CHAPTER 1. INTRODUCTION

1.1 Overview and Geographic Scope of TMDL

The Shasta River Total Maximum Daily Loads (TMDLs) for Temperature and Dissolved Oxygen are being established in accordance with Section 303(d) of the federal Clean Water Act (CWA). The State of California has determined that the water quality standards for the Shasta River are not being achieved due to elevated water temperature and organic enrichment/low dissolved oxygen concentrations. In accordance with CWA Section 303(d), the State of California periodically identifies those waters that are not meeting water quality standards. The United States Environmental Protection Agency (USEPA) added the Shasta River watershed to California's 303(d) List of Impaired Waters (303(d) List) in 1992 due to organic enrichment/low dissolved oxygen and in 1994 due to elevated temperature. The Shasta River watershed has continued to be identified as impaired in subsequent 303(d) listing cycles, the latest in 2002. These listings of the Shasta River watershed apply to the Shasta River from its mouth to headwaters, and include all tributaries and Lake Shastina.

Elevated water temperatures and low dissolved oxygen levels in the Shasta River and its tributaries have resulted in the impairment of designated beneficial uses of water and the non-attainment of water quality objectives. The primary adverse impacts of elevated water temperature and low dissolved oxygen in the Shasta River and its tributaries are associated with cold water fish. The cold freshwater habitat beneficial use includes the migration, spawning, reproduction, and early development of cold water fish including coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*O. tshawytscha*), and steelhead trout (*O. mykiss*). The coho salmon population in this watershed is listed as threatened under the federal Endangered Species Act and the California Endangered Species Act. Elevated water temperatures and low dissolved oxygen levels may also affect recreational use, subsistence fishing, and commercial and sport fishing uses. Additionally, elevated water temperatures may be linked to impairment of the municipal and domestic water supply beneficial use of Lake Shastina.

1.2 Report Organization

The Shasta River TMDL is comprised of two distinct parts: the Staff Report and the Action Plan. This document is the Staff Report that supports and justifies the Action Plan. The content of each chapter in this Staff Report are outlined here:

- Chapter 1- Regulatory framework and watershed overview
- Chapter 2 – Temperature and dissolved oxygen conditions of the Shasta River watershed
- Chapter 3 – Factors affecting temperatures of the Shasta River watershed
- Chapter 4 – Factors affecting dissolved oxygen concentrations of the Shasta River watershed
- Chapter 5 – Analytical methods and approach
- Chapter 6 – Temperature TMDL and load allocations
- Chapter 7 – Dissolved oxygen TMDL and load allocations

- Chapter 8 - Implementation strategy
- Chapter 9 - Monitoring plan
- Chapter 10 – Reassessment
- Chapter 11 – Antidegradation analysis
- Chapter 12 – Environmental analysis
- Chapter 13 - Economic analysis
- Chapter 14 – Public participation process

The full title of the Action Plan is the *Action Plan for the Shasta River Temperature and Dissolved Oxygen Total Maximum Daily Loads*. The Action Plan, hereinafter known as the Shasta River TMDL Action Plan, includes the temperature and dissolved oxygen TMDLs and is based upon the information presented in the Staff Report. The Shasta River TMDL Action Plan is proposed as an amendment to the *Water Quality Control Plan for the North Coast Region* (Basin Plan) for adoption by the North Coast Regional Water Quality Control Board (Regional Water Board) and approval by the State Water Resources Control Board (State Water Board), Office of Administrative Law (OAL), and the United States Environmental Protection Agency (USEPA).

1.3 Regulatory Framework and Purpose

The Regional Water Board is the California State agency responsible for the protection of water quality in the Shasta River Basin. The North Coast Regional Water Board is one of nine Regional Water Boards that function as part of the California State Water Board system within the California Environmental Protection Agency. The Regional Water Board implements both the Porter-Cologne Water Quality Control Act, part of the California Water Code, and the federal Clean Water Act. Water quality standards and control measures for waters of the North Coast Region are contained in the *Water Quality Control Plan for the North Coast Region* (Basin Plan).

1.3.1 Clean Water Act Section 303(d)

Under CWA Section 303(d), states are required to develop a list of water bodies where technology based effluent limits or other legally required pollution control mechanisms are not sufficient or stringent enough to meet water quality standards applicable to such waters. The 303(d) List also identifies the pollutant/stressor causing the impairment, and establishes a prioritized schedule for addressing the water quality impairment. Placement of a water body on the 303(d) List acts as the trigger for developing a pollution control plan, called a Total Maximum Daily Load (TMDL), for each water body-pollutant/ stressor combination and associated pollutant/stressor on the 303(d) List. The TMDL serves as the means to attain and maintain water quality standards for the impaired water body. The specific requirements of a TMDL are described in the United States Code of Federal Regulations (CFR) Title 40, Sections 130.2 and 130.7 (40 CFR § 130.2 and 130.7), and Section 303(d) of the CWA.

In California, the authority and responsibility to develop TMDLs rests with the Regional Water Boards. The USEPA has federal oversight authority for the CWA Section 303(d) program and may approve or disapprove TMDLs developed by the state. USEPA Region

9 is responsible for the North Coast region of California. If the USEPA disapproves a TMDL developed by the State, the USEPA is then required to establish a TMDL for the subject water body.

1.3.2 California Porter-Cologne Water Quality Control Act

In California, the Porter-Cologne Water Quality Control Act (California Water Code, Division 7, Water Quality) requires a program of implementation for a TMDL to be included into the Basin Plan (CWC § 13050(j)(3)). This program of implementation must include a description of actions necessary to achieve Basin Plan water quality objectives, a time schedule for specific actions to be taken, and a description of monitoring to determine attainment of objectives.

In March 1997 US EPA signed a consent decree addressing 17 rivers in the California North Coast, including the Shasta River (*Pacific Coast Fisherman's Association et al. v. EPA*). Under the terms of the consent decree, a court-ordered schedule for completing TMDLs for these rivers was developed. The schedule requires approval of the Shasta River TMDLs by January 2007.

1.3.3 Endangered Species Act Consultation

The USEPA and the Regional Water Board have initiated an informal consultation process with the U.S. Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration, Fisheries (NOAA Fisheries) on Klamath River Basin TMDLs, including the Shasta River. Regional Water Board and USEPA staff have used this process to provide information and updates on the TMDLs in the Klamath Basin, namely the Salmon, Scott, Shasta, Lower Lost, and Klamath River TMDLs. In addition, both NOAA Fisheries and the USFWS have participated in the Shasta River TMDL Technical Advisory Group (see Section 1.3.6) meetings.

1.3.4 What is a TMDL?

A TMDL is a planning and management tool intended to identify, quantify, and control the sources of pollution within a given watershed such that water quality objectives are achieved and the beneficial uses of water are fully protected. A TMDL is defined as the sum of the individual waste load allocations to point sources, load allocations to non-point sources and natural background loading. The amount of pollutant that a water body can receive without violating the applicable water quality objectives is the loading or assimilative capacity of the water body, and is calculated as the TMDL. Loading from all pollutant sources must not exceed the loading or assimilative capacity (TMDL) of a water body, including an appropriate margin of safety.

1.3.5 Purpose and Goals of the Shasta River TMDL Action Plan

The purpose of the Shasta River Temperature and Dissolved Oxygen TMDLs is to estimate the assimilative capacity of the system with respect to the total thermal, nutrient and oxygen-consuming loads that can be delivered to the Shasta River and its tributaries without causing an exceedance of water quality standards. The TMDLs then allocate the total loads among the identified sources of these pollutants in the watershed. Although factors other than elevated stream temperature and low dissolved oxygen in the watershed may be affecting cold water fish related beneficial uses and thus affecting salmonid populations (e.g., climate change and ocean conditions), these TMDLs focus only on stream temperature and dissolved oxygen conditions in the watershed; the impairments for which the Shasta River is listed under CWA Section 303(d).

The Action Plan component of the TMDL outlines a strategy to meet the TMDL loading allocations. The goal of the Shasta River TMDL Action Plan is to achieve the temperature and dissolved oxygen water quality objectives, and restore and protect the beneficial uses of water in the Shasta River watershed. TMDL Action Plans apply to those portions of the watershed governed by California water quality standards, and do not apply to lands under tribal jurisdiction.

1.3.6 Public Participation

The public was involved during the development of the Shasta River TMDL in several ways. Regional Water Board staff met with key stakeholder groups, including the Shasta Valley Resource Conservation District (SVRCD), Shasta River Coordinated Resource Management Planning Council, Siskiyou County Board of Supervisors, and the Klamath Basin Fisheries Task Force (KBFTF). In addition, Regional Water Board staff met with individual property owners upon request. The purpose of these meetings was to provide information on the TMDL development process and approach, to update the groups on the status of TMDL development activities, and to answer questions. Regional Water Board staff also regularly attended the public meetings of the Shasta-Scott Coho Recovery Team to assure that recommendations regarding coho salmon recovery were consistent with the TMDLs.

In January 2003, Regional Water Board staff organized the Shasta River TMDL Technical Advisory Group (TAG). The TAG was composed of individuals familiar with the water resources of the Shasta Valley including landowners and representatives of irrigation districts, municipalities, resource management agencies, tribes, and regulatory agencies. The purpose of the TAG is to advise Regional Water Board staff on issues relating to the development of the Shasta River TMDLs.

1.4 Watershed Overview

1.4.1 Area and Location

The Shasta River drains a 795 square mile basin in northern California, within Siskiyou County, and flows generally northward into the Klamath River (Figure 1.1 and Figure 1.2). The Shasta River watershed is bounded to the north by the Siskiyou Range, to the west by the Klamath Mountains, to the east by the Cascade Range, and to the south by Mt. Shasta and Mt. Eddy (SVRCD Undated). The watershed shares divides with the Scott River to the west, Butte Creek to the east, and the Trinity and Sacramento Rivers to the south.

1.4.2 Population

The population of the Shasta River basin is estimated at about 16,000. The majority of the population in this basin is centered around towns including Yreka, Weed, Montague,

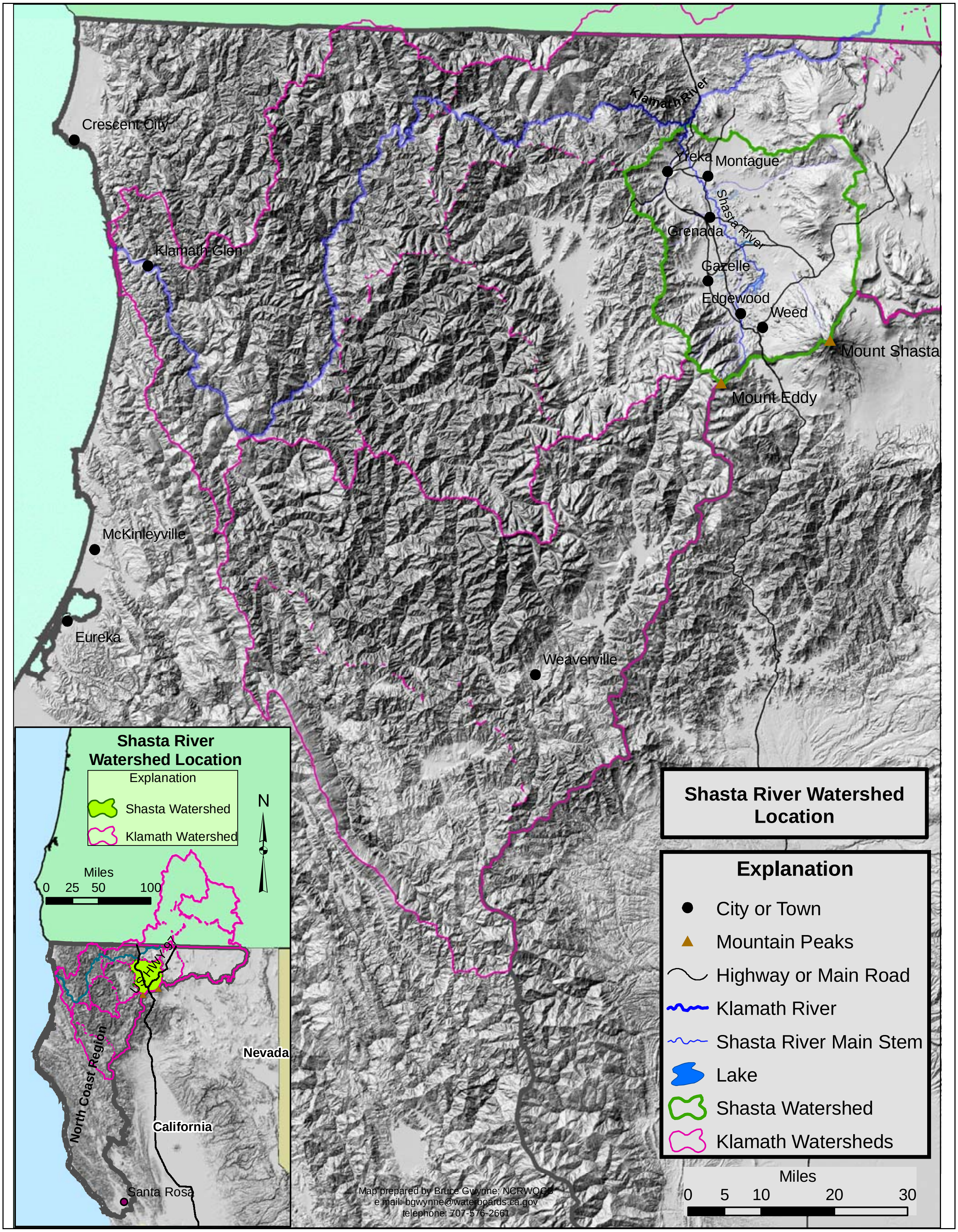

Figure 1.1: Shasta River Watershed – Location

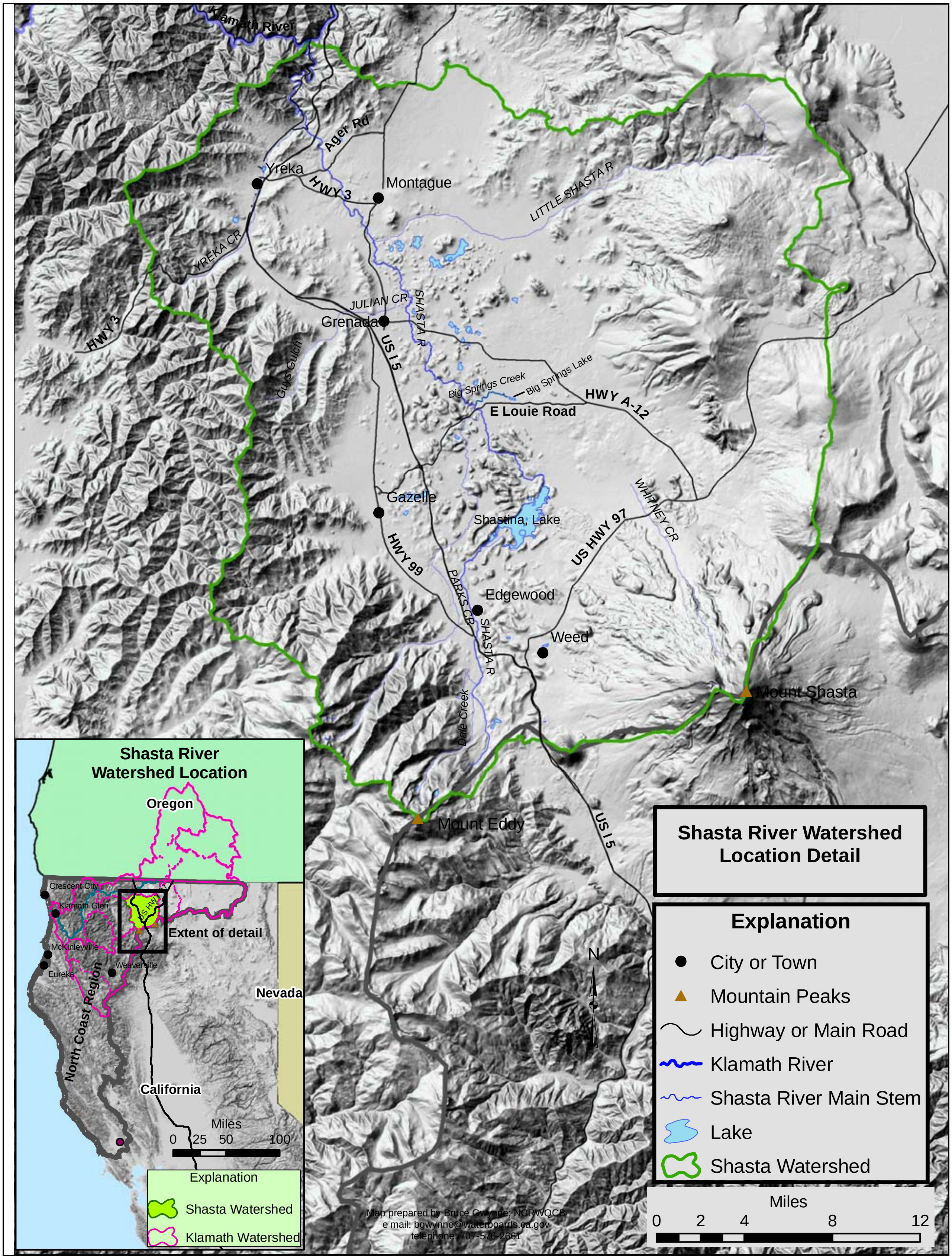

Figure 1.2: Shasta River Watershed – Location Detail

Grenada, Gazelle, and Edgewood. The largest town in the basin is Yreka, with a population of 7,290 according to 2000 census information (United States Census Bureau [USCB] Undated). This census estimated the population of Weed at 2,978 people, 1,456 people in Montague, 315 in Grenada, 136 in Gazelle, and 67 in Edgewood (USCB Undated).

1.4.3 Climate

The Shasta River basin is predominantly a low rainfall, high desert environment characterized by hot, dry summers and cool winters (Ouzel Enterprises 1991, p.1-5; SVRCD Undated). Temperatures range from above 100°F in the summer to below freezing in the winter. Typically there are about 130 frost-free days a year (SVRCD Undated).

Annual mean precipitation in the basin ranges from a low of 2.5-9 up to 85-125 inches, with much of the winter precipitation falling as snow (Figure 1.3). Average annual precipitation can reach 45 inches in the Eddy and Klamath Mountains and ranges from 85-125 inches at Mt. Shasta. Although average rainfall is high in the mountains, moist air masses are stripped of their water as they move eastward from the Pacific and climb over the Klamath Mountains (Klamath Resource Information System [KRIS] 2005). Thus, the Shasta Valley is in the rain shadow created by these mountains and receives as little as 2.5-9 inches of precipitation annually.

1.4.4 Topography

The watershed consists of two major types of topography, the low-gradient floor of the Shasta Valley, and surrounding steep mountains, punctuated by Mt. Shasta at the southern border of the Basin (Figure 1.4). The river drops about 220 feet in elevation in the valley. Throughout the valley are small hillocks that are deposited debris from a huge avalanche and debris flow that occurred more than 300,000 years ago (Crandell 1989). In the canyon section of the watershed, downstream of the valley, the Shasta River descends approximately 370 feet in approximately 7 miles to its confluence with the Klamath River. Watershed elevations range from approximately 2020 feet at the confluence with the Klamath River to a peak elevation of 14,200 feet at the summit of Mt. Shasta (KRIS 2005; SVRCD Undated).

1.4.5 Water Bodies and Hydrology

The Shasta River originates in the Scott Mountains on the north slope of Mt. Eddy as a precipitation and snow melt based stream. Mt. Shasta contributes significantly to the hydrology of the basin. With an elevation exceeding 14,000 feet, Mt. Shasta has permanent (and growing) glaciers, which provide a constant source of surface and spring flows. The melted snow percolates down through lava tubes on the mountain and pops up as springs on the Shasta Valley floor. These springs and others in the Little Shasta River watershed, along with mountain precipitation, are the source of flow in the Shasta River.

The predominantly volcanic groundwater units in the basin provide storage and recharge areas both inside and outside the basin. Due to the complexity of this extensive network of volcanic recharge/storage areas, however, the amount of groundwater in storage has not been estimated (Department of Water Resources [DWR] 2004).

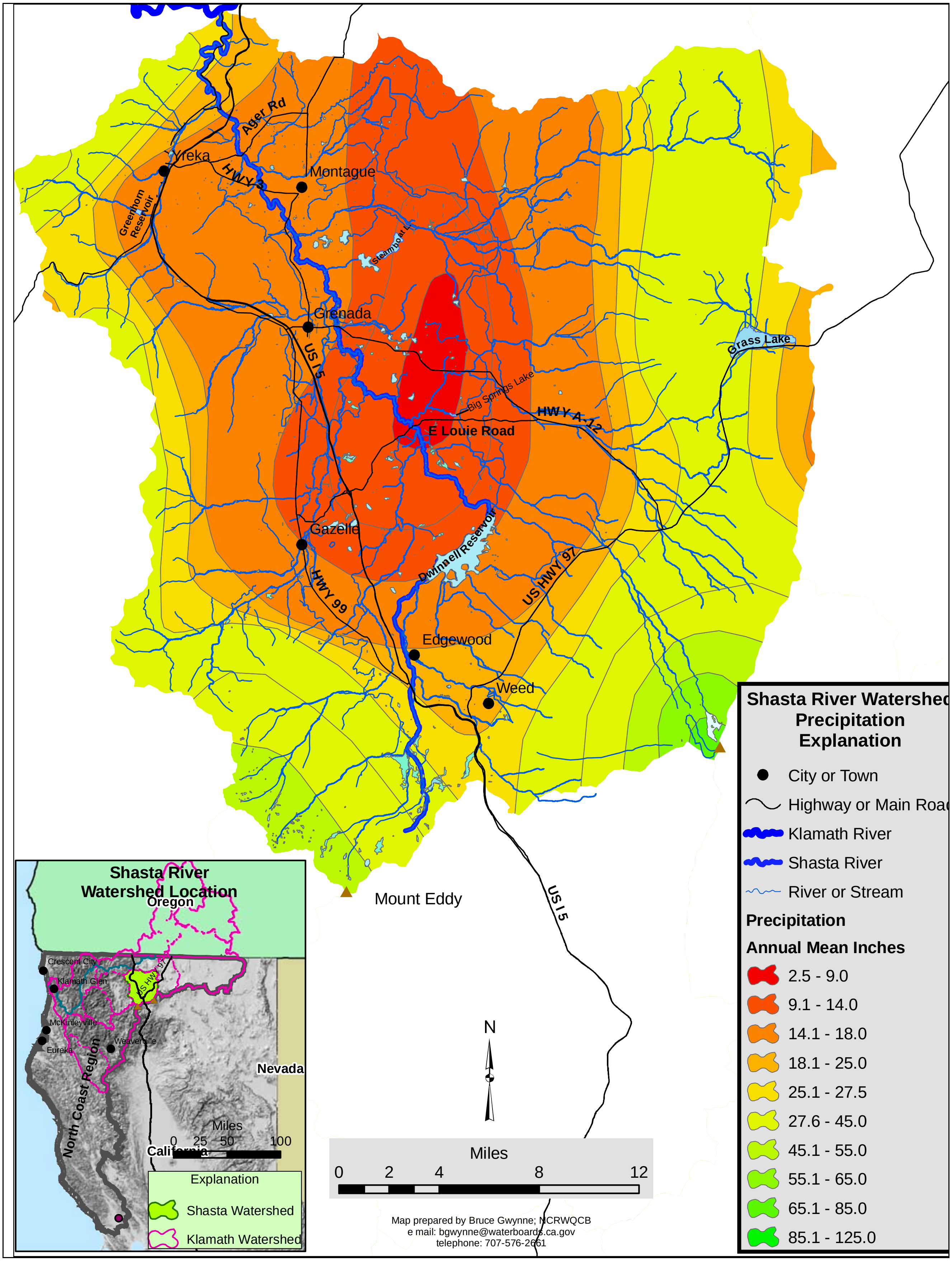

Figure 1.3: Shasta River Watershed - Rainfall

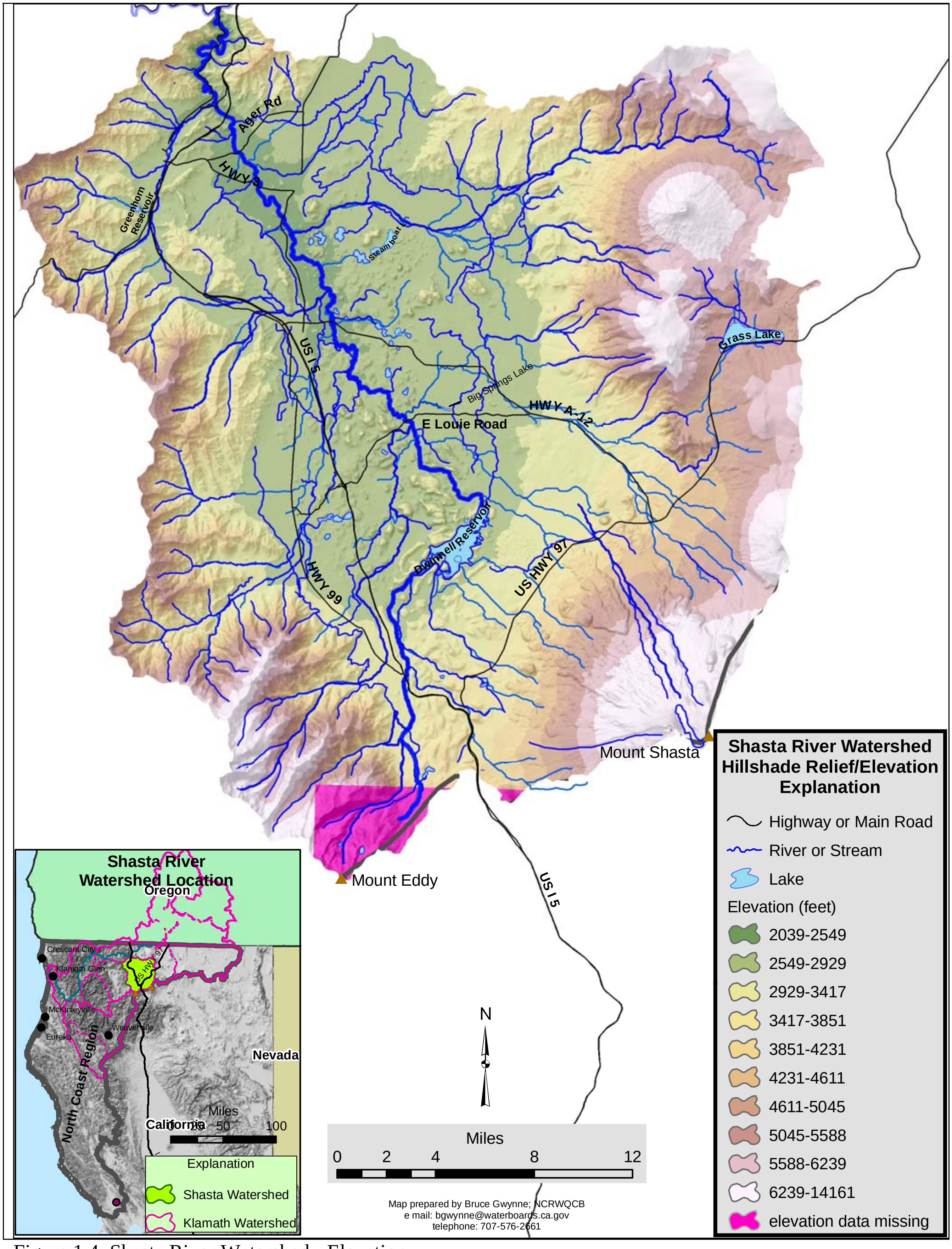

Figure 1.4: Shasta River Watershed - Elevation

From its origin in the Scott Mountains the Shasta River flows north and northwestward for approximately 60 miles before entering the Klamath River at Klamath River Mile (RM) 176.8. The river is dammed at Shasta RM 40.6 by Dwinnell Dam, which impounds Lake Shastina (also called Dwinnell Reservoir) to provide water storage for agricultural use, municipal supply for the town of Montague, and recreational use; but has no scheduled instream flow release. Shasta River Miles at select locations are identified in Figure 1.5.

Tributaries to the Shasta River include Eddy, Boles, Beaughton, Carrick, Julian, Jackson, Parks, Big Springs, Willow, and Yreka Creeks, Guys Gulch, Oregon Slough and the Little Shasta River (Figure 1.6). There are only minor tributaries in the canyon (lower 7.3 miles).

Construction of Dwinnell Dam was completed in 1928 as a water supply project for the Montague Water Conservation District (MWCD). Besides the dam and the reservoir, MWCD owns 60 miles of canals (the main canal is approximately 35 miles long) and lateral ditches to direct water into and away from Lake Shastina to farmers during the irrigation season. Although a relatively small reservoir, with a capacity of approximately 50,000 acre-feet, the reservoir only fills in above normal runoff years due to the relatively modest yield from upstream watershed areas, seasonal water use, and appreciable seepage loss (6,500 to 42,000 acre-feet per year) from the reservoir.

Relatively high precipitation in the area of the watershed above Lake Shastina creates precipitation-based flow in Dale and Eddy Creeks and the Shasta River. Spring flows from the flanks of Mount Shasta to Boles Creek, Beaughton Creek, and Carrick Creek account for much of the inflow to Lake Shastina. Flows can be flashy in Dale Creek, Eddy Creek, and the Shasta River, while flows in the spring fed creeks tend to be more stable and provide reliable base flows in wet and dry years. Parks Creek is spring fed from Mt. Eddy, and substantial flows are diverted into the Shasta River above Dwinnell Dam for storage in Lake Shastina by the MWCD. Based on United States Geologic Survey (USGS) and Department of Water Resources (DWR) Watermaster reports, the mean annual flow for the Shasta River at Edgewood Road (located upstream of Lake Shastina and including Parks Creek diversion flows) is approximately 60,000 acre-feet (Figure 1.7).

Releases of stored water to the Shasta River channel below Dwinnell Dam range from 0 to approximately 10 cubic feet per second (cfs) (approximately 20 acre feet per day) during the irrigation season. Releases to the Shasta River are delivered on an as-needed basis to provide water to several landowners downstream of Dwinnell Dam in lieu of their historic water rights that were blocked by construction of the dam (Vignola and Deas 2005).

Between Dwinnell Dam (RM 40.6) and the canyon (RM 7.3) the Shasta River meanders along the Valley floor, and is slow moving and sluggish with much of the shoreline covered by bullrush (tules) and to a lesser extent cattails (Ouzel Enterprises 1991, p.1-5). Numerous accretions from tributaries (including Big Springs, Parks, Willow, Julian, and Yreka Creeks, and Oregon Slough and the Little Shasta River), springs, and agricultural diversions, and return flows in this portion of the river contribute to a complex flow regime (Deas et al. 2003, p.i). During summer months Big Springs Creek inflow accounts for up to 50% of the flow in the river below Big Springs Creek.

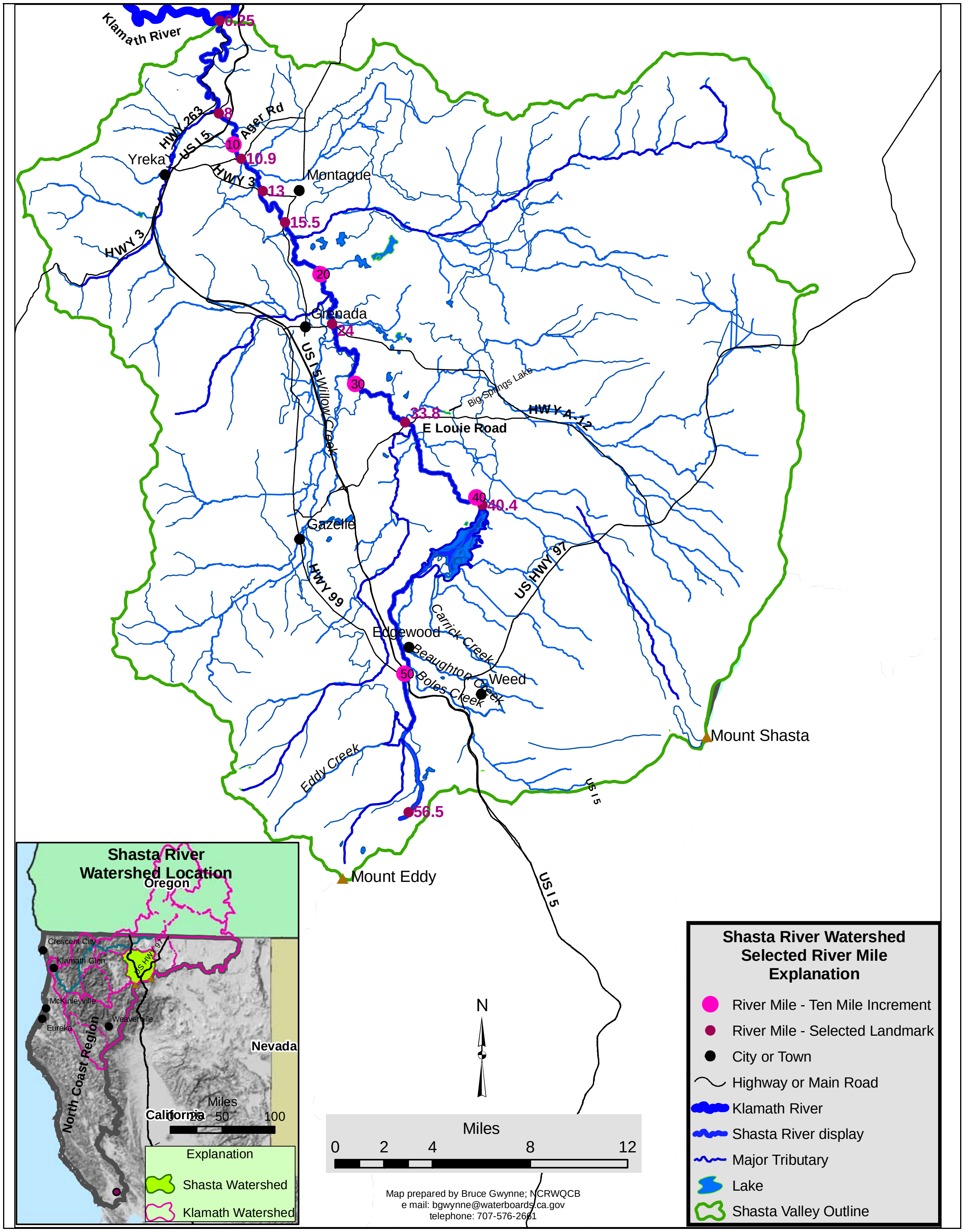

Figure 1.5: Shasta River Miles at Select Locations

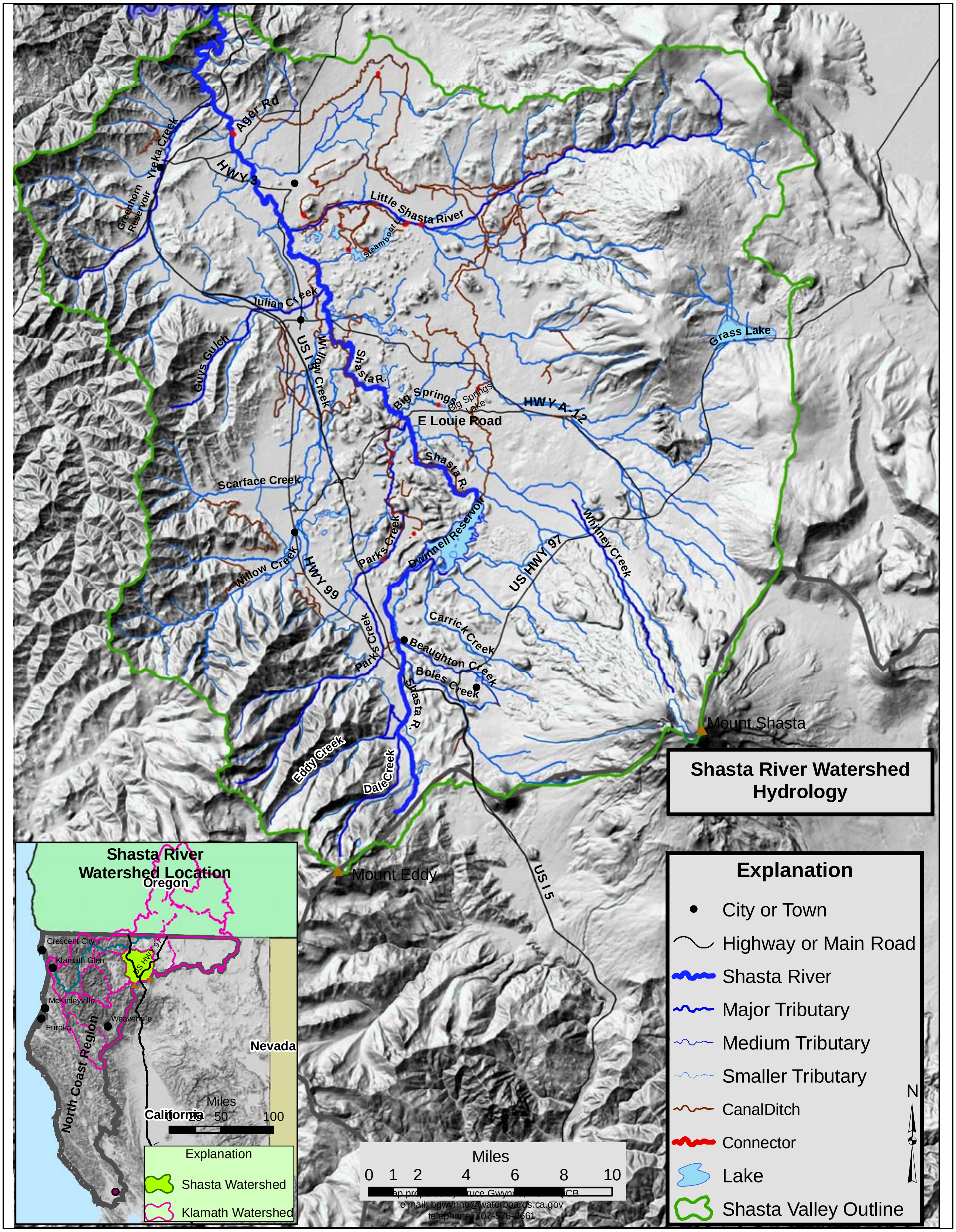

Figure 1.6: Shasta River Watershed - Waterbodies

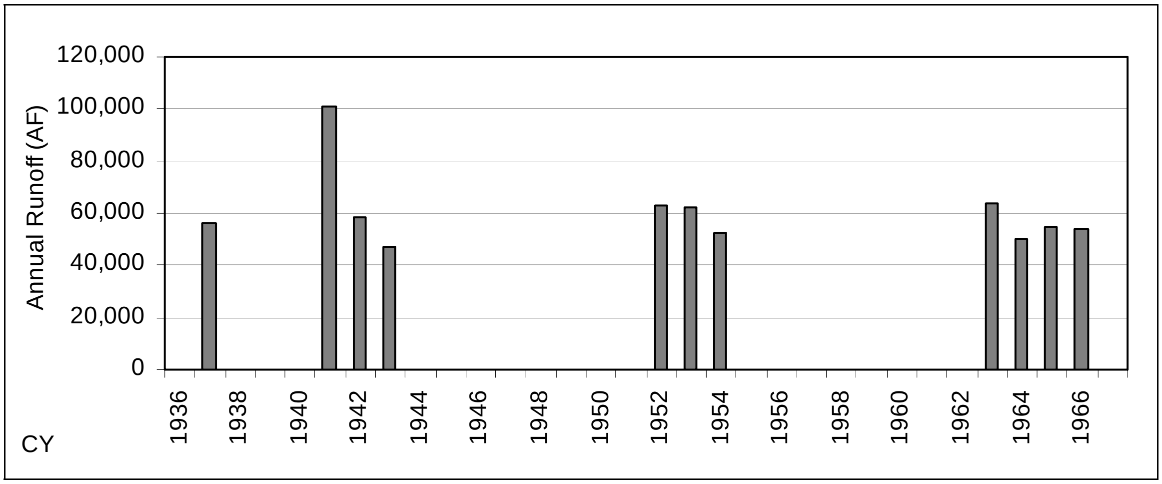

Figure 1.7: Annual Flow at Edgewood
Source: Vignola and Deas 2005. Data presented only for years with complete data record.

There are currently two real-time flow gauges on the Shasta River, both operated by USGS. One is located near Montague at RM 15.5 and is operated by USGS on behalf of DWR (station #11517000 [DWR Weir]). The other is located near the mouth (called the Yreka station, #11517500 [USGS Gage]) at RM 0.6. Flow records at the Montague station are available for 19 years during the period from 1911-1933, and 2001-2004. Flow records at the Yreka station are available from 1933 to the present.

Mean annual flow at the Yreka station for the period 1933 to 2004 is 133,000 acre-feet, with annual flows ranging from 56,000 to 264,000 acre-feet (Figure 1.8). As shown in Figure 1.8, annual Shasta River discharge responds to varying annual precipitation measured at Yreka. Flows are considerably lower during summer months compared to winter months, with typical summer season flows less than 5000 acre-feet (Figure 1.9). Finally, a review of recent Shasta River flow records shows that flows drop at the onset of the irrigation season (around April 1) and increase at the end of the irrigation season (around October 1) (Figure 1.10).

1.4.6 Geology and Soils
The Shasta River watershed spans the junction between two major geologic/geomorphic provinces. Mount Shasta and the mountains on the east side of Shasta Valley are formed of relatively young Cenozoic volcanic and intrusive rocks and are part of the Cascade Range volcanic province. The mountains on the west side of the watershed are older Franciscan rocks of the Klamath Mountains province. The valley floor between these major provinces are mostly alluvium. However, a single area stands out as unique: a gigantic landslide deposit that covers about 180 square miles. The geology of the watershed is considered below in terms of the Cascade volcanic province, the Franciscan province, and alluvial and landslide units within the valley deposits (Figure 1.11).

The mountains of the Cascade province are primarily igneous rocks that have been erupted to the surface. Some are intrusive igneous rocks that were not erupted to the surface but have been exposed by erosion. This area has undergone some uplift, but the rocks are not strongly deformed.

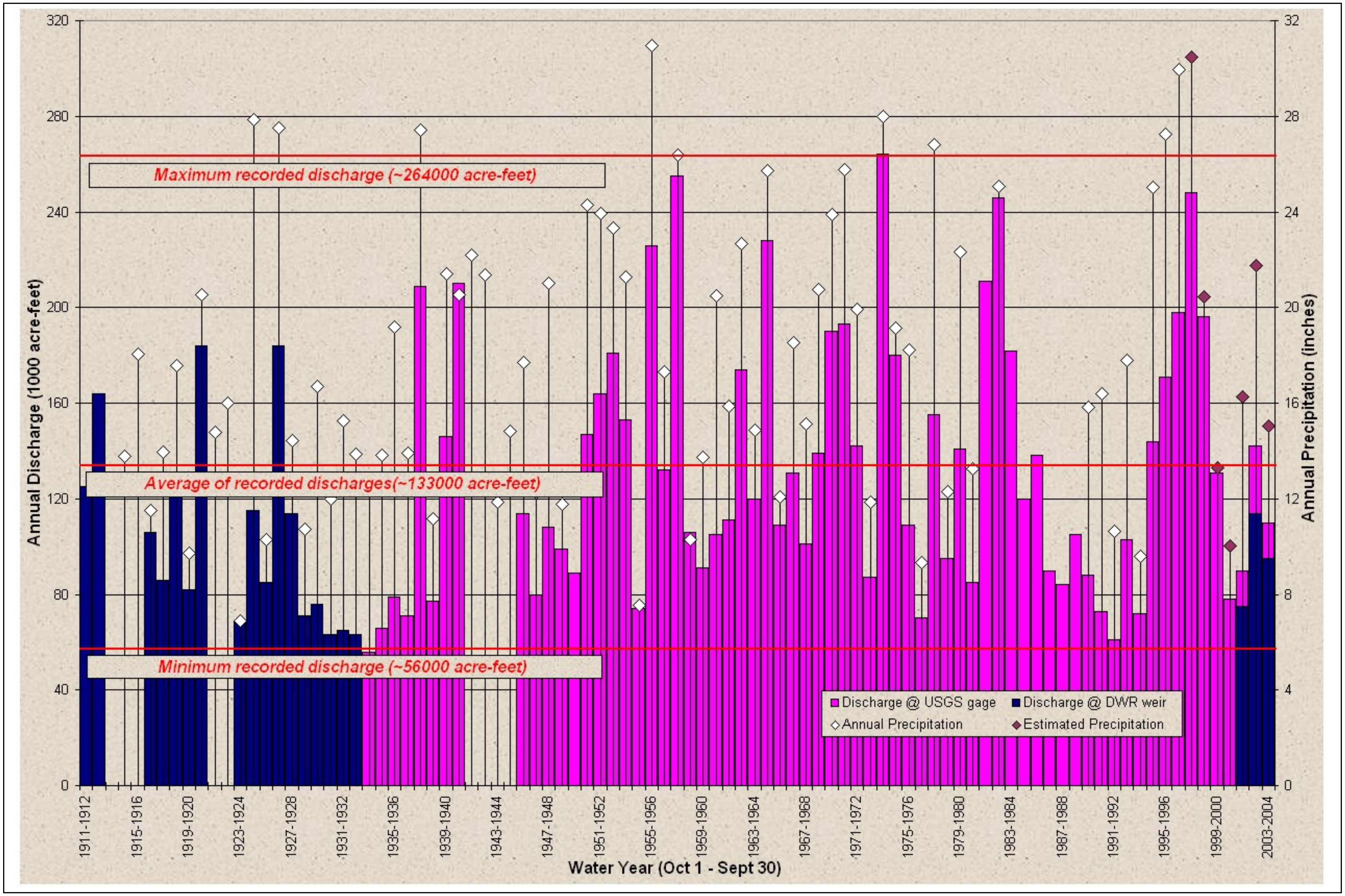

Figure 1.8: Shasta River Annual Discharge and Precipitation, 1911-2004
Note: Flow records from USGS; precipitation records from NOAA National Climatic Data Center.

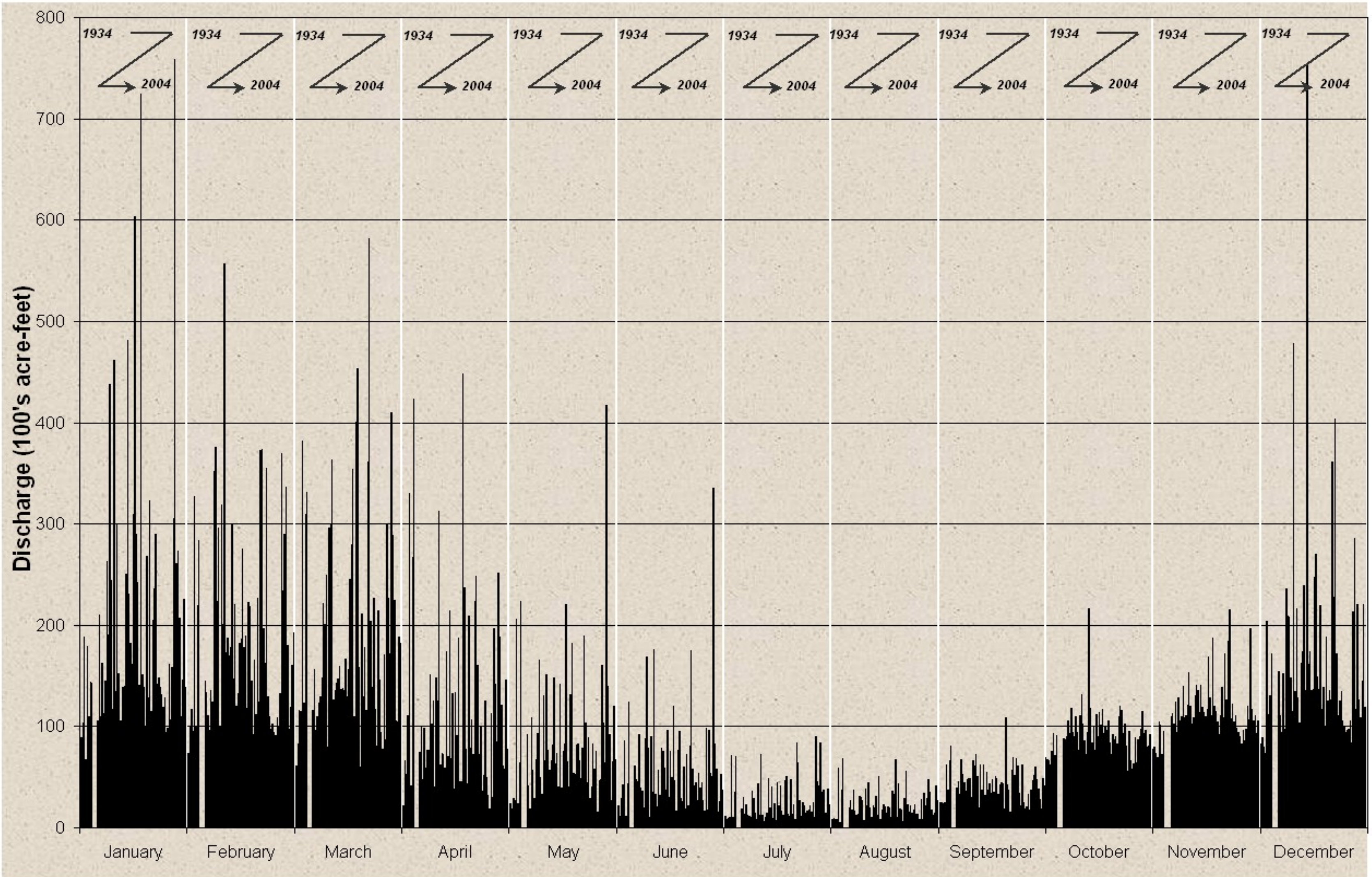

Figure 1.9: Monthly Shasta River Discharge, 1934–2004

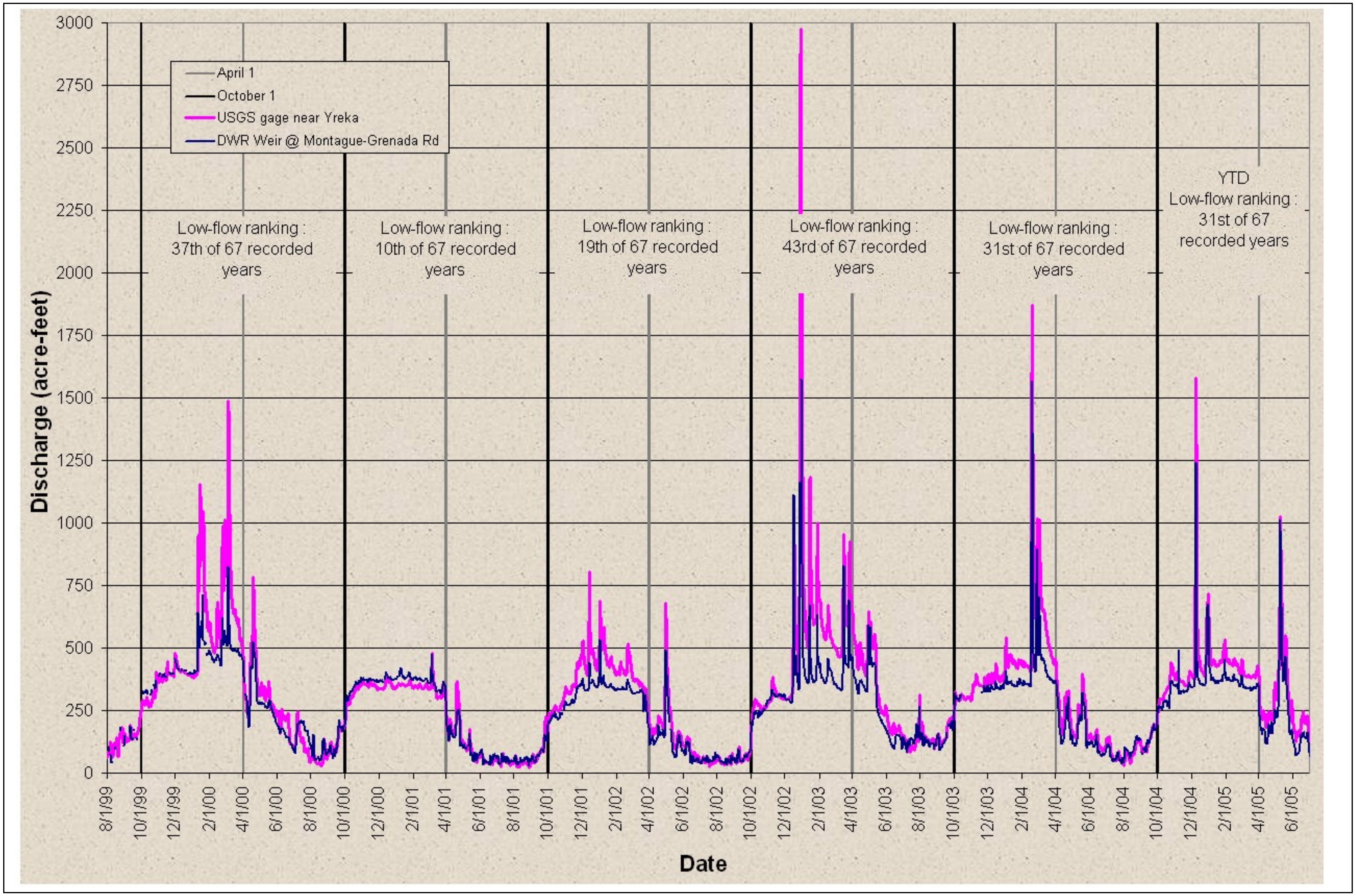

Figure 1.10: Seasonal Discharge Variation, Shasta River at DWR Weir and USGS Gage, 1999-2005

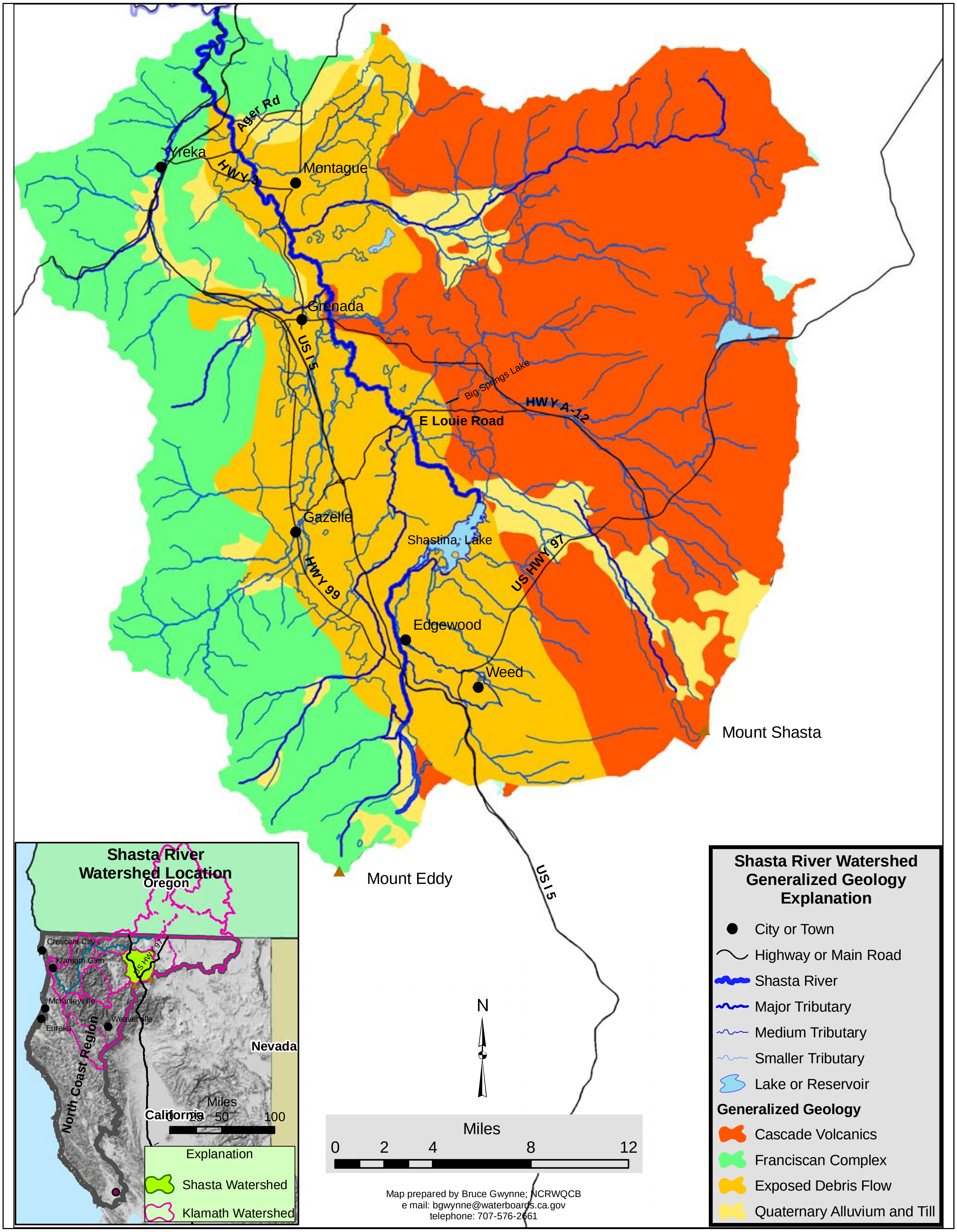

Figure 1.11: Shasta River Watershed – Geology

The mountains along the west side of the watershed are underlain by older rocks of the Franciscan Group. This suite of rocks is highly varied and includes high and medium grade metamorphic rocks, slightly metamorphosed sedimentary rocks and volcanics, granite and diorite, mafic and ultramafic rocks that are largely altered to serpentine, and small amounts of limestone. This complex has been deformed by folding, intense shearing, and thrust faulting. Deformation in the last 1-2 million years has resulted in uplift of the mountains along the west flank of the Shasta Valley.

Quaternary deposits of much of the floor of the Shasta Valley and the major tributary valleys are gravel, sand, and silt brought into the valley from the adjoining mountains by streams and mudflows. These deposits form the substrate for much of the agriculture in the valley. In the Cascades, some of the Quaternary deposits in the higher valleys are glacial deposits.

The geologic origin of deposits in a large area along the axis of Shasta Valley was not understood until 1989. This is a hummocky area having many closed depressions and little integrated drainage in many parts. It is underlain by unsorted rocky debris. Crandell (1989) interpreted this area as the deposit of a gigantic debris avalanche, or avalanches, that originated on the north slope of a mountain preceding the current Mount Shasta in Pleistocene time. This interpretation is generally accepted and explains the disrupted topography and large area of fragmental material. The deposit extends northward to the head of the Shasta Canyon, where erosion has effectively removed nearly all traces of its toe, where the Shasta River meets the Klamath.

The implication of the underlying geology of the Shasta basin is that much of the soil in the basin is of volcanic origin, and therefore can have high levels of phosphorus. These natural sources of phosphorus contribute to relatively high concentrations of inorganic phosphorus in the Shasta River.

1.4.7 Vegetation

The vegetation of the Shasta River watershed is heterogeneous and is reflective of the climatic variation that occurs in the watershed (Figure 1.12). Conifer tree species are the most common vegetation in the mountainous regions of the watershed. Herbaceous plants, including agricultural crops, dominate the valley region.

1.4.7.1 <u>Woody Riparian Vegetation of the Shasta River</u>

The following discussion is based upon information found in Deas et al. (1997). Woody riparian vegetation along the Shasta River varies both in its extent and location, ranging from areas completely absent of woody vegetation to areas of dense riparian forest. There are few areas along the river that can be considered a riparian "forest," characterized by a thicket of trees on both banks and extending more than one tree width from the top of the bank. However, there are locations where woody riparian vegetation forms roughly continuous rows of trees lining the river banks. In general there is little breadth (distance perpendicular to the axis of the river) to these rows of riparian vegetation. These roughly continuous rows of trees occur intermittently in places from Dwinnell Dam (RM 40.6) to south of Highway A-12 (RM 24.1) and from south of

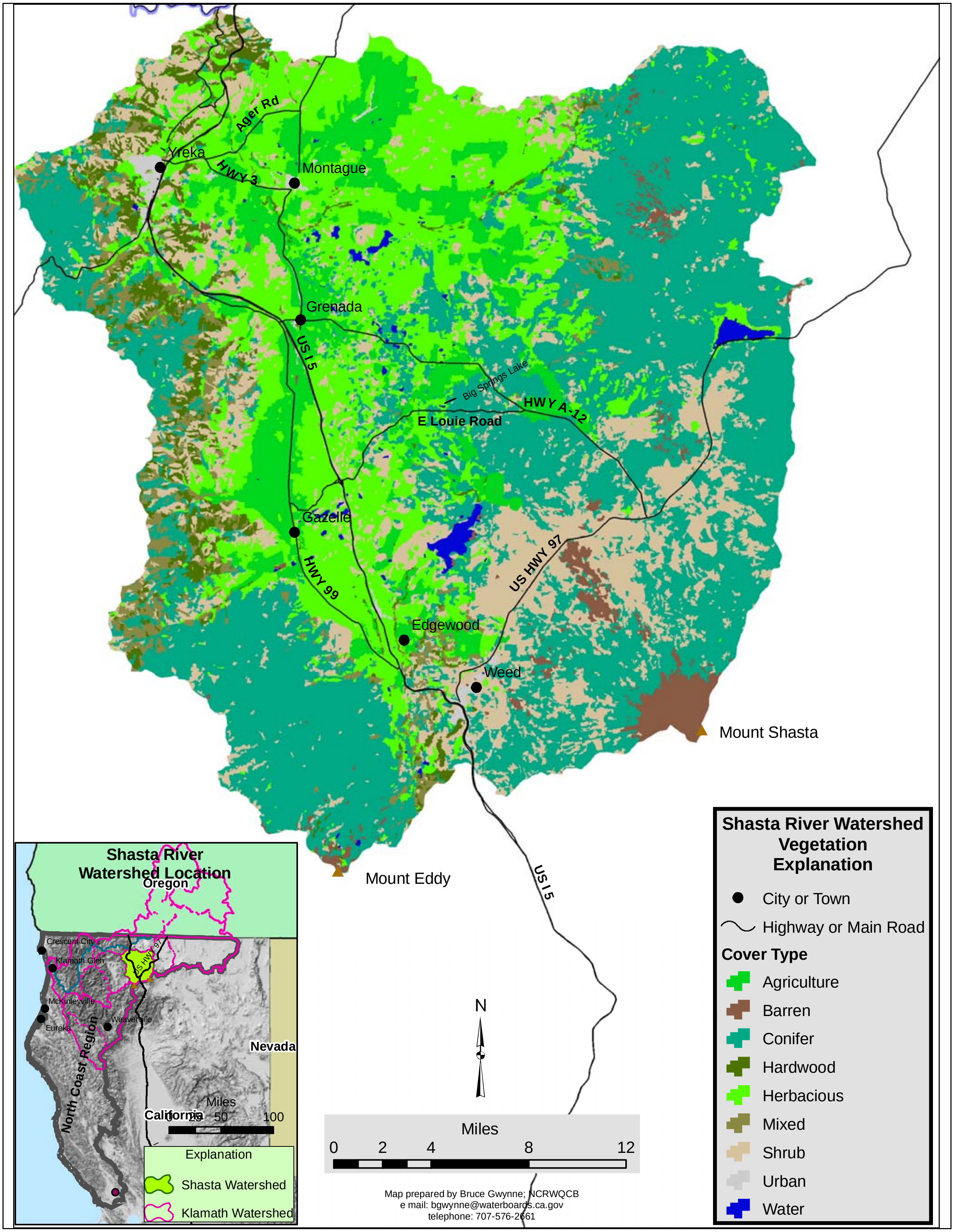

Figure 1.12: Shasta River Watershed – Vegetation and Land Use

Montague-Grenada Road near Breceda Lane (RM 16.5) to the mouth of the Shasta River (RM 0). Although other reaches of the river also have continuous vegetation, it generally occurs in intermittent areas and on one side of the bank or the other. In the area of the Shasta River between Highway A-12 to Montague-Grenada Road woody riparian vegetation is generally absent.

Table 1.1 includes a list of riparian tree species native to the Shasta Valley. In 2001, a survey of Shasta River riparian tree heights was conducted (Watercourse Engineering, Inc. 2004), and the results are summarized in Table 1.1.

Table 1.1: Tree Species and Height Statistics for Shasta River Riparian Vegetation

Common Name	Scientific Name	Range of Height (ft)	Average Height (ft)	Sample Size
While Alder	*Alnus rhombifolia*	21-35	27	3
Oregon Ash	*Fraxinus latifolia*	17-37	27	4
Black Cottonwood	*Populus trichocarpa*	32-45	39	2
Red Birch	*Betula fontanalis*	16-36	24	7
Oregon White Oak	*Quercus garryana*	55-73	64	2
Red Willow	*Salix laevigata*	-	-	-
Arroyo Willow	*Salix lasiolepsis var.bracelinea*	20-54	38	23
Pacific Willow	*Salix lasiandra*	-	-	-
Sandbar Willow	*Salix hindsiana*	13-35	22	27

In 2004 a follow-up survey of riparian vegetation was conducted (Appendix A, *Shasta River Water Quality Related Investigations-2004*) whereby riparian conditions were classified by tree density, as follows:

Description	Riparian Category
No trees	0
Less than 2 trees per 100 feet	1
Greater than 2 trees per 100 feet	2
Gallery Forest	3

Results of the 2004 survey are presented in Table 1.2.

Table 1.2: Shasta River Riparian Classification

Downstream River Mile	Upstream River Mile	Length (Miles)	Riparian Category
0.17	0.67	0.5	2
1	2.87	1.87	1
4.05	4.51	0.46	2
5.73	6.58	0.85	2
8.58	10.53	1.95	2
10.54	14.64	4.1	1
14.65	16.09	1.44	2
16.1	19.26	3.16	0
19.26	19.72	0.46	2
19.72	21.64	1.92	0
21.64	21.98	0.34	2
21.98	25.82	3.84	0
27.48	28.33	0.85	0
28.33	28.9	0.57	2
28.9	32.42	3.52	0
37.84	38.87	1.03	1
39.92	40.22	0.3	2

Note: Riparian Classification was identified only where river access was granted.

1.4.8 History and Land Use

Information on the history and land use of the Shasta River basin is synthesized from the following sources: DWR (1964, p.15-16), Siskiyou County Library (2000), SVRCD (2005b), and United States Department of Agriculture [USDA] (1983, p.1-4).

The Shasta Nation ancestral territory included much of the Shasta Valley. The first European exploration of Siskiyou County and the Shasta basin was in the late 1820s, when fur trappers from the Hudson's Bay Company entered the area in search of pelts. These explorers were soon followed by cattle drovers, bringing cattle from the Sacramento Valley to the Oregon settlements. With the exception of small military missions, these were the only explorers to the area until the 1849 gold rush, which established the first permanent settlers in the basin. The first discovery of gold in Siskiyou County was near the town of Yreka in 1851, and in a few months there were over 2,000 miners working in the area.

With the increased population came an increased need for food, supplies, and lumber. Many ranchers, farmers, and businessmen followed the gold rush settling in the area. By the early 1900s, farming, ranching, and timber harvest were the dominant land uses within the basin.

Today the economy of the Shasta River basin is mainly supported through agriculture and ranching, although lumber mills in the Shasta Valley also contribute to the economy. Cow-calf operations extend throughout much of the Shasta basin, supported by irrigated pasture and hay fields, as well as dry upland grazing lands. Due to local springtime flooding and a short growing season, crops grown in the Shasta Valley are limited to grass for hay and pasture, alfalfa and small grains grown for local and outside livestock feed, and a small selection of row crops.

Timber harvest and associated road building were heavy in parts of the watershed into the 1960s. Today, only limited timber harvest occurs in parts of the watershed on both US Forest Service and private lands. There are currently two active sawmills within the watershed, though much of the milled lumber is harvested outside the watershed.

Recreation has become an important industry for the area. Mount Shasta is a popular place for both downhill and cross country skiing during the winter, and for hiking and mountain climbing in the summer. Lake Shastina, mountain lakes, and streams are kept stocked with trout, and wildlife is abundant.

Though still dominated by agricultural land and open space, the Shasta Valley is experiencing increased residential development and associated urbanization. Urbanization is most evident within established urban areas such as the City of Yreka, but is also occurring in lower elevation areas through out the basin, along the Interstate 5 corridor, and around Lake Shastina. Lot splits and subdivision of agricultural land are on the rise.

1.4.9 Water Resource Management

Information on water resource management is synthesized from the following sources: California Department of Fish and Game [CDFG] (1997), DWR (1964, p.55-61), Klamath River Basin Fisheries Task Force [KRBFTF] (1991), State of California Department of Public Works [CADPW] (1932), and SVRCD (2005b).

Shasta Basin water resources have been managed for irrigation and stock watering, municipal drinking water supply, and small hydropower generation. The first hydroelectric power generation facility was built in the Shasta canyon in 1892. One small non-commercial hydro facility is in operation today.

Agricultural use of water in the Shasta River basin began with the settlement of miners in the early 1850s. By the 1940s, gold mining had diminished in the basin and agricultural development became the economic focus, resulting in increased irrigation and water use. In the early 1900s, four water service agencies were formed in the Shasta basin. The Shasta River Water Users Association (SRWA) is a corporation formed in 1912. The SRWA serves an area near the town of Montague along the west side of the Shasta Valley. The Grenada Irrigation District (GID), Montague Water Conservation District (MWCD), and Big Springs Irrigation District (BSID) formed under the California Irrigation District Act in 1921, 1925, and 1927, respectively. The GID (formerly known as the Lucerne Water District) serves the area located west of the town of Grenada. Succeeding the Big Springs Water Company (organized in 1913), the BSID serves the area north of Big Springs Lake. The MWCD, also known as the Montague Irrigation District, serves the irrigation needs of the Little Shasta Valley and the northeast part of the Shasta Valley.

The Shasta River is fully appropriated from May 1 through October 31 (SWRCB 1998). In the 1920s, surface waters of the Shasta River were subject to a statutory adjudication and on December 30, 1932 the Superior Court of California issued its judgment and decree that quantifies the amount and priority date of each surface water right on the river. Since 1934, the Department of Water Resources (DWR) Watermaster Service has managed the delivery of the adjudicated water rights using a weir located at RM 15.5. The watermaster's job is to apportion available water in order of priority of right, many are fairly far downstream in the Shasta basin. Water users along the riparian zone of the Shasta River below Dwinnell Dam and groundwater withdrawals are not subject to the adjudication. A summary of the water rights for the Shasta River basin during irrigation and non-irrigation season is presented in Table 1.3.

Winter storage of the Shasta River and Parks Creek in Lake Shastina in the amount of up to 70,000 acre-feet is appropriated to the Montague Water Conservation District during April 1 through October 1. This water is for the irrigation of approximately 10,000 acres within the boundaries of the MWCD, and use by the Town of Montague as its drinking water supply. With the exception of above normal water years when Lake Shastina is full, the only flow releases made to the Shasta River below the dam are those intended to satisfy the needs of several small users immediately downstream of the dam.

There are approximately 15 diversions on the mainstem Shasta River between Dwinnell Dam (RM 40.6) and Highway A-12 (RM 24.1) with a maximum diversion quantity totaling approximately 120 cfs. In some years major diversions in this reach are restricted during the summer to ensure that shortages do not occur downstream. There are currently approximately 27 diversions along the length of Parks Creek totaling a maximum diversion quantity of 46.2 cfs, although full diversion of this quantity of water is unlikely to be available throughout the summer.

Table 1.3: Summary of the 1932 Appropriation of Water Rights in the Shasta Basin

IRRIGATION SEASON	
Location	**Appropriation (cfs)**
Shasta River above the confluence of Big Springs Creek	111.4
Boles Creek and Tributaries	17.6
Beaughan Creek and Tributaries	10.3
Jackson Creek and Tributaries	2.8
Carrick Creek and Tributaries	11.7
Parks Creek and Tributaries	56.3
Shasta River below the confluence of Big Springs Creek and Big Springs Creek and Tributaries	184.8
Little Shasta River and Tributaries	90.0
Willow Creek and Tributaries	55.7
Yreka Creek and Tributaries	36.0
Miscellaneous Independent Springs, Gulches, and Sloughs	32.9
Total	**609.5**
NON-IRRIGATION SEASON	
Location	**Appropriation (cfs)**
Shasta River and its Tributaries	327.4

Source: CADPW 1932, p.247-314

The Big Springs Irrigation District has rights to 30 cfs from Big Springs Lake (feeding Big Springs Creek which enters the Shasta River at RM 33.71) to be used within the boundary of its district. However, since the late 1980s, the BSID has used groundwater in lieu of water diverted from Big Springs Lake.

The Grenada Irrigation District has a right to 40 cfs from the Shasta River for the period April 1 through October 1, which is diverted at RM 30.58. This water is designated for irrigation of approximately 1,700 acres within the GID. Prior downstream water rights, totaling about 80 cfs, have limited the ability of GID to take its full entitlement in some years.

In the mainstem Shasta from Highway A-12 (RM 24.1) to Yreka Creek (RM 7.7), about 16 small diversions are found with a combined maximum diversion quantity (not including diversions from Willow Creek) of approximately 27 cfs. On the Little Shasta River, current records indicate a total maximum diversion quantity of 85.6 cfs from approximately 29 diversions, although by the end of the summer most of these water users are severely restricted.

In addition to the above mentioned small diversions, the Shasta River Water Users Association has rights to 42 cfs from the Shasta River diverted at RM 17.8 during the period from April 1-Oct 1 to irrigate approximately 3,600 acres.

The City of Yreka receives water from Fall Creek (tributary to the Klamath River upstream of Iron Gate Reservoir). An underflow well in Yreka Creek occasionally supplements the Fall Creek water supply.

Management of these appropriated water rights and delivery of water to users is conducted by the California Department of Water Resources Watermaster Service, with the exception of rights on Willow Creek and Yreka Creek. In order to meet all appropriated water rights, water is reused via a complex array of ditches, and relies on return flows to the river for delivery to downstream users.

Flood irrigation is the predominant irrigation method in the basin. Records of irrigated crop area and the amount of applied water in the Shasta Valley in 2000 and 2001 are summarized in Table 1.4.

Table 1.4: Irrigated crop area and applied water in the Shasta River basin in 2000 and 2001

Crop Type	Irrigated Crop Area (acres)		Applied Water (acre-feet per acre)	
	2000	2001	2000	2001
Grain	3000	700	1.76	2.11
Alfalfa	7500	5800	3.07	3.56
Pasture	39,100	39,200	3.71	2.99
Onions and Garlic	400	100	3.01	3.15
Other Truck Crops	600	500	2.05	2.18
Other Deciduous crops	0	100	.00	3.29
Totals	**50,600**	**46,400**	**NA**	**NA**

NA = Not Applicable
Sources: DWR Undated a, DWR Undated b

1.4.10 Anadromous Fish of the Shasta River Watershed

Anadromous fish populations currently utilizing the Shasta River watershed include fall Chinook (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*), and fall and winter steelhead trout (*Oncorhynchus mykiss*) (Hardy and Addley 2001, p.11; KRBFTF 1991, p.4-10, 4-11). The Shasta River was once one of the most productive streams of its size for anadromous fish in California (National Research Council [NRC] 2003, p. 246). Data indicate that the historic fall Chinook population within the Shasta River basin was large, and has experienced a sharp decline since the 1930s (Hardy and Addley 2001, p.11; PacifiCorp 2004, p.2-40). Available data for coho and fall and winter steelhead runs are not entirely reliable for determining long-term trends, however both species are considered to have experienced declines from historic numbers throughout the Klamath River basin (Brown and Moyle 1991, p.13-14; Brown et al. 1994; CDFG 2002, p.1; Hardy and Addley 2001, p.11; PacifiCorp 2004, p.2-40). Historically, there were summer steelhead and spring Chinook runs in the Shasta River, however those runs no longer occur in the basin (KRBFTF 1991, p.2-87 and 2-99).

1.4.10.1 <u>Fall Chinook</u>

Fall Chinook salmon are the predominant run in the Klamath River basin, and are the only Chinook run believed to currently exist in the Shasta River basin (CDFG 1997). An estimate of spawner abundance from CDFG (1965, p.372) showed that on average there were 20,000 fall Chinook per year in the Shasta River basin in the years 1959 to 1963. Fall Chinook spawning populations as measured at the Shasta River Fish Counting Facility have ranged from a high of 81,848 fish in 1930 to fewer than 750 fish in 1990-1992, excluding 1938-1955 when the weir was located 6.5 miles upstream in the Shasta River and thus did not count adults spawning downstream (Figure 1.13). Fall Chinook numbers were 1,450 and 5,203 fish, respectively, in 1993 and 1994, but increased dramatically in 1995 to 13,511 fish. In 1996 to 1999 fall Chinook numbers dropped again, ranging from 1,450 to 3,197 fish. In 2000 and 2001 fall Chinook numbers were over 11,000 fish, but declined again in 2002-2004 ranging from 6,818 to 962 fish. Preliminary information for 2005 reflect a total of 1,983 fall Chinook in the Shasta River.

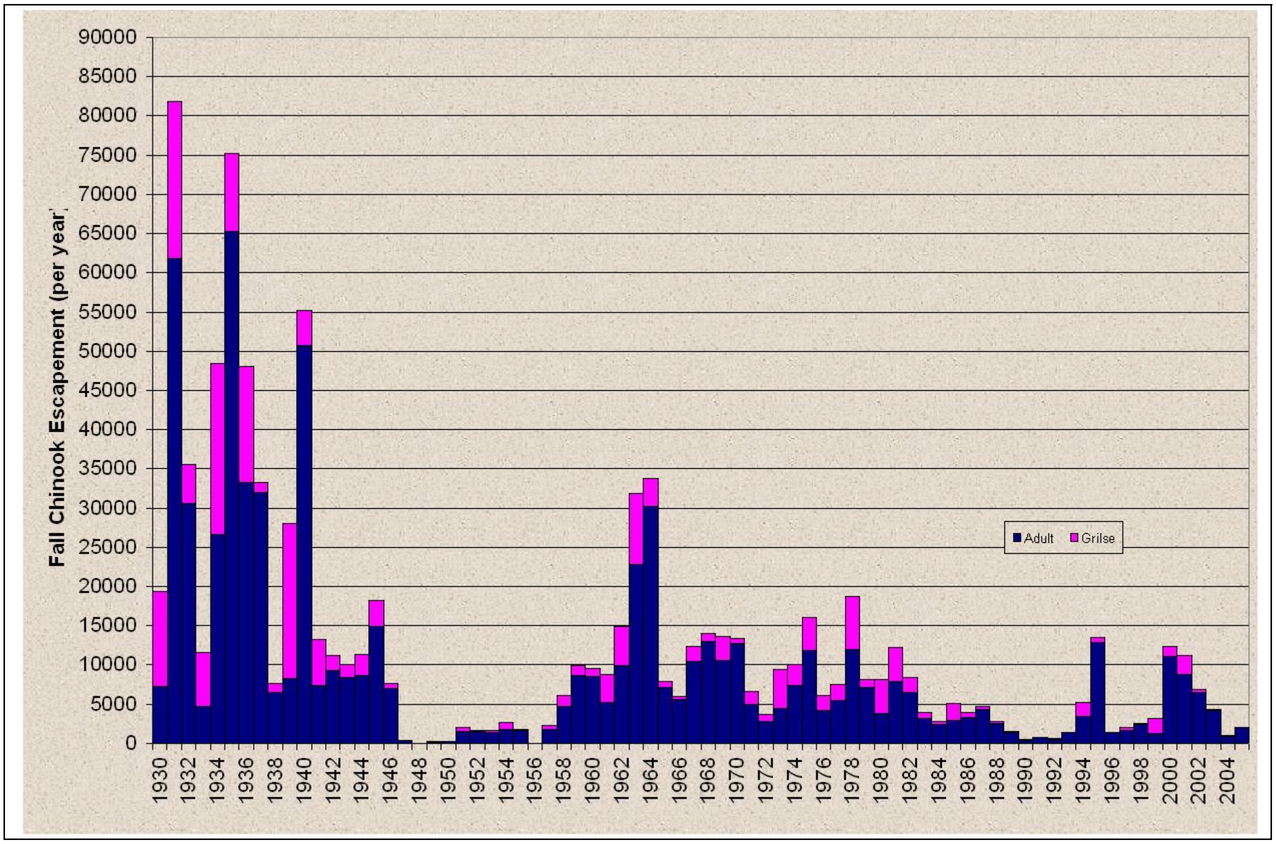

Figure 1.13: Shasta River Fall Chinook Spawning Escapement (Estimated), 1930-2005
Note: Data from 2005 are preliminary and represents total Chinook; data source does not differentiate between adults and grilse.
Source: Pacific Fishery Management Council 2005, p.185, CDFG 2004b, Hampton 2005a, p.1, and Hampton 2005b

1.4.10.2 Spring Chinook

A population of more than 100,000 spring-run Chinook was once present in the Klamath River basin (Moyle 2002, p.259). In 1931, Snyder wrote that the spring Chinook migration in the Klamath basin, while once very pronounced, "has now come to be limited as to the number of individuals, and is of relatively little economic importance (Snyder 1931, p.19)." This same decreasing trend is reflected in information from the Shasta River. CDFG (1990, as cited by Moyle 2002, p.259) states that historically spring Chinook run sizes for the Shasta River were estimated to be at least 5,000 fish. The run in the Shasta is noted as being one of the largest runs in the Klamath basin (Moyle 2002, p.259). Moyle (2002, p.259) suggests that by the early 1930s increased summer water temperatures and habitat degradation caused by the presence of Dwinnell Dam resulted in the disappearance of the spring Chinook run in the Shasta basin. In addition, the construction of Dwinnell Dam created a migration barrier for salmonids, and cut off spring Chinook and other salmonids from areas of prime habitat and cold water refuge that would have been important for spring Chinook holding throughout the summer months.

1.4.10.3 Steelhead

In 1932, an estimated 8,513 fall steelhead migrated up the Shasta River (Snyder 1933). An estimate of steelhead trout spawner abundance by CDFG (1965, p.372) recorded an average of 6,000 fall and winter steelhead in the Shasta River basin annually from 1959 to 1963. A study of angler harvest in the Shasta River in 1970 estimated a total of 172 fall steelhead (20% of the population) were harvested (Lanse 1971), which would mean an estimated population of 860 adult fall steelhead in the basin. Steelhead numbers are available from the Shasta River Fish Counting Facility, and are summarized in Figure 1.14. The Shasta River Fish Counting Facility has been operating since 1930. It is important to note, however, that the primary purpose of this facility is to count fall run Chinook, and the weir is not generally operated past November, and thus does not capture the entire run of steelhead. Therefore, these data cannot be taken as representative of entire population sizes.

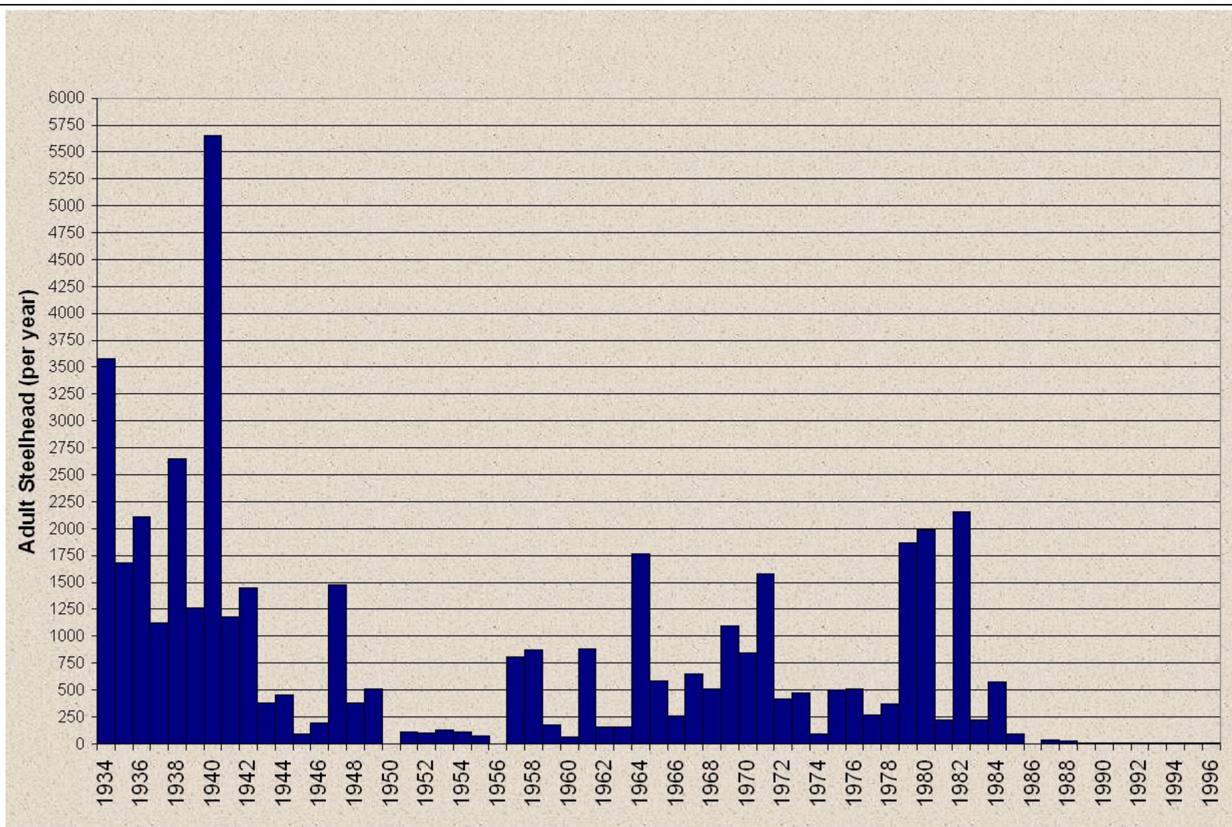

Figure 1.14: Shasta River Adult Steelhead, 1934-1996
Source: KRIS 2006

1.4.10.4 Coho

Little is known regarding the coho salmon population in the Shasta River, although it is believed that these fish follow the migration and behavior patterns of coho salmon in other areas of the Klamath River basin (CDFG 1997). It is clear from the information available that coho salmon populations statewide have undergone a dramatic decline from historic levels (Brown and Moyle 1991, p.8; Brown et al. 1994; CDFG 2002, p.1). Brown et al. (1994) state that California coho populations are probably less than 6% of what they were in the 1940s, and there has been at least a 70% decline since the 1960s. Coho salmon occupy only 61% of the Southern Oregon/Northern California Coastal Coho Salmon Evolutionarily Significant Unit streams that were previously identified as historical coho salmon streams (CDFG 2002, p.2). In 1965, CDFG estimated 800 coho spawners per year in the Shasta River basin (CDFG 1965, p.372). No other estimates of spawner abundance or population could be found for coho in the Shasta River basin, however there is information available on coho numbers from the Shasta River Fish Counting Facility managed by CDFG. It is the longest fish dataset in the Klamath basin, beginning in 1930 and continuing through the present. The primary purpose of the facility is to count fall Chinook, but steelhead and coho are also counted incidentally. Therefore, these coho numbers cannot be used as estimates of population but indicate the minimum number of coho present in the Shasta River basin during various years. Figure 1.15 presents coho numbers from the Shasta River Fish Counting Facility for the years from 1934-2005 (2005 data are preliminary).

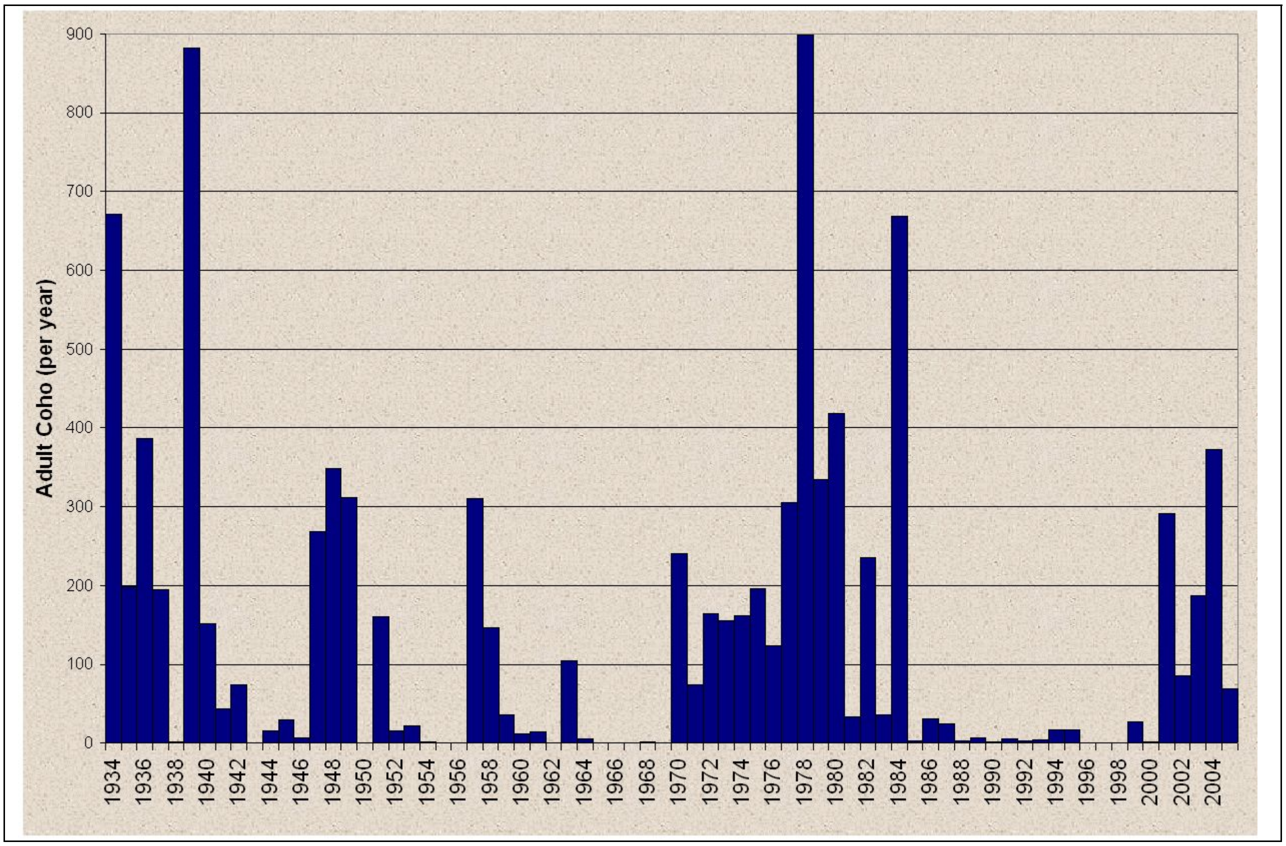

Figure 1.15: Shasta River Adult Coho, 1934-2005
Note: Data from 2005 are preliminary
Source: KRIS 2006, Hampton 2004, p.1, Hampton 2005a, p.1, and Hampton 2005b

1.4.10.5 <u>Habitat and Fish Distribution</u>

The continued survival and persistence of sustainable populations of salmonids in the Shasta River basin depends on the amount and suitability of the habitat. The construction of Dwinnell Dam in 1928 eliminated an estimated 22 percent of the total spawning habitat formerly available to salmon and steelhead (Wales 1951, as cited by CDFG 1997). A habitat survey performed by the CDFG (1965, p.372) found that there were 34 miles of habitat in the Shasta River basin suitable for Chinook and coho, and 64 miles of habitat suitable for steelhead. More current information from Hardy and Addley (2001, p.11) estimate that there are 35 miles of fall

Chinook, 38 miles of coho, and 55 miles of steelhead habitat in the basin. The authors state, however, that actual utilization of this habitat is contingent upon suitable flow conditions that may not be met during average and dry weather years due to water diversions (Hardy and Addley 2001, p.11). Others contend that stream diversions have reduced the amount of available salmon and steelhead habitat in the Shasta River basin to a subsistence level, and may have been the primary cause for the loss of the summer steelhead and spring Chinook runs in this basin (KRBFTF 1991, p.2-99). Figure 1.16 shows the distribution of migratory fish in the Shasta River watershed.

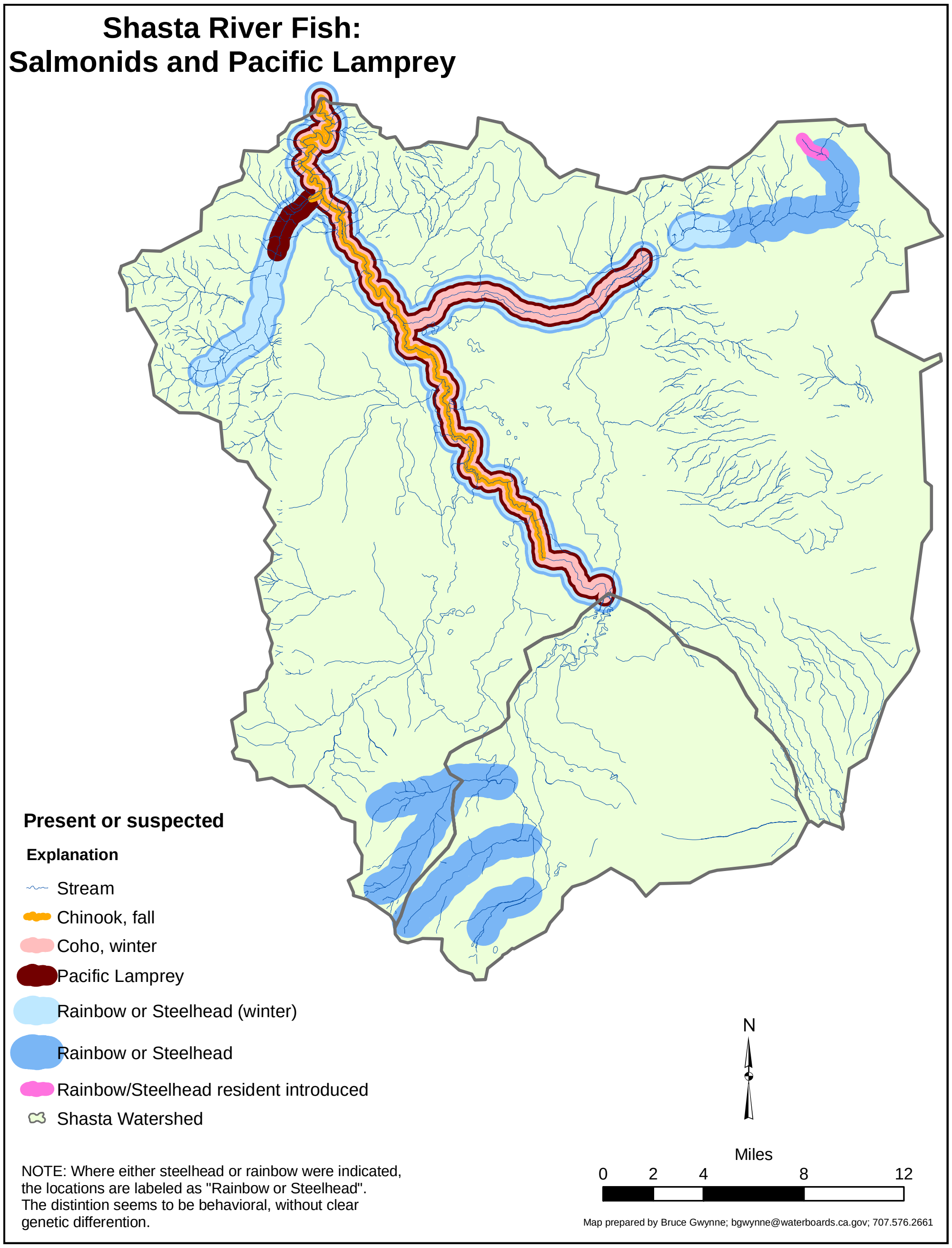

Figure 1.16: Distribution of Salmonids and Pacific Lamprey of the Shasta River watershed
Source: USFS 2005

Information in Figure 1.16 was compiled by the Klamath National Forest (United States Forest Service [USFS] 2005), and reflects the best readily available information. Locations at which fish presence is not indicated on the map do not necessarily indicate the absence of fish in these areas, as surveys may not have been conducted to determine presence/absence.

1.4.10.6 Periodicity

Considered together, the fall Chinook, coho, fall and winter steelhead are present year-round in the Shasta River basin (Figure 1.17). Many of the smaller tributaries in the Shasta basin have minimal flows during the summer, making access to and movement within in these tributaries difficult. According to CDFG, juvenile salmonids in the Shasta basin rear throughout the summer in the upper reaches of the mainstem Shasta River including Big Springs Creek, and steelhead have been observed rearing in the upper Little Shasta, and Parks Creek (Chesney 2005; Whelan, 2005c). It is important to note that the Shasta River has type II juvenile fall Chinook, which spend their first spring and summer in the stream and outmigrate in the fall (CDFG 1997, p.10; Whelan 2005a). This life history pattern results in the presence of juvenile Chinook rearing year-round in the Shasta River.

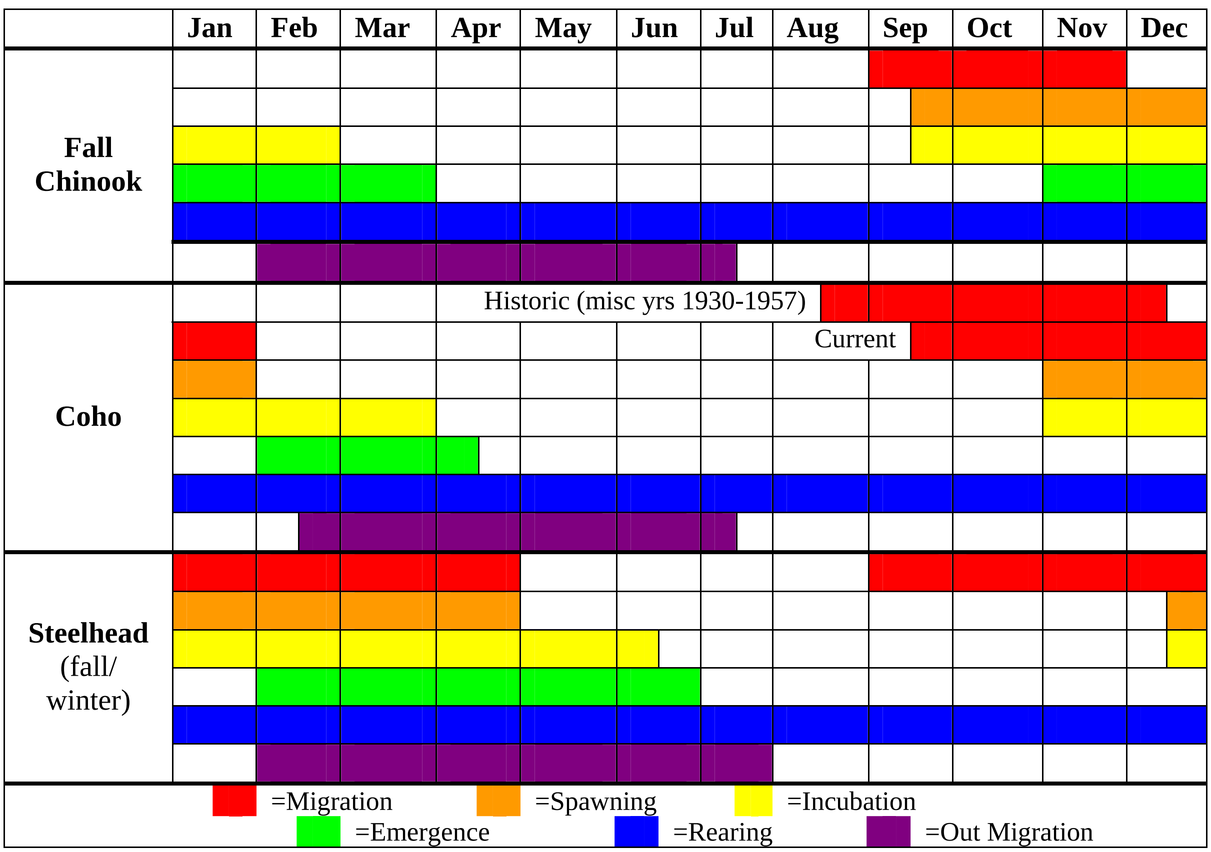

Figure 1.17: Salmonid Periodicity in the Shasta River Basin

Sources: CDFG 1997, Chesney 2000, Chesney 2002, Chesney and Yokel 2003, Chesney et al. 2004, Hampton 2002, Hampton 2003, Hampton 2004, Leidy and Leidy 1984, Shaw et al. 1997, Whelan 2005a

Periodicity information (presence of salmonids at varying life stages throughout the year) for the runs is fairly easy to interpret with the exception of data for the fall and winter run steelhead. At times references do not distinguish between fall and winter steelhead, some calling all fish winter run steelhead (see for example Leidy and Leidy 1984, Table 10), while others only refer to fall fish (see for example Hardy and Addley 2001, p.11). In other references the discussion of fall and winter run steelhead is combined (see for example KRBFTF 1991, p.4-11). Finally, some documents discuss the fall and winter steelhead separately, but then mention that there was almost no distinction between the timing of the fall and winter run into the Shasta River (see for example CDFG 1997; Shaw et al. 1997). For this reason, periodicity information for fall and winter steelhead in this document is combined into one group (Figure 1.17). Figure 1.17 shows that one or more life stage of fall Chinook, coho, and steelhead are present in the Shasta River Basin during every month of the year.

1.4.11 Non-Migratory Fish of the Shasta River Watershed

The Shasta River watershed hosts numerous populations of non-migratory fish species. Native fish persisting in the river include a variety of sculpin species, including marbled sculpin, and speckled dace. Introduced species include yellow perch, brown bullhead, bluegill, largemouth bass, mosquitofish, green sunfish, and brook and brown trout. The distribution of these non-migratory fish in the Shasta River watershed is presented in Figure 1.18, and is based on readily available data compiled by the Klamath National Forest (USFS 2005) and may not reflect all species that are present in the river, including above Dwinnell Dam. Locations at which fish presence is not indicated on the map do not necessarily indicate the absence of fish in these areas, as surveys to determine presence/absence may not have been conducted at all locations within the watershed.

The construction of Dwinnell Dam on the Shasta River in 1928 did not include any fish passage facilities and thus became a barrier to salmon and steelhead migration. However, populations of both native and introduced non-anadromous species persist in the Shasta River basin above the dam, as summarized in Table 1.5.

Table 1.5: Fishes found above Dwinnell Dam in the Shasta River Basin

Native Fish	**Introduced Fish**
Rainbow trout, *Oncorynchus mykiss*	Brown trout, *Salmo trutta*
Speckled dace, *Rhinichthys osculus*	Brook trout, *Salvelinus fontinalis*
Marbled sculpin, *Cottus klamathensis*	Brown bullhead, *Ictalurus nebulosa*
Lamprey, *Lampetra sp.*	Largemouth bass, *Micropterus salmoides*
Klamath smallscale sucker, *Catostomus rimiculus*	White crappie, *Pomoxis annularis*
-	Black crappie, *Pomoxis nigromaculatus*
-	Green sunfish, Lepom*is cyanellus*
-	Pond smelt (Wakasagi,) *Hypomesus nipponensis*
-	Golden shiner, *Notemigonus crysoleucas*
-	Tui chub, *Gila bicolor**

* It is unclear whether Tui chub were present in the river prior to Dwinnell Dam construction or whether they were introduced after construction was complete.
Source: Whelan 2005b

The California Department of Fish and Game (CDFG) regularly plants rainbow trout in Lake Shastina and along Highway 97 in Boles Creek, and brown trout brood stock is occasionally placed in Lake Shastina (CDFG 2005c; Whelan 2005b). In the past CDFG planted coho salmon in Lake Shastina, but because they did not provide any substantial angling benefit this practice was discontinued (Whelan 2005b).

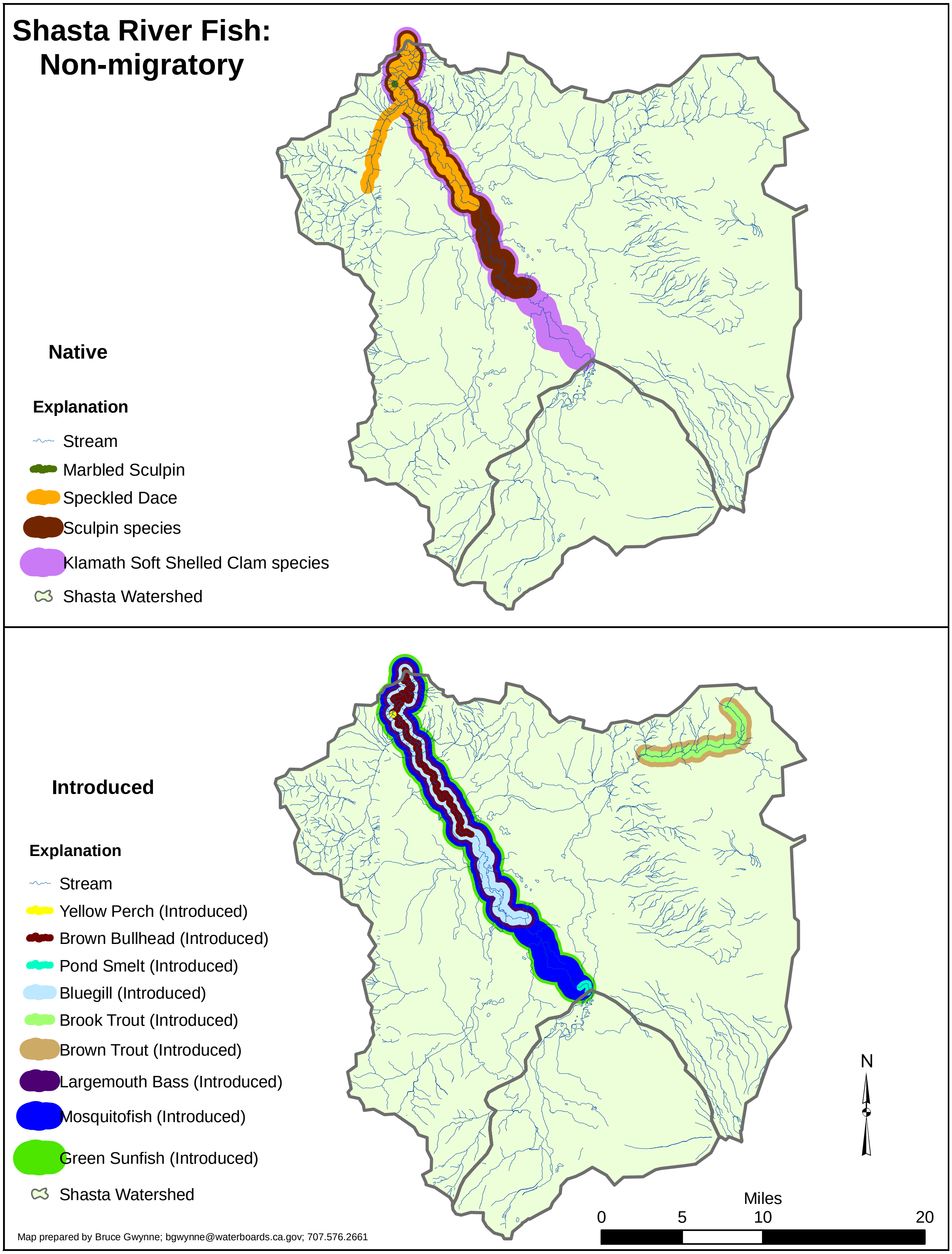

Figure 1.18: Distribution of non-migratory fish of the Shasta River watershed
Source: USFS 2005
Note: Klamath National Forest data (USFS 2005) do not include any information on these species above Dwinnell Dam, however CDFG (Whelan 2005b) have noted self-sustaining populations of brook trout in tributaries above Dwinnell Dam.

The following information on the status of some of the fish species in the Shasta River above the dam is from Whelan (2005b). The largemouth bass population appears strong and stable, while crappie numbers are lower than they have been in past years. This may be due to natural fluctuations in the crappie cycle or suppression in their numbers resulting from interactions with the strong year class of bass in the system. Information from electrofishing surveys indicate that brown trout appear to be doing well, although population size is not known. The upper reaches of various tributaries above Dwinnell Dam host self-sustaining populations of brook trout. Pond smelt are doing well and constitute a good forage base for the bass and trout. Angler data reflect stable brown bullhead numbers, while the status of the lamprey population is unknown.

1.4.12 Watershed Restoration and Water Quality Protection Efforts

Throughout the Shasta River watershed many individuals, groups, and agencies have been working to enhance and restore fish habitat and water quality. These proactive efforts have given the Shasta River watershed an advantage over other impaired watersheds with less active stakeholders. The implementation actions described in this document (Chapter 8) reflect the good work and watershed restoration efforts already underway within the Shasta River watershed.

The following sections describe some of the proactive and beneficial accomplishments of concerned citizens and agencies within the Shasta River watershed that address water quality and fisheries protection.

1.4.12.1 Shasta Valley Resource Conservation District

The Shasta Valley Resource Conservation District (SVRCD), like other resource conservation districts, is a local unit of government established to carry out natural resource management programs. The SVRCD was established in 1953 and focuses on coordinating and supporting landowner activities, both public and private. The SVRCD works to benefit agriculture while also protecting fish, wildlife, plants, and water quality. For further information please access the SVRCD website at <http://www.svrcd.org>.

1.4.12.2 Shasta River Coordinated Resource Management Planning

With fiscal and project management assistance from the SVRCD, the Shasta River Coordinated Resource Management Planning (Shasta River CRMP) group, a subcommittee of the SVRCD, has also been making significant strides in the restoration and management of the Shasta River and its tributaries. The Shasta River CRMP focuses on the diverse group of landowners and land use activities throughout the Shasta River watershed. The community-based nature of the Shasta CRMP, their accomplishments to date, their technical knowledge, their established history in the watershed, and the trust they have established with a diverse group of community members make the Shasta River CRMP an ideal group to help implement nutrient, dissolved oxygen, and temperature control practices.

1.4.12.3 Joint Projects of the Shasta Valley RCD and Shasta River CRMP

Since 1986, the SVRCD and the Shasta River CRMP together have been involved in developing and implementing many significant and beneficial water quality projects.

From 1986 until present a total of 164 projects have been implemented within the Shasta River watershed. The majority of these projects have been on private land. A total of $7.7 million dollars have been received from various funding sources including the California Department of Fish and Game, California Department of Water Resources, Klamath River Basin Fisheries Task Force, U.S. Fish and Wildlife Service, Natural Resources Conservation Service, National Marine Fisheries Service, U.S. Bureau of Reclamation, Environmental Protection Agency, North Coast Regional Water Quality Control Board, College of the Siskiyous, Fish and Game Commission, Cantara Council, and Siskiyou County Resource Advisory Committee

The following summary is based on the Shasta River restoration projects database maintained by the SVRCD and Shasta River CRMP.

- *Riparian Fencing projects* – A total of 39 riparian fencing projects are in progress or are completed in the watershed. Over 160,000 feet (30.3 miles) of fencing is in place along the banks of the Shasta River and its tributaries. This fencing protects the riparian zones from potential damage and pollutants associated with the numerous cattle ranches in the vicinity. These fences have created a buffer of non-grazed land along the Shasta, which helps protect the Shasta River's water quality and beneficial uses.
- *Riparian Planting projects* – A total of 22 riparian planting projects have been completed or are in progress in the Shasta River watershed. Multiple planting projects have been completed over the years in an effort to help protect the Shasta River. The river's banks at project locations have been repopulated with native riparian trees, which should both provide shade to help maintain lower water temperatures and also reduce sedimentation from eroding banks. Further steps have been taken to protect these newly replanted trees from the local beaver population by wrapping the lower trunks of the trees with 2" X 4" fence wire.
- *Bank Stabilization projects* – A total of 13 bioengineered bank stabilization projects are underway or completed in the Shasta River watershed. The task of bank stabilization has proven problematic as materials for willow mattresses, that prevent rapid erosion and gives time for vegetation to take root, are in very short supply. A number of trees have been planted along the Shasta River, which has greatly reduced the amount of erosion along the bank, and therefore the amount of sediment in the river.
- *Habitat Restoration projects* – A total of 7 projects aimed at restoring the riparian environment have been completed since 1986. These projects have included: the removal of garbage, the installation of boulder deflectors and general maintenance on the existing infrastructure.
- *Tailwater Management projects* – A total of 11 tailwater management projects are in progress or completed in the basin. These projects capture tailwater as it flows off a landowner's property and pump it to storage areas where it can be re-used for irrigation. By capturing and re-using this irrigation water, heated nutrient rich runoff is prevented from entering the Shasta River and its tributaries.
- *Education and Outreach projects* – A total of 9 education and outreach activities have been completed or are in progress throughout the watershed. This outreach

varies from providing ongoing support and coordination for the Shasta River CRMP to providing education and outreach to local landowners and groups throughout the basin.

- *Water Quality and Flow Monitoring projects* – A total of 13 water quality and flow monitoring projects have been conducted in the basin. In order to assess the progress made, several monitoring stations have been set up near the river to collect data. In addition to these stations, various groups and organizations have assisted in gathering data in cooperation with and independently of the Regional Water Board.
- *Fish Screening and Fish Passage projects* – A total of 4 fish passage and 13 fish screening projects are in-progress or completed in the Shasta River basin. Fish passage projects, including impoundment removal, have restored fish passage to parts of the system formerly inaccessible, while fish screens on water intake structures ensure than juvenile fish are not entrained in irrigation water.