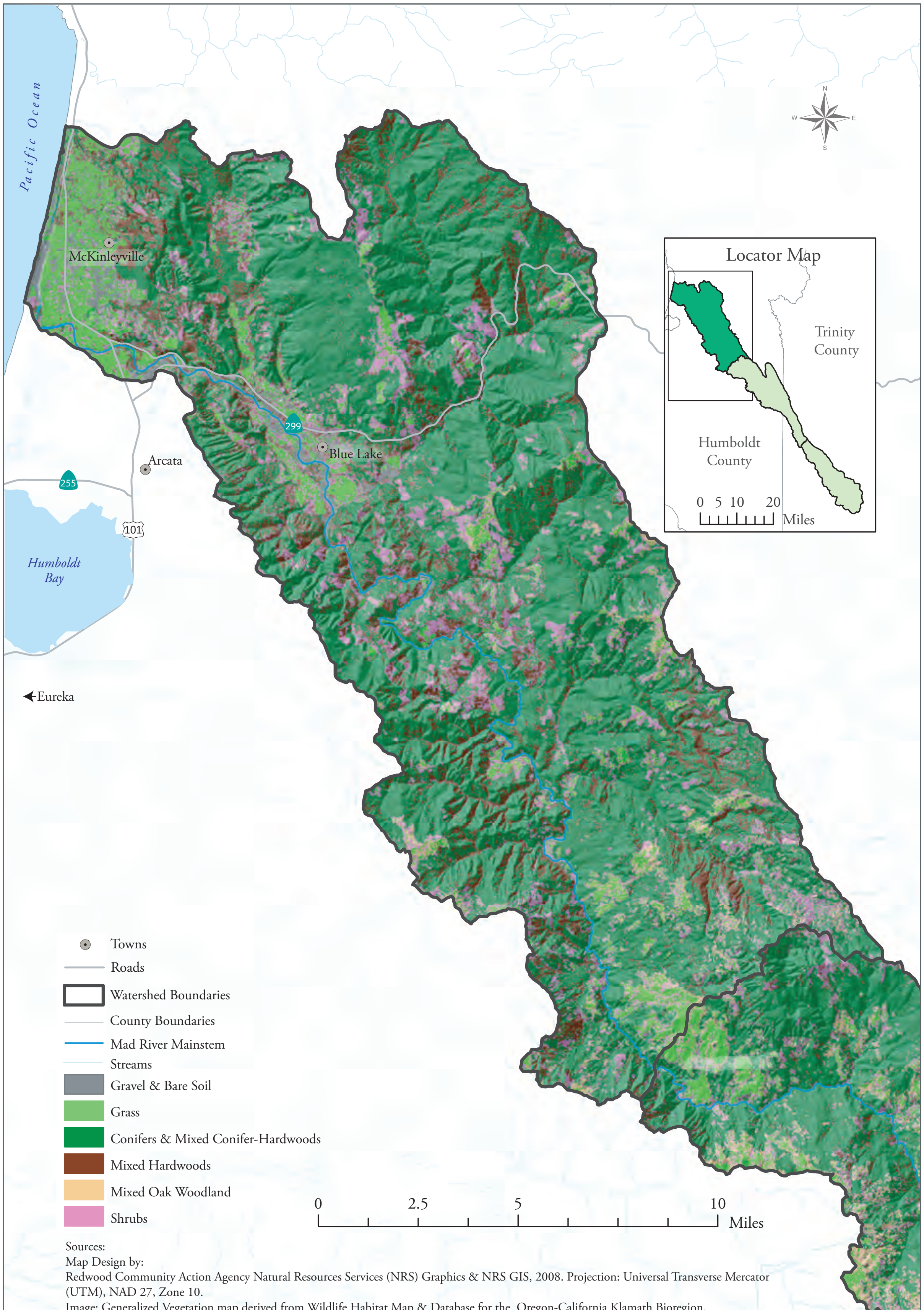


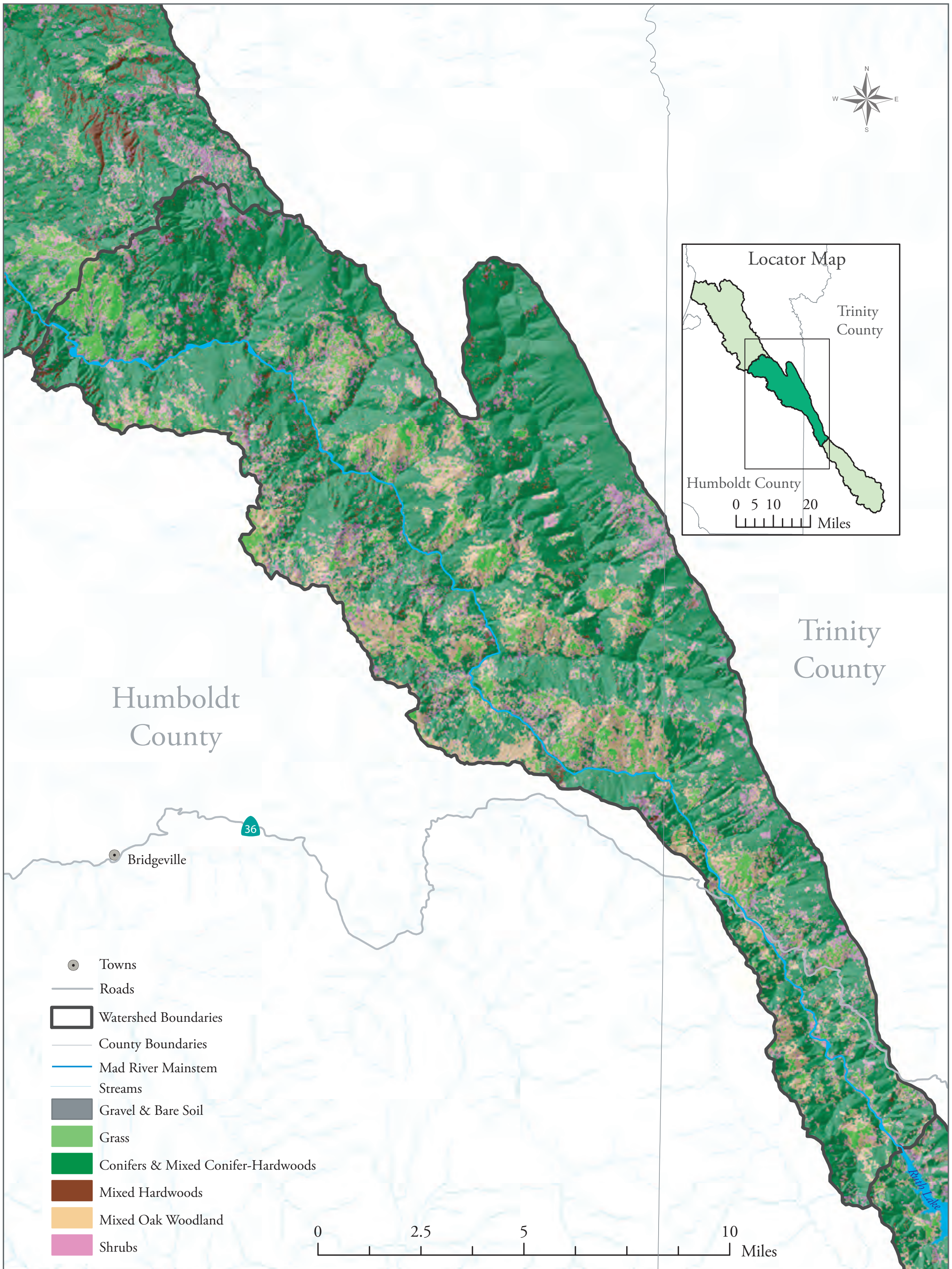
Figure A-1. **Mad River Watershed and Sub-basins**

Figure A-2a. Lower Mad River Watershed Vegetation Types



Sources:
Map Design by:
Redwood Community Action Agency Natural Resources Services (NRS) Graphics & NRS GIS, 2008. Projection: Universal Transverse Mercator (UTM), NAD 27, Zone 10.
Image: Generalized Vegetation map derived from Wildlife Habitat Map & Database for the Oregon-California Klamath Bioregion, College of Natural Resources and Sciences, Humboldt State University, Arcata, CA. 1997. The KlamathBioregional Assessment Project. Altered by RCAA-NRS GIS, 2008.
Streams: California Department of Forestry & Fire Protection (CDF) & United States Forest Service (USFS) Scale: 1:24000
Roads: California Department of Forestry & Fire Protection, 2001. Altered by RCAA-NRS GIS, 2008. Scale: 1:24000
Towns: United States Bureau of Land Management, 1997. Scale: 1:250,000

Figure A-2b. Middle Mad River Watershed Vegetation Types



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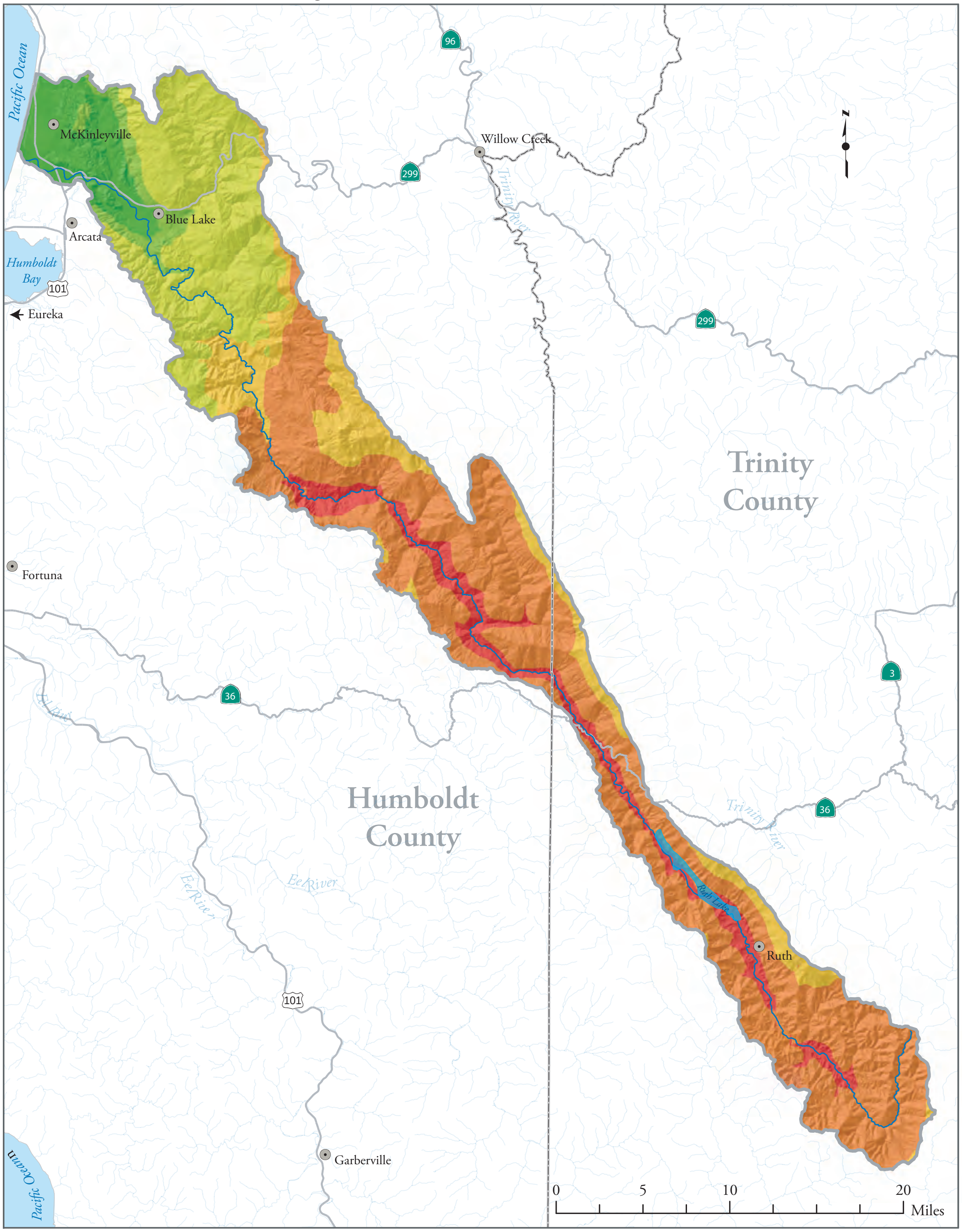
Redwood Community Action Agency Natural Resources Services (NRS) Graphics & NRS GIS, 2008. Projection: Universal Transverse Mercator (UTM), NAD 27, Zone 10.
Image: Generalized Vegetation map derived from Wildlife Habitat Map & Database for the Oregon-California Klamath Bioregion, College of Natural Resources and Sciences, Humboldt State University, Arcata, CA. 1997. The KlamathBioregional Assessment Project. Altered by RCAA-NRS GIS, 2008.
Streams: California Department of Forestry & Fire Protection (CDF) & United States Forest Service (USFS) Scale: 1:24000
Roads: California Department of Forestry & Fire Protection, 2001. Altered by RCAA-NRS GIS, 2008. Scale: 1:24000
Towns: United States Bureau of Land Management, 1997. Scale: 1:250,000

Figure A-2c. Upper Mad River Watershed Vegetation Types

Sources:
Map Design by:
Redwood Community Action Agency Natural Resources Services (NRS) Graphics & NRS GIS, 2008. Projection: Universal Transverse Mercator (UTM), NAD 27, Zone 10.
Image: Generalized Vegetation map derived from Wildlife Habitat Map & Database for the Oregon-California Klamath Bioregion, College of Natural Resources and Sciences, Humboldt State University, Arcata, CA. 1997. The KlamathBioregional Assessment Project. Altered by RCAA-NRS GIS, 2008.
Streams: California Department of Forestry & Fire Protection (CDF) & United States Forest Service (USFS) Scale: 1:24000
Roads: California Department of Forestry & Fire Protection, 2001. Altered by RCAA-NRS GIS, 2008. Scale: 1:24000
Towns: United States Bureau of Land Management, 1997. Scale: 1:250,000

Figure A-3. Mad River Watershed Assessment:
Average Daily Maximum Temperature According to a Model Using Point Data for the 30-Year Period 1971-2000



Legend

Mad River Maximum Daily Fahrenheit Temperature

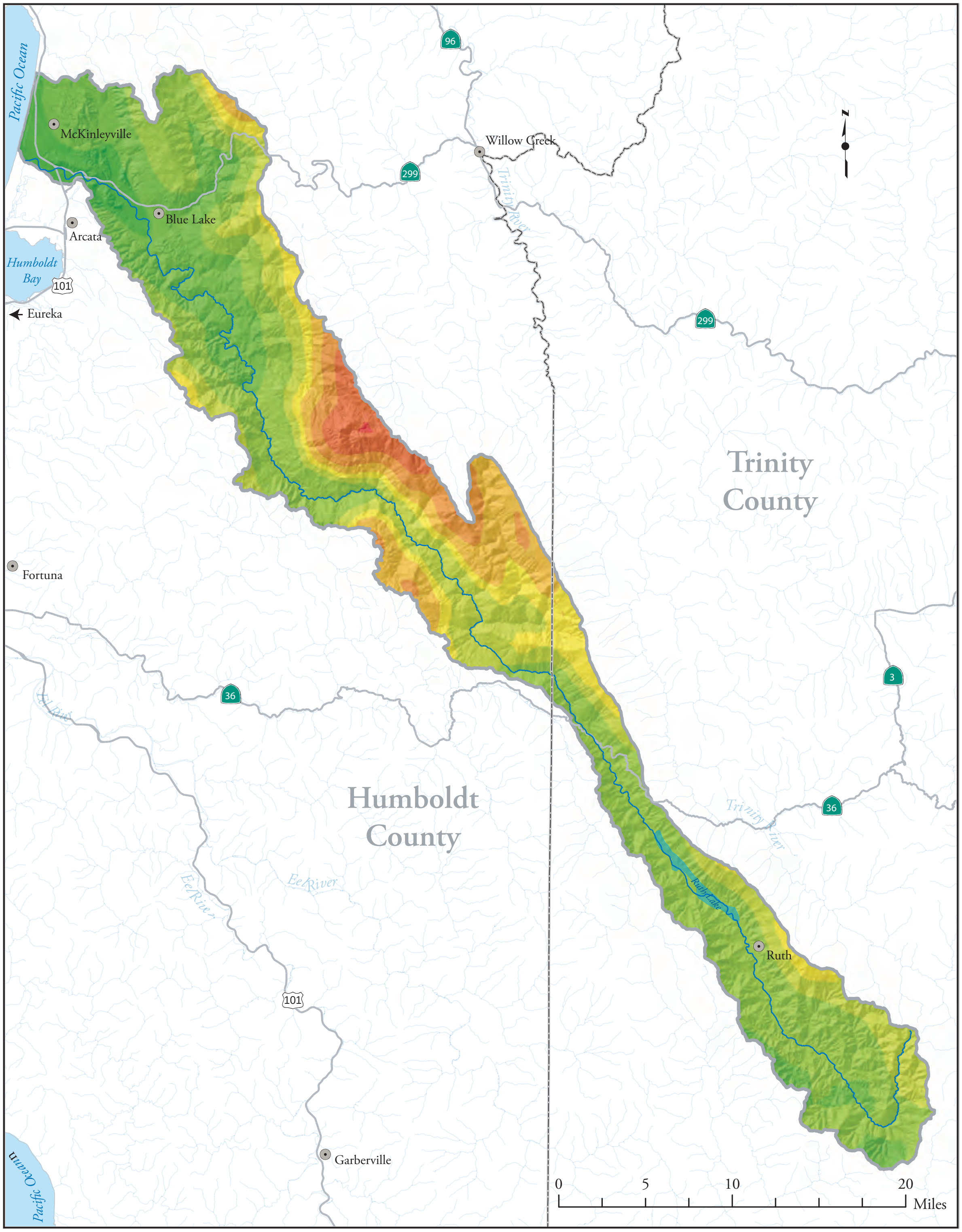
RANGE

- 63 - 65
- 65 - 70
- 70 - 75
- 75 - 80
- 80 - 85
- 85- 89

- County Boundary
- Mad River Mainstem
- Streams
- Towns
- State & US Highways
- Lake

Sources: Map Design by Redwood Community Action Agency Natural Resources Services Division GIS, 2008.
Temperature Data: United States Dept. of Agriculture/Natural Resources Conservation Service (USDA/NRCS) - National Cartography & Geospatial Center, 2006.
Hillshade Background: United States Geological Survey (USGS) National Elevation Data Sets (NEDs)15 minute quadrangles: 25 NEDs were used. Dates range 1967-1982. NEDs processed for hillshading by RCAA-NRS GIS, 2008.
County Boundaries: California Department of Forestry & Fire Protection, 1997.
Roads: California Department of Forestry & Fire Protection, 2001, altered by RCAA-NRS GIS, 2008.
United States Census Department Tiger Files altered by Humboldt County Planning Department, 1998; altered by RCAA-NRS GIS, 2008.
Streams: California Department of Forestry & Fire Protection, 2001, altered by RCAA-NRS GIS, 2008.

Figure A-4. Mad River Watershed Assessment: Mean Annual Precipitation



Mad River Precipitation
Mean Inches Per Year

RANGE

45 - 50	91 - 100
51 - 60	101 - 110
61 - 70	111 - 120
71 - 80	121 - 130
81 - 90	

County Boundary
Mad River Mainstem
Streams
Towns
State & US Highways
Lake

Sources: Map Design by Redwood Community Action Agency Natural Resources Services Division GIS, 2008.
Precipitation Data: United States Dept. of Agriculture/Natural Resources Conservation Service (USDA/NRCS) - National Cartography & Geospatial Center, 2006.
Hillshade Background: United States Geological Survey (USGS) National Elevation Data Sets (NEDs)15 minute quadrangles: 25 NEDs were used. Dates range 1967-1982. NEDs processed for hillshading by RCAA-NRS GIS, 2008.
County Boundaries: California Department of Forestry & Fire Protection, 1997.
Roads: California Department of Forestry & Fire Protection, 2001, altered by RCAA-NRS GIS, 2008.
United States Census Department Tiger Files altered by Humboldt County Planning Department, 1998; altered by RCAA-NRS GIS, 2008.
Streams: California Department of Forestry & Fire Protection, 2001, altered by RCAA-NRS GIS, 2008.

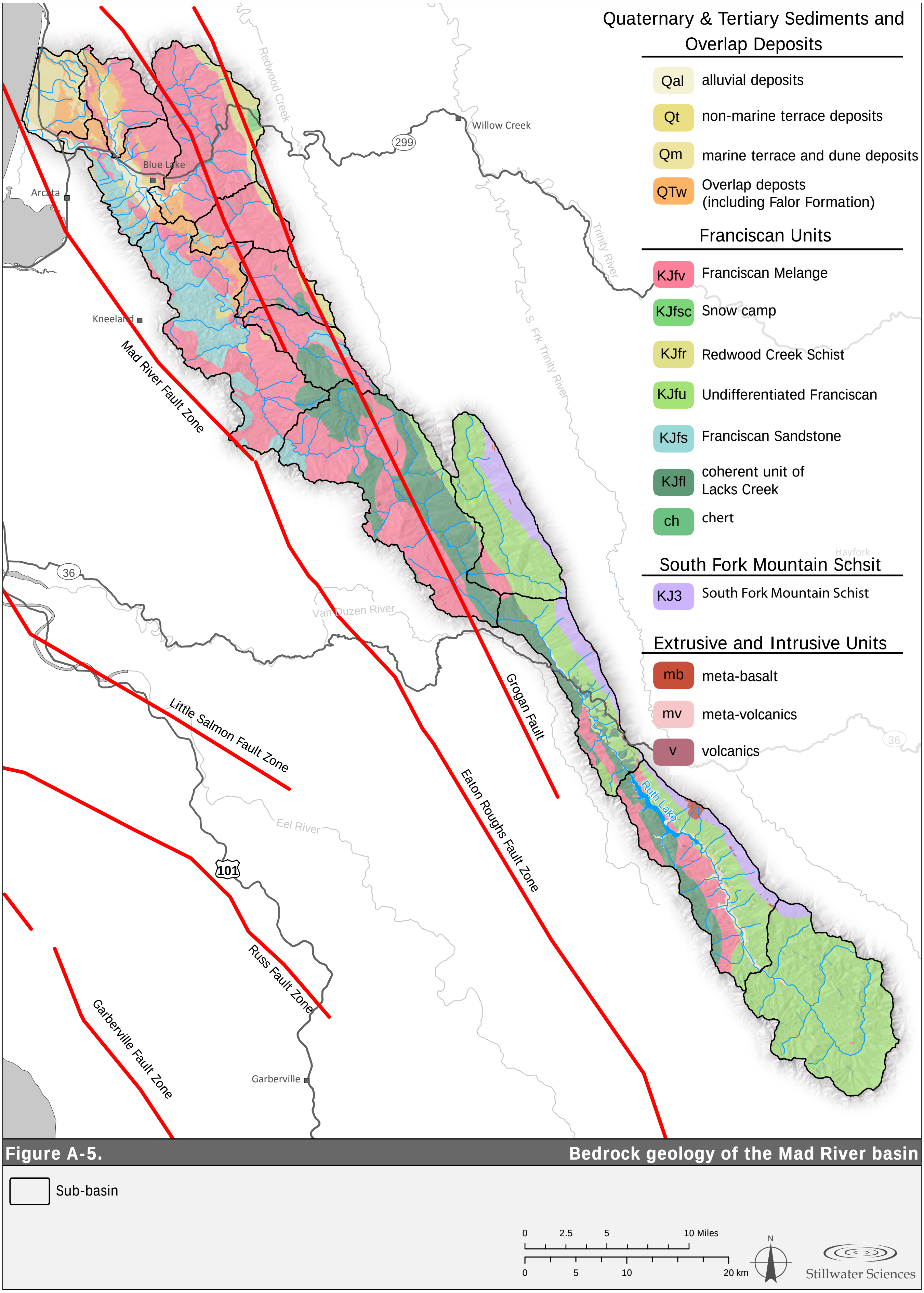


Figure A-5. **Bedrock geology of the Mad River basin**

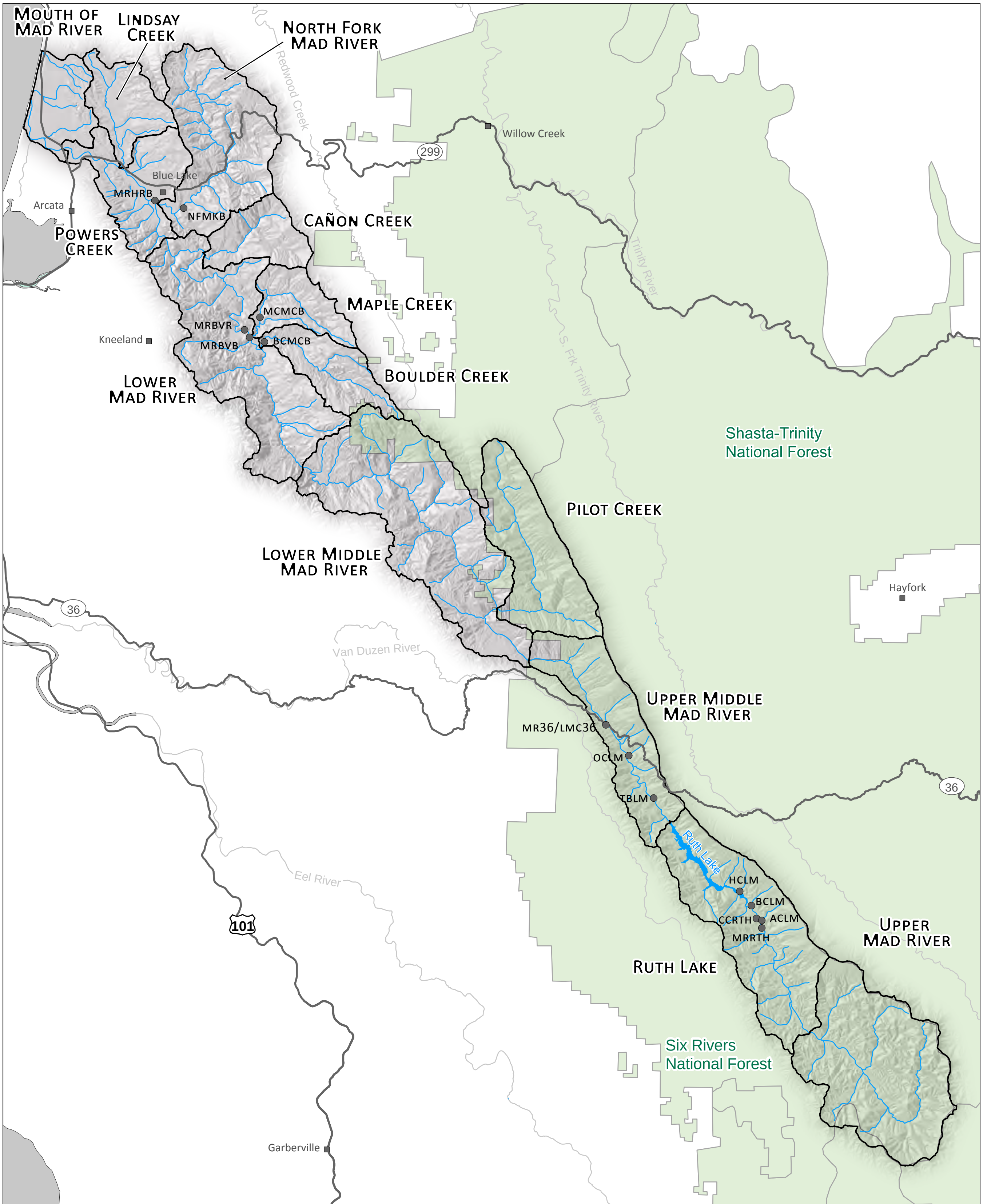


Figure A-6. **Location of important monitoring sites in the Mad River Watershed**

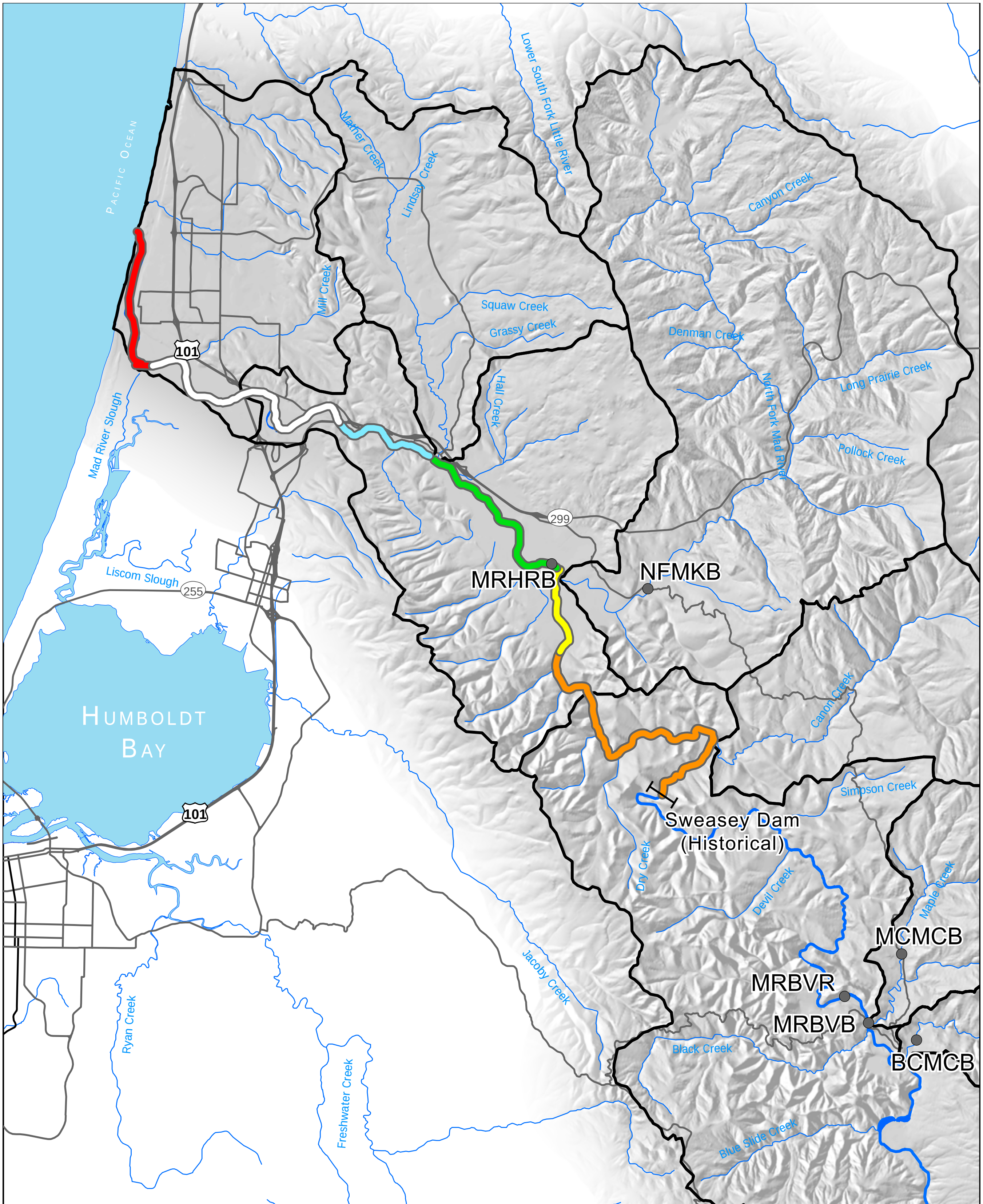


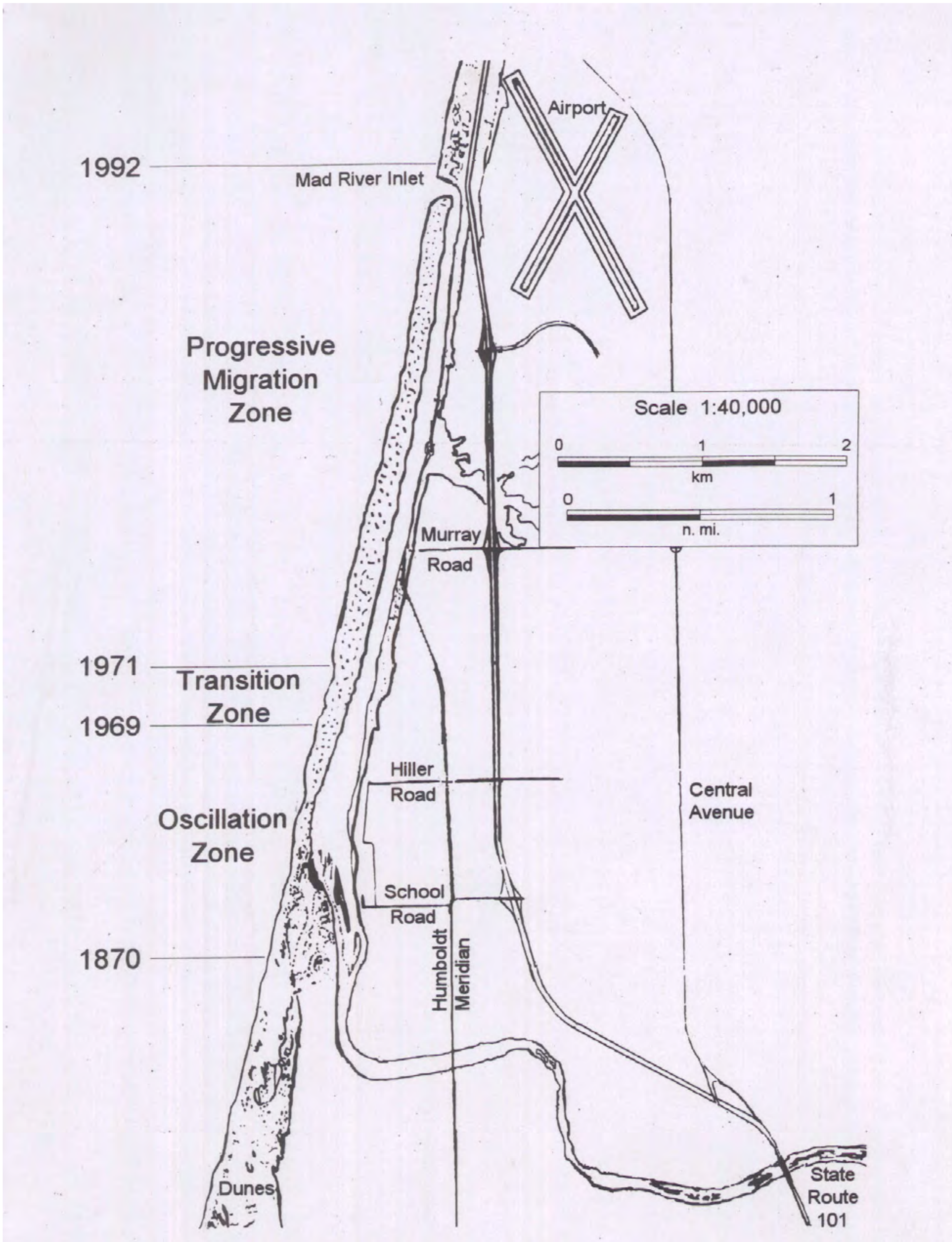
Figure A-7. Mainstem channel reaches in the Lower Mad River

- Mad River TMDL Sampling Station Location
- Reach 1 - Sweasey Dam to Fish Hatchery
- Reach 2 - Fish Hatchery to Blue Lake Bridge
- Reach 3 - Blue Lake Bridge to Annie & Mary Bridge
- Reach 4 - Annie & Mary Bridge to Hwy 299 Bridge
- Reach 5 - Hwy 299 Bridge to Hammond Trail Bridge
- Reach 6 - Hammond Trail Bridge to river mouth

0 1 2 4 Miles
0 2 4 8 km

N

Stillwater Sciences



Fiugure A-8. **Historical positions of the Mad River inlet**

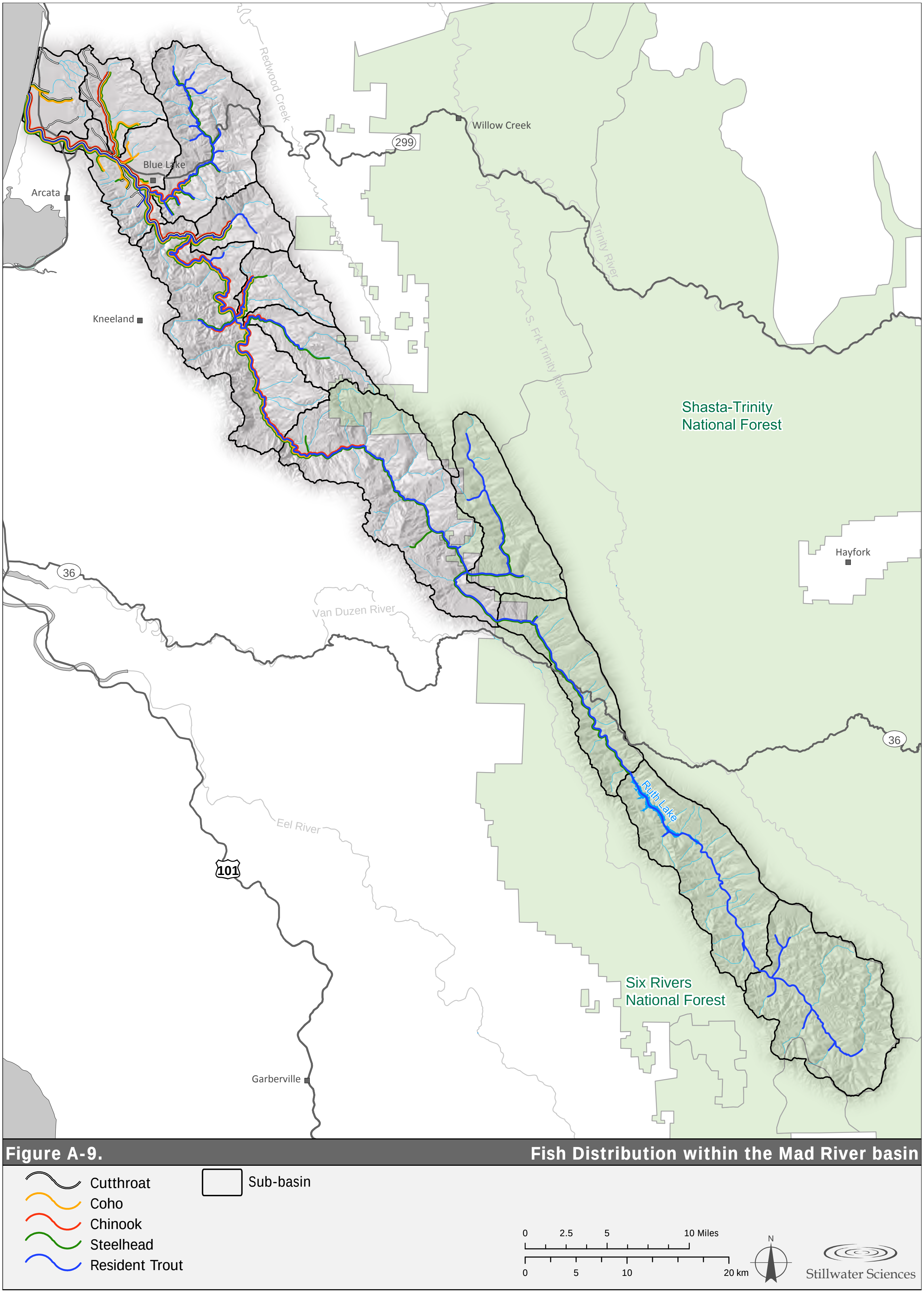


Figure A-9. Fish Distribution within the Mad River basin

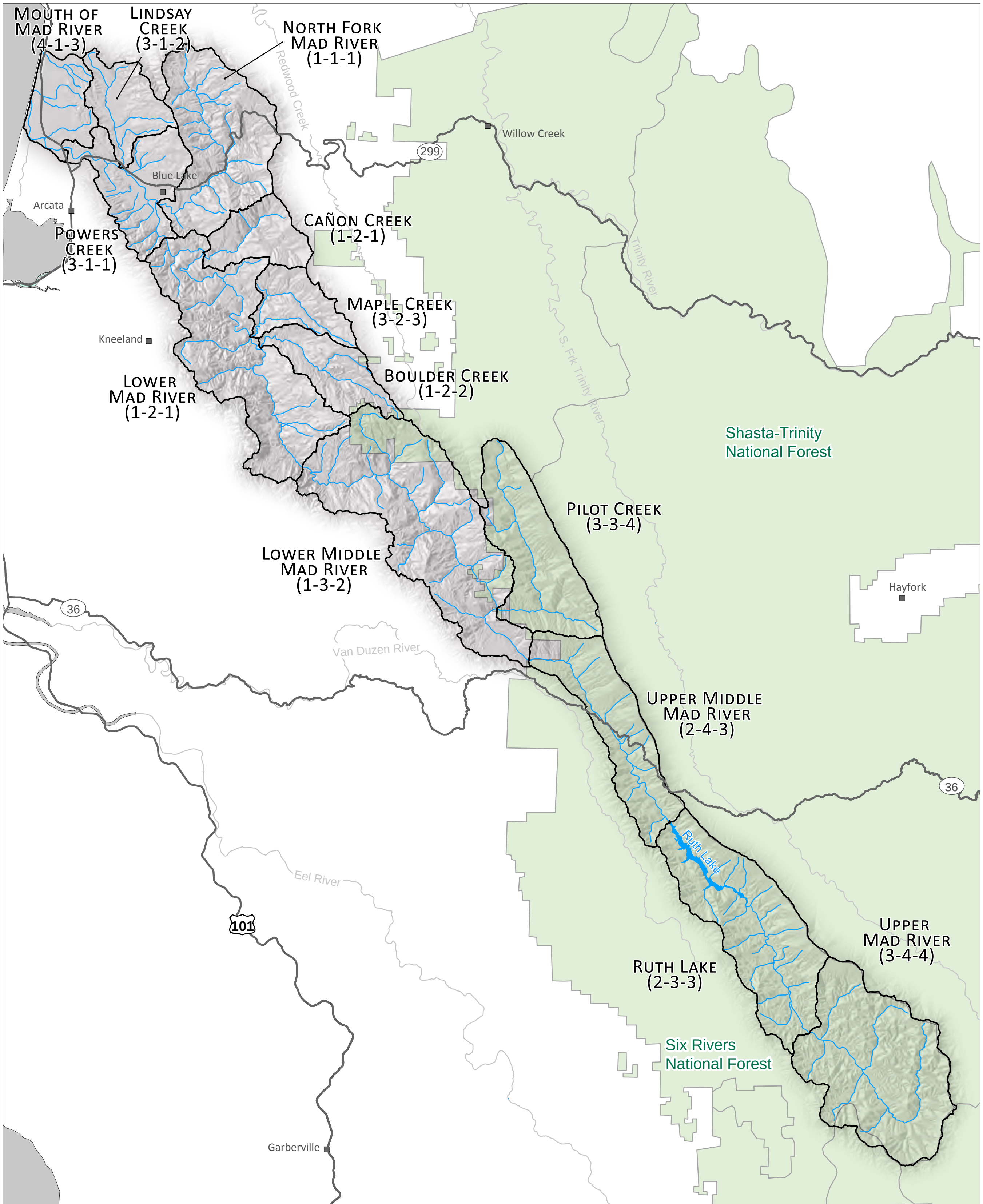


Figure A-10. **Risk of sediment impairment in the Mad River Watershed**

Sub-basin

Risk Levels - (#1 - #2 - #3)
#1 - Sediment Delivery Hazard
#2 - Aquatic Habitat Sensitivity
#3 - Risk of Sediment Impairment

Appendix B

Stakeholder Interviews.

Interview B-1. Interview with Carolyn Cook, USDA Forest Service.
Interview B-2. The Activities of Humboldt Bay Municipal Water District Summarized, approved by Carol Rische.
Interview B-3. Interview with Michelle Fuller, Blue Lake Rancheria.
Interview B-4. Interview with Margo Moorhouse, Lindsay Creek Watershed Coordinator.
Interview B-5. Interview with Claire McAdams, landowner.
Interview B-6. Interview with Judy Dixon and Jim Russ, landowners.
Interview B-7. Interview with Jay Russ, landowner.
Interview B-8. Interview with Francis Carrington, landowner.

Interview B-1.

Carolyn Cook – Watershed Program Manager – Six Rivers National Forest
June 12, 2008 2:30 p.m.
Contact: cacook@fs.fed.us phone: 445-3551

Preliminary Discussion Questions for Mad River Watershed Assessment

1) **Where does your organization/land use activity/ownership fit into the timeline we have created? (i.e. when was it founded, what are the major milestones in your management efforts such as watershed documents created by you or consultants, etc.)**

1905 - Six Rivers National Forest was created
1947 - Six Rivers National Forest was created
1961 - Mathews Dam (Ruth Reservoir) is constructed
1963 - Logging in the Upper Mad River began
1994 – Northwest Forest Plan is adopted
1995 – SRNF Land and Resource Management Plan is adopted

---

2) **What are your current projects or activities within the watershed?**

Six Rivers National Forest (SRNF) owns 89% (77,058 acres) of the Upper Mad watershed (above Ruth Reservoir). Most of the land is allocate as General Forest/Matrix (61,126 acres) with a small amount of land allocated as Late-Successional Reserve (4,240 acres) and Administratively or Congressionally withdrawn (2,654 acres). Timber harvest is precluded from Administratively or Congressionally withdrawn lands and restricted in Late- Successional Reserve lands. Management activities in the General Forest designated lands include: timber harvest, cattle grazing, off-road vehicle (OHV) use, hunting, recreation, and fuel reduction for fire protection.

---

3) **What do you believe your land use activity impacts on the Mad River are?**

Six Rivers National Forest uses Threshold of Concern (TOH) to evaluate the cumulative effects of managementment practices on a watershed. This threshold represents the acreage a watershed can be impacted before resulting in a "significant effect" and a more detailed environmental analysis is warranted. Some management effects stay at static levels. For example, the miles of road within the Upper Mad and the acreage grazed by cattle remain relatively constant. Other activities such as OHV use and timber harvest are more dynamic and the use varies from year to year. The effects of all land use activities in the Upper Mad are determined and then managed to stay within the TOH. The level of acceptable disturbance to a watershed in much lower for the US Forest Service than on private land regulated by the State.

From a water quality perspective, land use activities in the Upper Mad on US Forest Service land is low. Humboldt Bay Municipal Water District cross section data from Ruth Reservoir near the confluence with the Mad River indicate little aggradation in the reservoir from upland sources.

---

4) **Do you have reports or other organized data about water quality, temperature, hydrology, wildlife usage, other beneficial uses, etc. for the Mad River watershed assessment? If so, could these be made available to us to review and reference?**

Upper Mad River Watershed Analysis – Version 1.0. January 1998

Pilot Creek Watershed Analysis – September 1994
Little Doe and Low Gulch Timber Sale Project, Final Environmental Impact Statement, Trinity County, California. August 2007
Final Environmental Impact Statement, Pilot Creek, 1996
Assessment of Riparian Conditions on North Fork Eel River and Upper Mad River associated with Grazing. November, 2004

1.1.1.1.1.1.1 Fisheries Report For North Fork Eel Grazing Allotment Management. May 2005

Biological Assessment For North Fork Eel Allotment Management Plans. October 2005
Final Environmental Impact Statement – NF Eel River. December 2005
Water Quality Monitoring Report Associated with Grazing on the NF Eel River.
North Fork Eel and Upper Mad River Grazing Assessment Soils Report. May 2005

---

5) What could you contribute to the trendline of management efforts we have created? We are seeking information about general attitudes and trajectory for management in the watershed to create a plan that meshes with current efforts.

The Northwest Forest Plan of 1995 shifted land management practices in Six Rivers National Forest to towards more water quality and habitat conservation. The Upper Mad is mostly designated as General Forest/Matrix and will continue to be managed habitat conservation, recreation, and resource extraction. There are plans to continue timber harvest and grazing operations within the watershed. The cumulative effects of these activities will be evaluated using the established TOH.

SRNF is currently developing a plan to manage the access and routes for OHV users. This plan will eliminate unauthorized trails and establish trails for OHV use protecting vegetation, wildlife, and water quality.

---

6) If you work within more than one subwatershed or mainstem segment (upper, middle and lower), what are the differences in water quality, pollutants/ stressors, temperature, etc?

Monitoring within the subbasins are limited. Turbidity and suspended sediment are higher in Anada Creek due to an inner gorge slide.

---

7) In your opinion, what is/ are the greatest or most pressing management need(s) in the Mad River watershed?

Sediment contribution from range and forest roads. SRNF is currently conducting road inventory and assessment in select areas to identify sediment sources in the Upper Mad River. This will hopefully lead to road decommissioning and upgrade projects to reduce sediment delivery to the stream network. Managing OHV use will also help in this effort.

---

8) **Do you have any recommendations for other sources of information? This could be a state or federal agency contact, a specific landowner, etc.**

None other than the report provided.

---

9) **What kinds of management actions would improve water quality in the Mad River?**

Upgrading and decommissioning forest and range roads. Restricting cattle access to riparian areas.

Interview B-2.

The Humboldt Bay Municipal Water District's Mad River Activities

(in lieu of formal interview based on provided questions)

Drafted 09/29/08 by Natalie Arroyo, Redwood Community Action Agency based on available documents and conversation with Carol Rische

- HBMWD's History in the Watershed

Since its inception in 1956, the Humboldt Bay Municipal Water District has been a supplier of water to communities in the vicinity of Humboldt Bay. Currently, the District supplies 2/3 of the county with water for both domestic and industrial use. Approximately 80,000 people receive their household water supply from HBMWD at this time. The communities served include the cities of Eureka, Arcata, Blue Lake, and those served by Community Services Districts for McKinleyville, Fieldbrook, Manila and Humboldt.

The municipal and industrial water provided to these communities is collected by the District via four (4) Ranney wells which access water from the aquifer below the riverbed, and one (1) surface diversion collector which draws from the surface of the Mad River. These facilities are all located in the lower segment of the watershed at Essex. The annual diversion at these sites varies based upon consumer needs and river conditions, but constitutes a very small percentage of the total runoff. The Ranney wells collect water which is then treated and distributed as drinking water, while the surface collector's water is utilized for solely industrial purposes. According to the EPA Mad River TMDL document, "In 2005, HBMWD received an amended domestic water supply permit (DHS 2005), which included acknowledgement of the recently-completed Turbidity Reduction Facility (TRF) to its water treatment system. This eliminated the concerns DHS had previously expressed about the adequacy of the drinking water supply, which is taken from Ranney wells, 60 to 90 feet below the bed of the Mad River near Essex. The groundwater source accessed by the Ranney wells is classified as a "groundwater not under the significant direct influence of surface water" (DHS 2005)."

The District is responsible for managing the flow released from Ruth Lake/ Matthews Dam, located in the lower portion of the upper watershed. Ruth Reservoir and Matthews Dam were completed in 1961 and the reservoir stores about 48,000 acre-feet. It is the sole current impoundment on the river (Sweasey Dam – never managed by the Water District - quickly became dysfunctional and was removed in 1970). In addition to releasing water from the reservoir for collection and distribution to its users, the District also releases water to provide for aquatic species during the low-flow season, primarily the summer and fall months. According to the District's HCP, Coho and Chinook are unable to pass natural barriers below Matthews Dam. In optimal conditions, some Steelhead would be able to reach the dam, in which case it would become a migration barrier. Ruth Reservoir does provide recreational opportunities to the public, including boating and fishing.

- Current activities within watershed

The District's activities within the watershed are as described above, entailing flow management, collection and distribution to the listed wholesale purchasers.

- Impacts of the HBMWD's Activities in the Watershed

The District's activities have very little to no impact across the board, including impacts to fisheries, natural flow regime, and sedimentation.

- Existing Reports and Reference Materials from HBMWD

Existing documents include the HBMWD's Habitat Conservation Plan (final version approved in April 2004), Urban Water Management Plan and Ground Water Management Plan.

- General Future Trajectory/ Attitudes and Direction of the HBMWD

As the District is operating pursuant to a charter and a public service mission, there are no foreseen changes to their basic service requirements or practices.

- HBMWD Management Area

The HBMWD's managed area spans from Matthews Dam/ Ruth Lake to the diversion facility at Essex. There is no management influence or District work below this point, although the District does manage river flows which clearly travel beyond the Essex facilities.

Interview B-3.

Michelle Fuller – Blue Lake Rancheria Environmental Program Director
May 16, 2008 2:00 p.m.
Contact: mfuller@bluelakerancheria-nsn.gov, phone: 668-5101

Preliminary Discussion Questions for Mad River Watershed Assessment

1) Where does your organization/land use activity/ownership fit into the timeline we have created? (i.e. when was it founded, what are the major milestones in your management efforts such as watershed documents created by you or consultants, etc.)

Blue Lake Rancheria's congressional boundaries do not include any of the Mad River. The Rancheria was originally established in 1908 as a homeland for homeless Indians with 32 acres, unlawfully terminated in 1961, and reinstated as a federally-recognized tribe in 1983. In 2002, the Rancheria acquired a 40 acres parcel of land adjacent to their existing land that includes a section of the Mad River and is held in trust for the tribe by the Bureau of Indian Affairs. Current property holdings total about 80 acres, including the land held in trust.

In 2005, the BLR Environmental Programs Department began a water quality monitoring project that included 4 sites on the Mad River from Pump Station #4 at the downstream end to the hatchery upstream. There are 2 sites on Powers Creek at the mouth and below the rodeo grounds, as well as 2 wetland sites. This program is funded by the EPA under a Clean Water Act section 106 grant.

---

2) What are your current projects or activities within the watershed?

The water quality monitoring program has been continuously operated since it began in 2005. Parameters monitored on a twice weekly basis include pH, temperature, dissolved oxygen, conductivity and turbidity. Once per quarter (4 x per year) samples are collected for nitrogen, phosphorus and coliform bacteria and are analyzed by North Coast Labs. 2 years of data are currently in an Access database. The database format is changing to an open source database developed for the Yurok Tribe, which is being modified to meet BLR needs. This database will include air and water quality information, photos, etc.

In 2009, BLR will conduct some post-project restoration work following the completion of the bridge removal project NMFS is doing on Powers Creek. This is by way of Clean Water Act 319 funding, and will include revegetation and other restoration components.

---

3) What do you believe your land use activity impacts on the Mad River are?

The Tribe feels it has a responsibility to the environment and aims to be a good steward. Though the economic development activities of the Tribe undoubtedly have impacts on the environment, the Tribe attempts to minimize them by way of good planning. For example, their parking lots have more than enough infiltration basins for the amount of runoff estimated. Extreme care is taken at the gas station to prevent spills and, in the event of a spill, employees are trained to immediately cover storm drains and contain and clean up the spill properly.

The Rancheria's Environmental Programs Department is not only working to monitor water quality conditions on the Mad River, but is planning restoration activities for a wetland and tributary system to the Mad on tribal land to improve water quality and habitat conditions.

---

4) Do you have reports or other organized data about water quality, temperature, hydrology, wildlife usage, other beneficial uses, etc. for the Mad River watershed assessment? If so, could these be made available to us to review and reference?

   Annual summary of WQ data, other data dissemination would need to be approved by the tribe (should not be problematic). The 2007 WQ summary will be provided to RCAA.

---

5) What could you contribute to the trendline of management efforts we have created? We are seeking information about general attitudes and trajectory for management in the watershed to create a plan that meshes with current efforts.

   While the Tribe is exempt from the TMDL, it supports this type of increased regulation of activities that impact the river and that will hopefully improve the health of the watershed. A collaborative effort towards an implementation plan seems like a good idea for moving forward as a watershed, and the Tribe has enjoyed participating.

---

6) If you work within more than one subwatershed or mainstem segment (upper, middle and lower), what are the differences in water quality, pollutants/ stressors, temperature, etc?

   Powers Creek does have more water quality issues than the mainstem monitoring sites, predominantly sediment and nutrient-related.

---

7) In your opinion, what is/ are the greatest or most pressing management need(s) in the Mad River watershed?

   It is my personal opinion that we need to see better practices in the lumber and gravel industries to reduce their impacts.

---

8) Do you have any recommendations for other sources of information? This could be a state or federal agency contact, a specific landowner, etc.

   NMFS Project contact is Doug Chow (GIS specialist): doug.chow@noaa.gov
   Paul Angell works with the Environmental Program and also on Cultural Heritage and History compilation. He would be a good source of information on native management practices and historical range, water usage, etc. His contact email is pangell@bluelakerancheria-nsn.gov

Interview B-4.

Margo Moorhouse – Lindsay Creek Watershed Coordinator
May 13, 2008 9:00 a.m.
Contact: margofish@humboldt1.com

Preliminary Discussion Questions for Mad River Watershed Assessment

1) Where does your organization/land use activity/ownership fit into the timeline we have created? (i.e. when was it founded, what are the major milestones in your management efforts such as watershed documents created by you or consultants, etc.)

   Problem saving – need to recover basic info for this question.

---

2) What are your current projects or activities within the watershed?

   Current and proposed fish habitat improvement and riparian revegetation and bedload transport – tributaries to lower Mad and lower mainstem
   No expected deadline for work with private landowners – fish passage and habitat improvement

   HFAC has been approached by NOAA/ NMFS biologists and engineers to do projects (above) - Margaret Tauzer and Dan Free

   Lindsay Creek – similar type projects and road assessment inventory

   North Fork Mad River Watershed-wide Road Assessment Inventory – Pacific Coast Fish and Wildlife Wetlands Restoration Association included prioritization

   PWA ranching road protocol

---

3) What do you believe your land use activity impacts on the Mad River are?

   Work with land managers in the lower Mad River area to minimize impacts but allow them to continue managing

---

4) Do you have reports or other organized data about water quality, temperature, hydrology, wildlife usage, other beneficial uses, etc. for the Mad River watershed assessment? If so, could these be made available to us to review and reference?

   Not really.

---

5) What could you contribute to the trendline of management efforts we have created? We are seeking information about general attitudes and trajectory for management in the watershed to create a plan that meshes with current efforts.

   Landowners and agency rep.s are not expecting an end date to their restoration efforts – long term management activities with a holistic perspective (not just riparian, instream, etc.)

---

6) If you work within more than one subwatershed or mainstem segment (upper, middle and lower), what are the differences in water quality, pollutants/ stressors, temperature, etc?

Work in several subwatersheds – temp. in tribs and lower mainstem are an issue. Channel connectivity

North Fork – dewatered in lower portion during summer months (lower mile and a half) – Hwy 299 revamped, in the process several enormous slides were created due to unstable construction. Channel is incising and staying wetted longer in the year, every year. Interstitial flows extending further down the system.

---

7) In your opinion, what is/ are the greatest or most pressing management need(s) in the Mad River watershed?

For lower Mad – riparian management, barrier (complete or temporal) assessment and treatment, identify and treat sediment sources, regain riparian area and channel incision in mainstem, increase rearing capacity, large wood recruitment and habitat development.

---

8) Do you have any recommendations for other sources of information? This could be a state or federal agency contact, a specific landowner, etc.

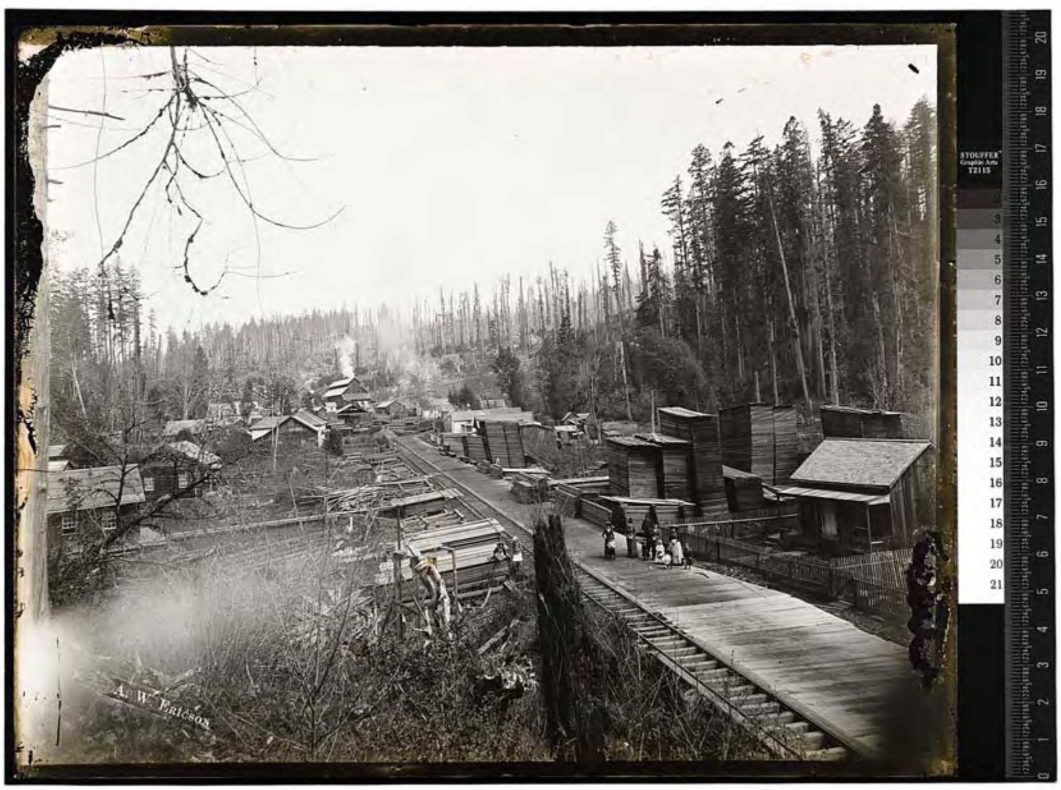
Allen Renger with CDFG.

Interview B-5.
Claire McAdams

Hall Creek, Mill and Noisy Creeks

Initial Entry
Isaac Minor acquired land within the Hall Creek Valley and the adjacent Mill and Noisy Creek watersheds in the 1880s. Minor built a railroad spur approximately a half-mile up the Hall Creek valley from Glendale Road and by 1886 a mill was under construction. This rail spur follows the current driveway of property located at 1975 Glendale Drive and the approximate site of the mill can easily be identified.

An 1890 newspaper story describes the mill as employing 45 persons and having a daily production output of 40,000 bf with a yard capacity for 3,000,000 bf and a log pond that could store an equal amount of logs. The story went on to state that attached to the mill was 2,000 acres of land and that the country surrounding the mill was not as steep as where most mills were located and that the land was destined to become valuable for grazing and fruit culture.

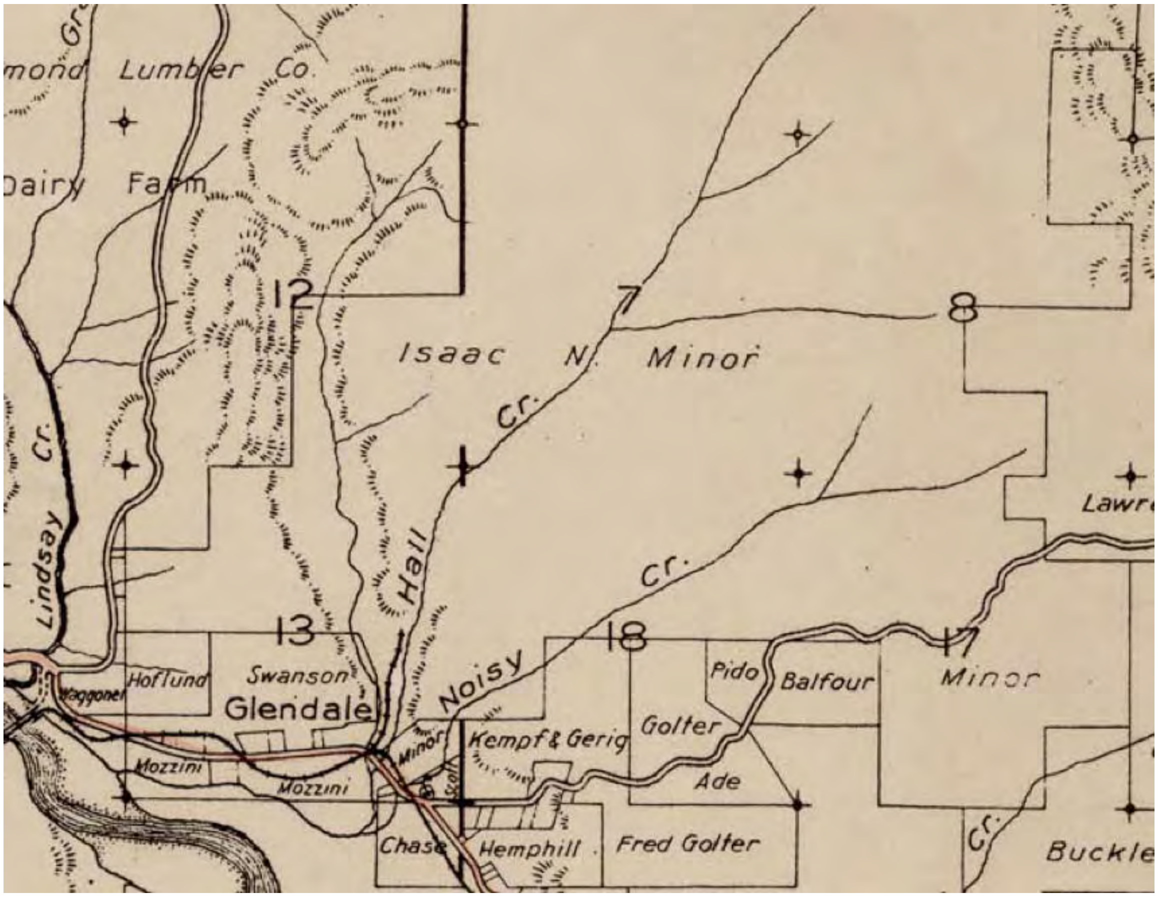


Minor Mill and Lower Hall Creek Valley

The Minor mill operated for 27 years until the supply of redwood was depleted and mill was closed.

Following closure of the mill, the Minor family retained ownership and the property was used for agriculture; primarily dairying and fruit growing.

Below is a 1920 map of the Glendale area showing the Minor property including the railroad spur to the mill site and the three creeks. Note that Hall Creek is shown as the middle creek. That apparently is an error; Hall is the westernmost creek on the Minor property. The middle creek is actually Mill Creek.



Glendale Area Circa 1920

At some point between 1920 and the 1940s, it appears that Noisy Creek was moved southeastward to irrigate land south and east of its original channel.

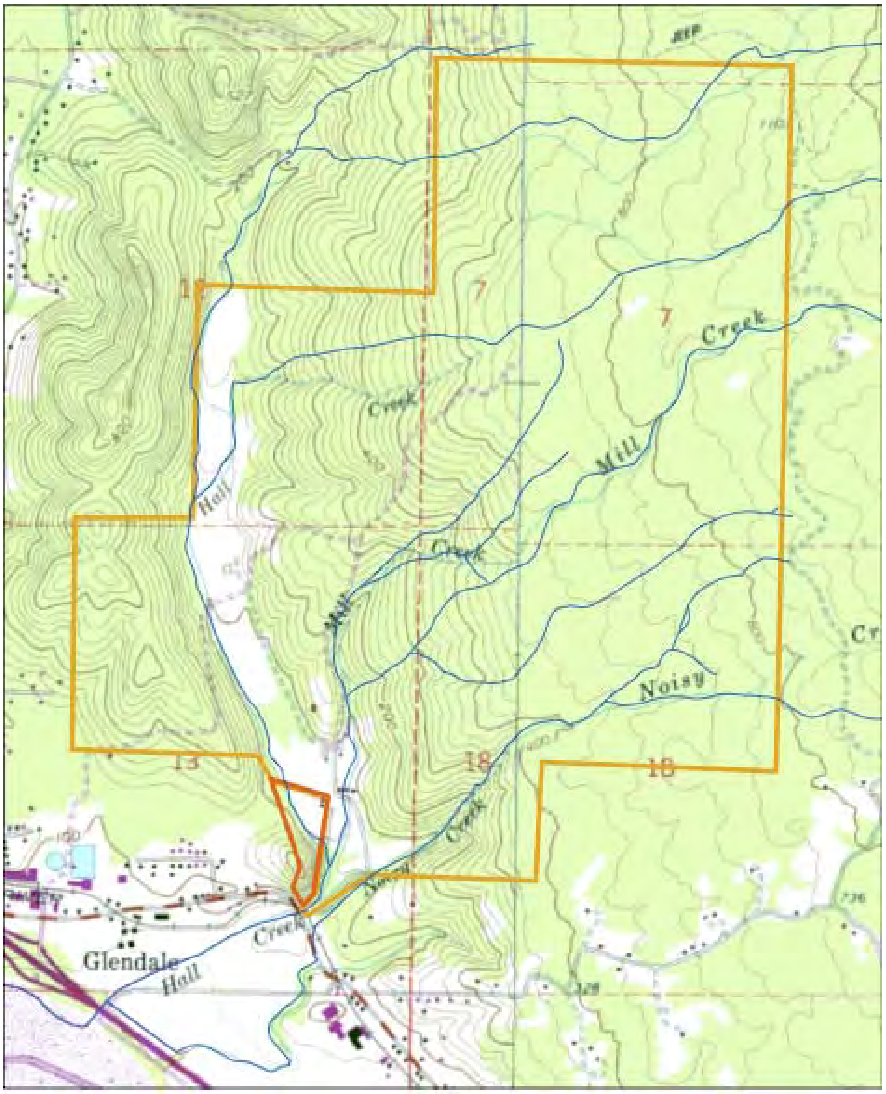
<u>McAdams</u>

In the mid-1940s the Minor property in the Glendale area was purchased by Kelly E. McAdams and his father-in-law G.R. Ogletree. A September 22,1947 Humboldt Herald newspaper story, states that the Minor Mill had been rebuilt and that operations had resumed. According to the story, the McAdams/Ogletree operation had intended to mill second-growth redwood but due to the lack of for demand second-growth redwood, old-growth Douglas-fir was purchased and milled. The mill's capacity was rated at 18,000-20,000 bf per day. Within a fairly short time, the mill failed and the equipment removed.

In the 1950s a market developed for second-growth wood and limited harvesting of second-growth redwood and Douglas-fir continued through the 1970s. Professional management began in 1980s with the engagement of Natural Resources Management Corp. (NRM) of Eureka, The property is currently owned by three families descended from Kelly E. and Ina May Ogletree McAdams and jointly managed under an NTMP (1-99NTMP-014 HUM) prepared by NRM. NRM continues to provide forestry services for the families.

In 2005, the property addressed as 1975 Glendale Drive was purchased by Claire McAdams and Ben Luckens completing family ownership of most of the Hall, Mill and Noisy Creek watersheds within the original Minor holdings in Glendale.

Below is a map of the McAdams Families' property within the Glendale area. With the exception of 1975 Glendale, this map does not break out individual ownerships within the jointly managed property.



Glendale Area with McAdams Families' Property Outline

Land Use Changes in the Hall and Mill Creek Valleys
Prior to initial entry in the 1880s, the valleys were forested with Coastal Redwood. Evidencing this is the number of old-growth stumps in the Hall Creek valley and existence of several stunted old-growth survivors.

After the valleys were clear-cut, they were used for dairying and for the growing of crops and fruit trees. The use of the valleys for agriculture continued through the 1980s and their use for cattle grazing ended in 2004 (although the neighbor's sheep still come on to graze in the lower meadow). The upland nature of the valleys is indicated by the existence of irrigation wells drilled in the 1970s to provide water for crops.

In 2004, after cattle grazing was eliminated, Hall Creek Valley was planted in Coastal Redwood. Following the elimination of cattle grazing, Roosevelt Elk moved into the valley.

For a variety of reasons described elsewhere in this document, Hall and, especially, Mill Creeks have slowly aggraded causing drainage problems in the lower portions of their valleys. Significant changes have also occurred in Noisy Creek where, according to anecdotal evidence, six- foot deep pools existed through the 1970s.

It is the intent of the families to continue to manage and improve the valleys for silvaculture and wildlife habitat.

Hall Creek Valley March 2007

Fish in Hall, Mill and Noisy Creeks

Hall, Mill and Noisy creeks have historically supported salmon and steelhead populations. Due to severe aggradation, Mill Creek no longer supports fish.

The NTMP covering the property states that NRM fisheries staff observed juvenile Coho salmon in Hall and Mill Creeks during the summer and fall of 1997. Also in 1997, NRM fisheries staff observed steelhead spawning and rearing in Hall, Mill and Noisy Creeks. The NTMP also states that CDF&G reported Chinook salmon in Hall and Mill Creeks in 1969.

In the Summer of 2007, CDF&G conducted extensive stream inventories of Hall, Mill and Noisy creeks documenting existing habitat conditions and recommending options to enhance habitat. During the surveys, juvenile salmonids were reporteded in Hall and Noisy creeks.

In addition to these technical studies, there are also personal reports regarding steelhead and salmon in Hall, Mill and Noisy Creeks. A neighbor reports excellent fishing in the three creeks during his boyhood in 1960s. A tenant on the property reports that he counted in excess of 100 fish at a time spawning in Hall Creek as late as the mid 1990s. The property owners report having seen dozens of salmon spawning in Noisy Creek over a period of several hours in 2002. The property owners also report seeing juvenile salmon in both Hall and Noisy Creeks within the property in the spring and summer of 2007.

Juvenile Salmon in Hall Creek Spring 2007

Interview B-6.

Judy Dixon and Jim Russ Responses by Paul Grunden
Mad River Watershed Assessment Questionnaire
June 6, 2008

Respondant: Paul Grunden, RPF #2296, has been the Forestland Manager for Russ Timber Partnership for the past twenty years. He was authorized to respond to the Mad River Questionnaire on behalf of the Russ Timber Partnership, represented by Judy Dixon and Jim Russ.

1. Where does your organization/land use activity/ ownership fit into the timeline we have created? (Please see the attached timeline for reference.) For example, when did your land use or presence begin?

   The Russ family purchased land in the Murphy Meadows area around 1900 and began running livestock. Currently Russ Timber Partnership owns approximately 2,000 acres that drains towards the Mad River via Maple Creek and Canon Creek. The primary activities carried out on the ranch are livestock grazing and timber management.

2. What are the major milestones in your management efforts such as watershed documents created by you or consultants, etc?

   The Type of records maintained as part of the forestland management include detailed inventory and depletion records, site preparation and planting, land surveys, road inventories and biological surveys. The Russ family maintains detailed records of livestock production.

3. What are your current projects or activities within the watershed?

   There is active livestock grazing and one active timber harvest plan within the Maple Creek watershed.

4. What do you believe your land use activity impacts on the Mad River are?

   The Murphy Meadow Ranch straddles the ridge between the Mad River and Redwood Creek. The slopes are gentle to moderate. There are nearly equal amounts of rangeland and timberland. Relatively speaking the area is lightly roaded. Observations made over the past twenty years are similar to many areas of Humboldt County. Historic logging and road building practices often impacted watercourses by poor construction techniques and lack of maintenance of roads and watercourse crossings. In addition, careless near stream logging lead to sediment inputs and a reduction in riparian habitat.
   More recent activities have resulted in upgraded road systems and harvesting under the California Forest Practice Rules. The implementation of Best Management Practices, Sustainable timber and range management and the passage of time have restored the land and watercourses of the ranch to excellent condition and impacts to downstream waters are insignificant.

5. In Your opinion , what is/are the greatest or most pressing management need(s) in the Mad River watershed.

Rural development, associated fire hazard and fragmentation of large ownerships. These issues are being driven by inefficient and overbearing regulations administered by multiple agencies that have overlapping and competing interests. The result is traditional land use practices are becoming economically less viable.

6. In Your opinion, what do you think are the issues in the watershed that can be addressed?

   Inefficient and over regulation can be addressed by a performance based system of regulation. Sustainable land use practices can be encouraged by tax incentives and a reform of the estate tax.

7. In your opinion, do you think that there are the issues in the watershed that are beyond anyone's control?

   Natural conditions such as geology, vegetation patterns and climate.

8. We are seeking information about general attitudes and trajectory for management in the watershed to create a plan that meshes with current efforts. Can you contribute to management efforts within the watershed?

   NA

9. Do you have goals or desires for a future land use?

   Continued timber and range management.

10. Is there any conceivable reason or fear of why you may not be able to realize this goal(s)?

    Federal, State, County and local government intervention.

11. Do you have reports or other organized data about water quality, temperature, hydrology, wildlife usage, other beneficial uses, etc. for the Mad River watershed assessment? If so, could these be made available to us to include and reference?

    NA

12. If you work within more than one subwatershed or mainstem segment (upper, middle and lower), have you noticed any differences in water quality, pollutants/ stressors, temperature, etc? (*Please see the attached map for reference.*)

    The Russ Timber Partnership property is located in the upper Maple Creek and Canon Creek subwatersheds. In my time on the ranch there has been a marked improvement of watercourse conditions as a result of road upgrading and maintenance.

13. Do you have any recommendations for other sources of information? This could be a state or federal agency contact, a specific landowner, etc.

    None.

14. What else would you like us to know?

    NA

15. Please share any specific experiences or beliefs that you have regarding the Mad River Watershed, which could encompass broad topics relating to land use, hardships, obstacles, conditions, and desires relevant to your relationship/presence in this region.

    NA

Interview B-7.
Jay Russ Replies
Preliminary Discussion Questions for inclusion in the Mad River Watershed Assessment

1) Where does your organization/land use activity/ownership fit into the timeline we have created? (*Please see the attached timeline for reference.*) For example, when did your land use or presence begin?
I began leasing in the watershed January 2008 so my knowledge and experience is very limited. However, my family has grazed cattle and harvested timber for 125 years.

2) What are the major milestones in your management efforts such as watershed documents created by you or consultants, etc.? NA

3) What are your current projects or activities within the watershed?
I will be grazing cattle and my family will be harvesting timber.

4) What do you believe your land use activity impacts on the Mad River are?
Negligible.

5) In your opinion, what is/are the greatest or most pressing management need(s) in the Mad River watershed?
No opinion.

6) In your opinion, what do you think are the issues in the watershed that can be addressed? NA

7) In your opinion, do you think that there are the issues in the watershed that are beyond anyone's control? NA

8) We are seeking information about general attitudes and trajectory for management in the watershed to create a plan that meshes with current efforts. Can you contribute to management efforts within the watershed? NA

9) Do you have goals or desires for a furure land use?
Continued sustainable grazing and timber production.

10) Is there any conceivable reason or fear of why you may not be able to realize this goal(s)? NA

11) Do you have reports or other organized data about water quality, temperature, hydrology, wildlife usage, other beneficial uses, etc. for the Mad River watershed assessment? If so, could these be made available to us to include and reference?
No.
(No more questions answered.)

Interview B-8.
Francis Carrington, May 2008

1) Where does your organization/land use activity/ownership fit into the timeline we have created? (*Please see the attached timeline for reference.*) For example, when did your land use or presence begin?

   Purchased ranch in 1978.

2) What are the major milestones in your management efforts such as watershed documents created by you or consultants, etc.,?

   Planted trees in slide area.
   Also use willows to stop erosion

3) What are your current projects or activities within the watershed?

   Raising cattle, hay and timber.
   Swimming with grandchildren in Mad River.
   Irrigating out of water.

4) What do you believe your land use activity impacts on the Mad River are?

   Nil.

5) In your opinion, what is/are the greatest or most pressing management need(s) in the Mad River watershed?

   Stopping the natural Serpentine slides with plantings of willow and alder, i.e. utilizing preventative measures.

6) In your opinion, what do you think are the issues in the watershed that can be addressed?

   Same as number 5 above.

7) In your opinion, do you think that there are the issues in the watershed that are beyond anyone's control?

   Floods.
   Wildfires can be controlled somewhat.
   Drought.
   Climate change.
   Earthquakes.

8) We are seeking information about general attitudes and trajectory for management in the watershed to create a plan that meshes with current efforts. Can you contribute to management efforts within the watershed?

   Every landowner should try to stop slides and erosion.

9) Do you have goals or desires for a future land use?
   Same rural living.
   Cattle and logging.
10) Is there any conceivable reason or fear of why you may not be able to realize this goal(s)?

Price of fuel.
Over regulation.
Age.

11) Do you have reports or other organized data about water quality, temperature, hydrology, wildlife usage, other beneficial uses, etc. for the Mad River watershed assessment? If so, could these be made available to us to include and reference?

Water quality has improved but slowly.
Elk have been introduced by the Department of Fish and Game and are becoming overstocked.
Geese are showing up.
There are more salmon and steelhead.

12) If you work within more than one subwatershed or mainstem segment (upper, middle and lower), have you noticed any differences in water quality, pollutants/ stressors, temperature, etc? (*Please see the attached map for reference.*)

Only one – middle.

13) Do you have any recommendations for other sources of information? This could be a state or federal agency contact, a specific landowner, etc.

Federal study on Butler Valley Dam.
Any Indian records.

14) What else would you like us to know?

The watershed assessment can be a co-op effort and should be. How the report is written and implemented is very important. It does not have to be abrasive.

15) Please share any specific experiences or beliefs that you have regarding the Mad River Watershed, which could encompass broad topics relating to land use, hardships, obstacles, conditions, and desires relevant to your relationship/presence in this region.

Ranchers and timberowners love the river and lands and though education are taking pretty good care of both as opposed to the past.

I believe that 70% or better of water quality problems are caused by nature. This may be controllable by planting several kinds of vegetation (such as alder, willows and grasses) in slide areas and poor soil conditions.

We have planted willows in an erosion area which solved the problem. Is there a State or Federal agency (such as Americorps or prisoners) to do this work? A plant biologist could need to prescribe the appropriate plant or solution.

Surely logging can continue as it well regulated now as compared to the past.

We all look forward to a clean river, and, this would be fast and inexpensive.

Francis Carrington
May 20, 2008

Appendix C

Comments on Draft Mad River Watershed Assessment.

Appendix C-1. Comments from Stakeholder Advisory Group meetings (verbal comments transcribed).

Appendix C-2. Comments from the CA Department of Fish and Game; responses from Stillwater Sciences team and Redwood Community Action Agency project team.

Appendix C-1.
Comments Received at Stakeholder Advisory Group Meetings During Discussion of the Draft Watershed Assessment.
(verbal comments transcribed)

Aldaron Laird – Commented that the fisheries section indicated that the lower Mad went dry, but to his knowledge both the lower and middle Mad went dry prior to the construction of the dam which managed flow quantity.

Pete Busman and Paul Kraus – Both noted that the Watershed Assessment was conducted in a fair and straightforward manner, and did not “take sides” against any specific user group. Other Stakeholder Advisory Group members agreed with these comments.

Janet Eisener – As the Blue Lake Rancheria’s cultural anthropology staffperson, Janet noted that the management history and population/ human impacts sections of the document were excellent and thorough.

Appendix C-2.
Comments from the CA Department of Fish and Game; responses from Stillwater Sciences team and Redwood Community Action Agency project team.

March 23, 2010

Mr. Craig Benson
Watershed Program Manager
Natural Resources Services Division
Redwood Community Action Agency
904 G Street
Eureka, CA 95001

Subject: Draft Mad River Watershed Assessment Review and Comments

Dear Mr. Benson:

Thank you for the opportunity to comment on the January 21, 2010 Draft Mad River Watershed Assessment (MRWA) prepared for Redwood Community Action Agency (RCAA) by Stillwater Sciences. Our review of the MRWA involved a five person team of coastal CA Department of Fish and Game (CDFG) staff from various disciplines. The attached comments are simply the observations of our local review team, and do not constitute CDFG's approval, support, or endorsement of this draft Mad River Watershed Assessment.

In fact, one team reviewer, a licensed Engineering Geologist took exception with some fundamental components of the document that generates some serious credibility issues, and compromises much of the MRWA. As such it seems critical for the Stillwater Sciences / RCAA team to consider and address these essential issues before considering the other CDFG team comments. Mr. Mark Smelser has provided his concerns via an Interoffice Technical Memorandum to team leads, Scott Downie and Michelle Gilroy. The memo in its entirety, along with the rest of the review team's comments follow immediately below.

If you have any questions or comments, please contact Environmental Scientist, Michelle Gilroy at (707) 441-5791, 619 Second Street, Eureka, California 95501.

Sincerely yours,

Scott T. Downie

Cc: Steve Turek
Fisheries Program Manager

ec: Mss. Jane Arnold, Gayle Garman, and Michelle Gilroy
Messrs. Mark Moore, Mark Smelser, Steve Turek, Scott Downie, Philip Bairrington, Tony LaBanca, and William Condon
Department of Fish and Game
jarnold@dfg.ca.gov, ggarman@dfg.ca.gov, mgilroy@dfg.ca.gov,

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Interoffice Technical
MEMORANDUM

To: Scott Downie and Michelle Gilroy

From: Mark Smelser, CEG 2192
Engineering Geologist
CDFG Region 1

Date: March 23, 2010

Subject: Mad River Watershed Assessment

As per your request, I attempted to review the Mad River Watershed Assessment (Draft Report) prepared by Stillwater Sciences and dated January 21, 2010. I use the word "attempted" because I terminated my review for three reasons; 1) lack of time for a thorough review; 2) possible transgressions with regard to the professional practice of geology; and 3) lack of references.

With regard to reason 1, the Mad River Watershed Assessment (MRWA) relies heavily on the Sediment Source Analysis (SSA) prepared by Graham Mathews Associates in December 2007. Both the MRWA and SSA are very complex with regard to analyses of erosion and sedimentation and a thorough review of the MRWA necessarily requires a thorough review and understanding of the SSA. Unfortunately I simply do not have the time for such an effort at this time. With regard to reason 2 above, the SSA involves the identification, characterization, analysis, and modeling of landslides with the expressed purpose of supporting management and policy decisions related to the mitigation of erosion and sediment discharge. In my opinion, such work falls under the category of "professional geologic work" and should be certified by a Professional Geologist licensed in the State of California. Both the MRWA and SSA are lacking formal certification by a Professional Geologist. As one example, the geologic map provided in the SSA does not include references, faults (of which there are many), or a description of lithologic units. In my opinion, such a map is below the standards of professional practice and undermines the validity of the SSA. With regard to reason 3 above, it is frustrating and essentially impossible to provide a meaningful review of a highly technical document that is lacking references.

In closing, it is my recommendation that the Department of Fish and Game in no way endorse or support the MRWA at this time. It is my opinion that the MRWA is fundamentally flawed in its reliance upon the SSA as well as its lack of certification by a licensed geologist practicing within their area of expertise.

The rest of the coastal MRWA review team's specific comments follow:

Pages 1, 2; Section 1.1: The methods used here are four modules from the Washington State methods with a limited number of key questions to be answered in the assessment. CDFG recommends adding key questions regarding the trends in salmonid populations and their relationship to the instream habitat. Although not part of the Washington methods, amphibian habitat should also be assessed as the Mad River has southern torrent salamander and foothill yellow-legged frogs. If the Washington State methods are to be used, then causal mechanism reports need to be produced to describe impacts and how to address them.

The critical questions need to include an assessment of the water management on instantaneous flow changes from the dam and from the downstream diversion. The effect of loss of flows between the diversion intake structure and the Mad River's confluence with the Pacific Ocean should be analyzed. In particular, what are the effects of managed flows on the estuary and the growth and survival of aquatic species in the estuary?

The Table of Contents and lists of figures and tables make no sense.

The maps, figures and tables should be embedded in the text nearby the textual references to their subjects.

The first section of history, background, and overview is overly long and often redundant. It is also in need of specifics and citations to strengthen the abundant generalities.

The spreadsheet / model on page 92 (sediment delivery hazard) uses three components to arrive at a tons of sediment delivery and a subsequent rating. By using the amount delivered as a rating criterion as well, the model in effect is double dipping. Why not simply compare the Sub-basins by the amount of estimated sediment delivery? Or dump it from the document.

Page 3, Section 1.3.1: Are the tributaries above the dam characterized?

Page 4, Section 1.3.1: Add listed, "CA Species of Special Concern", and nonlisted….add coastal cutthroat trout and other fish species (such as longfin smelt and estuarine species as listed later in the document).

Page 7, Table 1-3: Add 2005 - Coho salmon state-listed as Threatened under CESA. The following 2007 document should read Green Diamond Resource Company Aquatic Habitat Conservation Plan. (This change should be made throughout the document) Additionally, the timeline should also include commencement and scale of logging activities, gravel and water extraction to accurately portray the history of the watershed. Add peak flows in cubic feet per second for the flood years. Add El Nino years. Add 1997, 1999, 2000 – add that these were federal listings under ESA. Also add name of ESU or DPS for each. Add 2004 - CDFG Recovery Strategy for California Coho Salmon published.

Page 10, Section 1.4.2.2: This section describes the development of the watershed. However, it does not detail the hydrologic and geomorphic changes that occurred with land development such as clear-cutting. Typically, historic logging practices led to landslides, channel headcutting, and changes in hydrology. These changes have been described in other watershed assessments and analyses. It might be beneficial to review assessments (NCWAP) and analyses (PALCO) from north coast watersheds to find historic impacts and methods for assessments. See coastalwatersheds.ca.gov

Page 12, Section 1.4.2.3, 2nd Paragraph: Add more specifics regarding hatchery "fish". See CDFG's March1, 2006 Draft Mad River HGMP that is available online. CDFG contact is Philip Bairrington.

Page 12, Section 1.4.3.1: "Anecdotal information from …" The assessment attributes increased turbidity to flooding and storms. However, as previously stated, historic land management practices have been shown in other watersheds to have increased turbidity from increased road systems, landslides, and bank erosion rates and from a modified hydrograph due to channel headcutting and canopy changes. The conclusion that turbidity is caused by flooding and storms is unsupported given the historic management in the watershed, and underlying geology.

Page 14, Section 1.4.3.3, End of 1st Paragraph: It would be appropriate here to mention the most notable changes were in 2000 and 2009 with the Threatened or Impaired Watershed Rules and Anadromous Salmonid Protection Rules, respectively. These were implemented in response to the continued decline in anadromous salmonid populations.

Page 14, Section 1.4.3.4, 2nd Paragraph: Add citation after 1954 study. Recommend expanding hatchery background, noting the hatchery was established as an enhancement facility rather than a mitigation facility. Its purpose initially was to augment salmon numbers for an increased commercial harvest, and to provide enhanced sport fishing opportunities for both salmon and steelhead. Refer to
CDFG's Draft HGMP.

Page 15, 1.4.4.1: "The 1990s saw an increased emphasis on environmental effects, mitigation and responsibility." Is the emphasis on responsibility or protection of the aquatic resources in the Mad River, as they have experienced significant impacts and are, in part, in decline from the impacts?

Page 15, Section 1.4.4.2, 1st Sentence: Delete "released" and replace it with "completed" instead. Also, HCP should be changed to: Aquatic Habitat Conservation Plan (AHCP).

Page 16, Section 1.4.4.2: Reword sentence to read: Present regulatory requirements in the Mad River watershed include those emphasizing road-related protection measures necessary for anadromous salmonids. Extensive fisheries data has also been collected.

Page 16, Section 1.4.4.2: Reword/add the following information to paragraph: In 2008, Green Diamond obtained a consistency determination from the California Department of Fish and Game for protection of coho salmon under the California Endangered Species Act (CESA). Under the consistency determination, Green Diamond Resource Company's AHCP, with minor modifications, was determined to be "consistent" with those measures deemed necessary by CDFG to minimize and fully mitigate impacts to coho salmon associated with Green Diamond's federal incidental take permit.

Page 16, Section 1.4.4.2: Reword and separate this into another paragraph: Non-industrial timber management plans (NTMPs) and individual timber harvesting plans operate under the most recent forest practice rules developed for anadromous salmonid protection. The current rules require that roads are to be constructed and maintained to be "hydrologically disconnected" and as "hydrologically invisible" as possible to minimize sediment-related effects to area waters over the life of the road. The California Board of Forestry is proceeding in 2010 with a revision of the roads sections of the Forest Practice Rules to reflect the best available science and better organize the multitude of road rules sections.

Suggest reword for start of next paragraph: The current Forest Practice Rules specific to listed anadromous salmonids mandate the use of…

Page 16, Section 1.4.4.2, Last Paragraph: Add the word "some" before crossings, and reword the following to read: ….FPRs, pending updating of the FPRs relative to roads,…

Page 16, Section 1.4.4.2, End of Last Sentence: Replace "has been" with "is being" realized…

Page 16, Section 1.4.4.3: Recommend mentioning CDFG Code 1600 is required for instream work such as gravel extraction, water diversions, or modification of the bed, bank, or channel. The Coho Recovery Strategy (DFG 2004) is a document that affects the Mad River and as such should be included in this document. This section fails to describe the effects of surface erosion from timber harvest and other activities, and anthropogenic effects on the rate of mass wasting in the watershed.

Page 16, Section 1.4.4.3, End of First Paragraph. Add the following sentence: Coho salmon were listed as threatened under the California Endangered Species Act (CESA) in the Mad River watershed (part of the Northern California/Southern Oregon ESU) on March 30, 2005.

Page 17, Section 1.4.4.4: Adding comprehensive list of fisheries restoration projects in the Mad River is recommended, and is available upon request, from CDFG's Fortuna office.

Page 17, Section 1.4.4.4, Near End of 1st Paragraph. Correction: Change "CA Department of Fish and Game" to California Department of Fish and Game.

Page 17, Section 1.4.5.3: This section does not discuss the effects of regulated flows from the dam on instream habitat and geomorphology for aquatic species habitat and movement of wood and gravel in the mainstem Mad River. A discussion of diversions from tributaries and their effects should also be included. The last statement in this section needs to be supported with some observations of improvements.

Page 19, 2nd Paragraph, 1st Sentence: Define "seasonal" estuary.

Page 19, Figure 1: Ruth Lake (or Matthews Dam) and Cowan Creek should be identified on the graph since discussion refers to each. Along with Maple, Bug, and others….

Page 20, Table 2-1: The title of table is Tributary Channel…Shouldn't the Upper Mad and Middle Mad River sections have more tributaries listed? Is the 80.6 miles accurate for Powers Creek?

The criteria for demarking the several sub-basins should be clear. As is, they overlap and are very inconsistent in size, which makes it confusing. A map with river miles and landmarks would help. Sub-basins should be constituted on commonality of basic watershed attributes like aspect, climate, geology, vegetation, biology, landuse, etc. See coastalwatersheds.ca.gov

Page 23, Section 2.2.2: The assessment quotes that a net benefit results from increased flows in the summer to offset adverse impacts. However, there is no support for this conclusion. Many streams were naturally low flow. The aquatic resources have evolved with this hydrologic regime (e.g., dam impacts to upper Trinity, Russian rivers, etc.). Increasing summer flows at the expense of winter flows may be an impact that has not been analyzed. Until data can be shown to support the conclusion that more summer flows offset impacts, the conclusion should be modified to say the hydrology is changed and the impacts or benefits are not fully assessed at this time.

Page 33, 3.2.1: Is the landslide mapping from Green Diamond Company available now?

Page 35, Table 3-3: The assessment needs to clearly identify how background soil creep was determined. Typically, natural inputs are the natural soil creep rates (usually assumed to 1-2 mm per year) times twice the lineal stream distance in the watershed and natural mass wasting events. However, soil creep can be overestimated by including bank erosion in a managed system. Bank erosion and mass wasting would be expected to be higher in a system with timber and other management, thus, assuring the natural verses anthropogenic input are clearly identified are important to having an accurate sediment budget.

Page 36, Section 3.2.2: The assessment needs to clarify if bank erosion is from anthropogenic sources (e.g., increased erosion or mass wasting from management activities) or if it is actually natural soil creep.

Page 38, Table 3-4: Other assessments have shown a higher density of road and typically average 7-10 road miles per square mile. Were all spur and other less used roads accounted for?

Page 39, Table 3-5: Are only timber roads included or are rural residential and county roads and Highway 299 accounted for? These roads will have the same rate of input and could be a significant source of surface erosion in the watershed. Highway 299 has inboard ditches and other sources of sediment.

Page 47, Table 3-8: Background soil creep is not a landslide form and should be separate. Also, soil creep is expressed in the stream as bank erosion, so having both soil creep and bank erosion could be counting the same input unless bank erosion is considered to be from anthropogenic impacts.

Pages 49, 50; Section 3.4.2: Add distances of each reach.

Page 49, Section 3.4.2.1: Add citations to this paragraph.

Page 57, Section 4.1, First Paragraph: Does the WAU include the estuary? See page 89. Add Humboldt Sucker (*Catostomus occidentalis humboldtianus),* occasional sockeye salmon, northern red-legged frogs, tailed frogs, western pond turtles. Estuarine species are described on Page 89 and not here. Longfin smelt, green sturgeon, etc…

Page 57, Section 4.1.1: All listed salmonid sections should have their federal and state listing status disclosed in section titles/headers. Last sentence should start with Chinook salmon rather than "These".

Page 57, Section 4.1.1: Suggest consistent use of CDFG instead of "the CDFG" throughout document.

Page 58, Section 4.1.1: CDFG has additional data for Canon Creek and mainstem Mad River in the Eureka office fisheries files.

Page 59, Section 4.1.2: Additional coho salmon tributaries: Black (Black Dog), Blue slide, Boulder, Camp Bauer (aka Hatchery Creek), Dry, Grassy, Kelly, Mather, Noisy, Powers, Squaw, Sullivan Gulch, Warren Creeks (per Draft CDFG North Coast CA Coho Salmon Investigation, Jong et al, 2008. Available upon request from CDFG's Fisheries Branch, Kevin Shaffer).

Page 60, Section 4.1.3: Recommend disclosure on stocks of steelhead introduced into the Mad River (e.g. Washougal River summer steelhead in 1970s).

Page 60, Section 4.1.3: More long term summer steelhead data is available from CDFG fisheries files. Add Mark Zuspan's (CDFG) 2008 survey results into graph, etc…

Page 61, Section 4.1.3: The Mad River Hatchery was established as an enhancement hatchery to supplement ocean stocks to catchable levels, as well as provide for river sport fishing. See Draft 2006 Mad River Hatchery Genetic Management Plan located on CDFG's web site. Or contact Philip Bairrington at CDFG's Arcata office.

Page 62, Section 4.2: First bullet, second sentence should state "most" steelhead rather than "but not steelhead".

Page 62, Section 4.2: Insert (Ruth Lake) after Matthews Dam in the man made barriers section.

Page 62, Section 4.2. Insert the following sentence as the last sentence in this section: The California Forest Practice Rules require any road used for timber operations that is a barrier to anadromous salmonids be removed, repaired, or replaced with a crossing that provides for unimpeded up- and downstream movement by fish at all times. This is required of new timber harvesting plans and nonindustrial timber management plans.

Page 63, Section 5.1: Last sentence. Specify date/s for very recent?

Page 64, Section 5.2.1.1, First Two Sentences of First Paragraph: First sentence should begin "There is" rather than "There was". Tributary should be corrected to "tributaries" in the second sentence.

Page 65, Section 5.2.2.2: 3rd sentence needs correction: This sub-basin is upstream of the upper limit of salmonid distribution and supports steelhead and resident rainbow trout (?).

Page 66, Section 5.2.2.2. Suggested reword: Pilot Creek may be the only "major" tributary "with substantial reaches" suitable for steelhead spawning and rearing "for" 40 miles….

Page 66, Section 5.2.2.2: There may be many small tributaries to the Mad River in this reach that have short sections of anadromy near their confluences with the Mad River.

Page 68, Section 5.2.3.1: Were the stream lengths surveyed by BLM and CDFG the same? What were stream inventory methods used? Were they the same methods? Recommend added columns (stream length surveyed, who surveyed) to all stream habitat tables.

Page 68, Section 5.2.3.1, Table 5-2 and paragraph above: When (what months?) were the water temperatures recorded between 1994 and 2007?

Page 69, Section 5.2.3.2: Two different lengths of stream were surveyed. Were the methods used the same? End of 2nd paragraph: delete the word "compared". Suggest replacing it with "are presented". Data are not comparable. This is true for the rest of the sections that compare or suggest that habitat improved or degraded. Variability between different surveyors (and methods?) is normally too high for comparisons such as this.

Page 69, Section 5.2.3.2, Last Paragraph: When were temperatures recorded?

Page 71, Section 5.2.3.3: Can the LWD survey results be compared when there was such a difference in lengths of stream surveyed?

Page 71, Section 5.2.3.3, Table 5-7: "4093 and 4300" should be defined as locations.

Page 72, Section 5.2.3.3, Last Paragraph: Again, comparison of data from 1988 by RCAA to 2005 by Green Diamond Company is probably not valid. Different stream lengths were surveyed as well.

Page 74, Section 5.2.3.4: When (what months?) were water temperatures recorded?

Page 89, Section 5.2.3.8, 2nd Paragraph: Should also list the common surfperches, longfin smelt, etc…

Page 89, Section 5.2.3.8, 4th Paragraph: Note: Widow White Creek is somewhat unique in that it is more accessible to anadromous salmonids when it is captured by and tributary to the Mad River. At other times, Widow White flows directly to the ocean, but often surface flow does not persist as a passable channel due to its running subsurface into the beach sands before discharging to the sea.

Page 89, Section 5.2.3.8, Last Paragraph: The culvert under Highway 101 was baffled. Suggest contacting Tim Ash at CALTRANS to determine exact nature of improvement and date improved. Also, add date coho salmon were observed.

Page 90, Section 6.1: This section seems to be lacking explanation of the impacts, the causal mechanisms of the impacts, and what can be done to remediate them.

Page 97-102, Section 6.4: The key questions are limited in scope and do not encompass the full range of impacts/resources of concern. There needs to be more discussion of impacts and remediations.

Page 100, Section 6.4, 2nd Paragraph: Suggest separating this into more paragraphs.

Page 102, Section 6.4, 2nd Paragraph: Delete the word "analysis". This is an assessment, not an analysis.

Incorporation of these comments does not constitute CDFG's approval or disapproval of this draft Mad River Watershed Assessment.

April 20, 2010

Michelle Gilroy
CA Dept. of Fish and Game
619 Second St
Eureka, CA 95501

Re: Response to DFG Comments of the Mad River Watershed Assessment

Cc: Scott Downie

Dear Ms. Gilroy:

The Redwood Community Action Agency (RCAA), including our science team comprised of Stillwater Sciences and NRM Corporation, and our 28-member Stakeholder Advisory Group wish to thank the California Department of Fish and Game (DFG) staff for reviewing and providing comment the DRAFT Mad River Watershed Assessment (MRWA).

We received the following from DFG:

- 1-page cover letter from Scott Downie
- 1-page Interoffice Technical Memorandum from Mark Smelser
- 7 pages of comments on the DRAFT MRWA

I would like to take this opportunity to give you our general response and select detailed responses to some of DFG's comments, as well as an additional response from Stillwater Sciences. I would also like to discuss how I think DFG can be most helpful to this project in the future.

General Response
DFG has a very knowledgeable and technical staff who brought a lot of experience to this review. While there were very many useful comments and thoughtful questions provided by DFG staff, it became readily apparent in reading the comments that some of the staff reviewing the DRAFT WA did not have a sufficient background on the specific goals of this WA nor a good understanding of the scope of the investigation. It seemed likely that staff were not provided with parameters to conduct a focused review nor had adequate time to provide the type of review that would have been most helpful to RCAA, the science team, and SAG. In general, we were somewhat dismayed that DFG staff appeared to treat this more like a regulatory exercise or an after-the-fact peer review of the WA, rather than an opportunity for input as an interested stakeholder and SAG member.

From our perspective the overall review, particularly when front-end loaded with Mr. Downie's letter and Mr. Smelser's interoffice technical memorandum, was bluntly accusatory about the credibility of the WA and, by inference to Graham Mathews Sediment Source Analysis, demeaned the entire federal and state TMDL efforts to maintain beneficial uses of water in the Mad River. The review did not read as input and recommendations from a long-standing collaborator in the project. It read, in places, as an opportunity for some staff to express opinions about particular pet issues, some of them well out of scope of this WA. Despite DFG's obvious good intentions, some individual review comments were not aligned with, or germane to, the scope of this watershed assessment. Palpable was the absence of a single positive comment.

Missing was a single word of collaborative encouragement for finally initiating something we all have long worked towards: a community-based assessment of one of our County's key watersheds in order to develop a management plan to better protect its beneficial uses and aquatic resources.

DFG's Role
Please recall the genesis of the Mad River Watershed Management Plan project and DFG's role in it:

1. For several years RCAA, DFG, and Regional Board staff had been lamenting together about the "orphan" Mad River needing watershed assessment and the long-overdue TMDL. In 2005 RCAA applied for a grant to perform a water quality-focused assessment and help landowners comply with the anticipated TMDL. At that time, DFG was already talking about doing a separate "fish-centric" watershed assessment of the Mad River, so we intentionally kept the scope of our watershed assessment to sediment sources, water quality, and human management activities that affect those parameters. Hence, the general comments from DFG that our assessment focused too much on human history (management) and sediment and not enough on habitat assessment and aquatic species (fish & amphibians) other than salmonids was a foregone conclusion discussed with DFG informally since 2005. It was always our understanding that DFG will be making those more focused habitat and species assessments. As it was fish spawning and rearing were featured to a greater degree in our assessment than other beneficial uses of water.

2. The EPA came out with Graham Mathews Sediment Source Analysis (SSA) and the TMDL early on in the life of this project. The appropriate time and persons for Mr. Smelser to address perceived shortcomings to the SSA and TMDL were with the EPA and SWRCB back in 2007-08. The TMDL has been finalized and we are assisting landowners to comply with a *fait accompli*, a done deal. I believe that our WA succeeds in prioritizing sub-watersheds in order to guide landowner decisions about where to apply BMPs whereas the upcoming Management Plan will direct landowners as to what BMPs to apply.

3. Once RCAA received a grant award in 2007 to start this project, DFG was asked and accepted to be on our Stakeholder Advisory Group, the equivalent of a Technical Advisory Committee. The SAG met at the outset of this process to discuss the methodology to be used, to develop the key questions for the WA, and provide background data and reference documents. We continued to meet at every key juncture to present results and review the DRAFT WA. So current comments from DFG recommending alternative assessment methods, additional key questions to be asked, suggesting more recent fish studies be incorporated, and so on, are coming too late in the process to be incorporated. Many DFG comments that do not require an overhaul of the WA are being incorporated into the final version now.

4. The DRAFT WA was made available to DFG's representative on the SAG for four weeks prior to making it available to the general public. It was felt that this was adequate time for SAG review. The fact that DFG staff did not have time to get to it until the last minute is regrettable but out of our control.

As shown above, the context for DFG's involvement in this project has been set for a some time as an intimate team member and collaborator. That is why we are taken aback by a portion of the review comments, particularly those from Mr. Smelser, which the science team felt were misaligned with DFG's role, often pontifical, and, in places, so erroneous that Stillwater Sciences also felt compelled to provide DFG with an additional attached response.

Detailed Responses
I will address just a few of DFG's many comments in aggregate:

- Thank you for immediately catching several document errors, e.g. TOC format and lack of bibliography. Opening the document on some PC's caused the table of contents pagination and some document formatting to be lost. We should have posted it as an pdf file rather than as a word file. The WA is based on thorough review of all existing information, as well as gray literature, and interviews of landowners and land managers. Although the document extensively cites information where necessary, we regret that due to scheduling and budgetary constraints imposed by the freeze on state funding for the project in 2009, the draft watershed assessment was released to the Mad River advisory group for comment without a list of references. The complete list of references is now included in the draft document.

- We greatly appreciated comments that added to our events timeline, elucidated hatchery history, fine-tuned regulatory language, and added details about fisheries surveys/studies and projects. Many of these are being incorporated into the FINAL DRAFT WA. We will not be going into the level of detail on fish and amphibian species as recommended from some reviewers as this is getting away from our sediment-centric WA and into the fish-centric WA that DFG is planning. Also we collected existing information up to early 2008 and drew the line in time there. We will not be incorporating Mark Zuspan's 2008 survey results into the WA. In any event, up-to-date fish abundance data were not nearly as important to this WA as was the species distribution and composition information, which DFG augmented with the comments.

- We will, of course, make grammatical corrections your reviewers spotted and consider paragraph splitting and other word-smithing recommendations. Thanks!

- DFG's review was quite front-loaded. Comments were many in the introduction, moderate in the technical sections, and very light in the synthesis. We would love for that to be reversed since the real heart of the WA lies in the synthesis and the useful tools are also in the synthesis. As it was, the first three pages of comments address the Introduction (Pages 1-19 of the WA). Most of these early comments point out deficiencies in detail or ask questions that are addressed in the latter technical sections (Chapter 2, 3, and 4) that would not be appropriate for an introduction of the WA. This pattern of asking questions that are answered later continues throughout the review. It would have been nice if the reviewers would have gone back and deleted these negative comments after getting the detail, having the question answered, or viewing the figure later in the WA. It makes us question if some of the reviewers actually read the whole WA, skimmed, or jumped around to sections that interested them.

- Some reviewers rightly wanted to read about impacts and remediation methods. Treatment recommendations do not appear in this WA. This WA is leading to a stand-alone Mad River Watershed Management Plan which will basically be a comprehensive BMP guide by land use.

We are delighted to have DFG's continued participation on the SAG. We apologize that one critical meeting in which the DRAFT WA was presented to the SAG occurred on a DFG work furlough day because it was the best day for the majority of the SAG. Nonetheless, project involvement still offers DFG the opportunity to join us in helping Mad River landowners to maintain and enhance beneficial uses of waters of the Mad River which will also support DFG's mission to protect riparian and aquatic habitats and species. We still have the Watershed Management Plan, Monitoring Plan, and Mad River Symposium to produce over the coming months. Let me know if there is a way to better involve DFG staff in a manner that is more positive and gratifying for you and us.

Sincerely,

Craig Benson, Watershed Program Manager
Natural Resources Services Division of RCAA

Stillwater Sciences

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12 April 2010

Mr. Scott Downie
California Department of Fish and Game
1455 Sandy Prairie Ct.
Fortuna, CA 95540

Dear Scott,

We thank CDFG staff who provided comments on the Draft Mad River Watershed Assessment, many of which resulted in substantive improvements to the assessment. The Redwood Community Action Agency has prepared a general response to CDFG comments, and we respond herein specifically to Mr. Smelser's comments included in his interoffice technical memorandum to Scott Downie and Michelle Gilroy dated 23 March 2010. We believe the information provided in this response is necessary to correct misstatements that cast inappropriate doubt on the credibility of the Mad River Watershed Assessment.

Mr. Smelser stated that "both the MRWA (Mad River Watershed Assessment) and SSA (Mad River Sediment Source Assessment) are lacking formal certification by a Professional Geologist." The Mad River SSA was conducted for the Mad River Total Maximum Daily Loads for Sediment and Turbidity (TMDL)(EPA 2007) by Graham Matthews & Associates under the direction of Jim Fitzgerald, a Certified Engineering Geologist in the State of California (CEG #2436). Mr. Fitzgerald is identified on the acknowledgements page of the final SSA as the project manager with his CEG number. The Mad River TMDL underwent a formal review process by state and federal agencies with certified Professional Geologists and Engineering Geologists on staff. The final document was formally adopted on 10 January 2010.

At this time, the draft Mad River Watershed Assessment does not require formal certification by a Professional Geologist. The draft watershed assessment is a synthesis of existing information related to sediment delivery, transport, and storage. The draft watershed assessment was provided to the Mad River advisory group for voluntary, non-binding comment and has not been made available to the general public, and as such it is clearly exempt from the requirements of professional licensure. If and at such time as the Mad River Watershed Assessment is made final, is provided to the public, and its contents require formal certification by a Professional Geologist, the document will be stamped by the Professional Geologist at Stillwater Sciences (Derek Booth, PhD, PG (CA #8402; WA #195) who has overseen the work.

Mr. Smelser stated that it is "essentially impossible to provide a meaningful review of a highly technical document that is lacking references." Although the document extensively cites information where necessary, we regret that due to scheduling and budgetary constraints imposed by the freeze on state funding for the project in 2009, the draft watershed assessment was released to the Mad River advisory group for comment without a list of references cited. The complete list of references cited will be included in the final document. There is no question that the absence of references hinders a

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comprehensive review, but we regret not benefitting from *any* such input at this phase of document development.

Thank you for the opportunity to respond to CDFG comments. We hope the information provided in this response clarifies any misunderstanding.

Sincerely,

Dennis Halligan
Fisheries Biologist

cc. Michelle Gilroy, CDFG