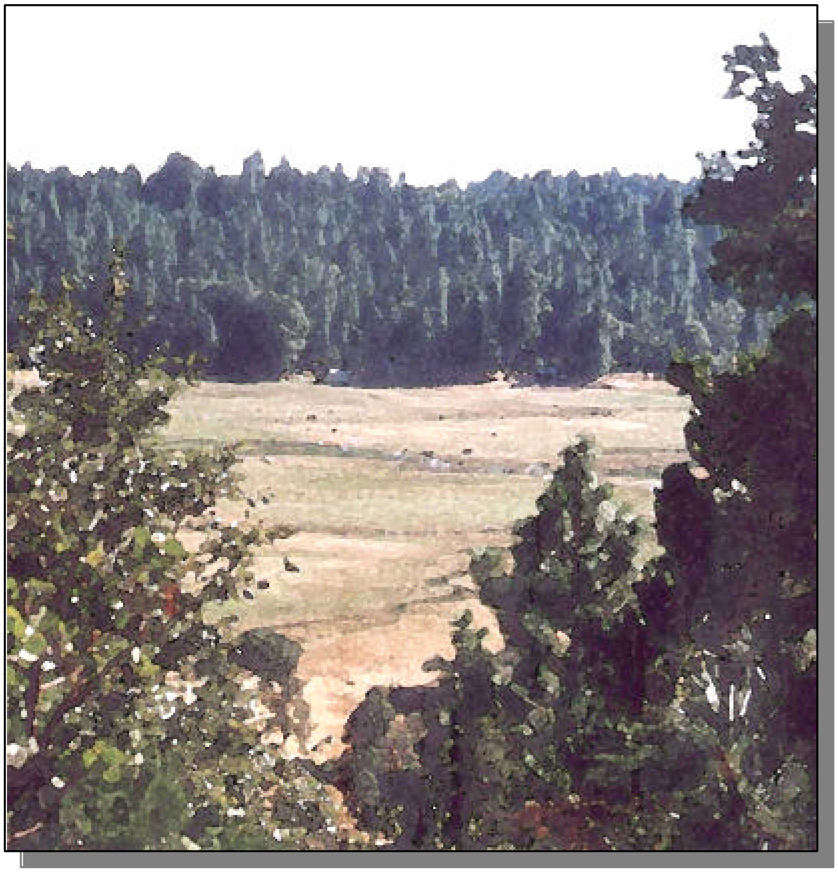
COW CREEK WATERSHED ASSESSMENT



Prepared for

**WESTERN SHASTA
RESOURCE CONSERVATION DISTRICT
and
COW CREEK WATERSHED MANAGEMENT GROUP**

Funding for this project was provided by grants from
the California State Water Resources Control Board (205J)
and the David and Lucille Packard Foundation.

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NOVEMBER 2001

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NOTE FROM THE AUTHOR

SHN Consulting Engineers has enjoyed preparing this Watershed Assessment for the Cow Creek Watershed Management Group. We appreciate the committed work of the Technical Advisory Committee and the Board of Directors. The process has not been without its differences of opinion. We have attempted, throughout the process, to incorporate comments and please all parties. This has not always been possible within the scope and budget of the project. With this in mind, we feel it is appropriate to clarify our target audience for this document, and our approach to technical conflicts, when they existed.

The document that follows is written for the watershed residents. Its goal is to present as much data as possible within the limited budget and scope of the process so that each individual in the watershed can begin their involvement in the watershed planning process with the same level of knowledge. The document is NOT a juried technical document, which was outside the scope of the project, and would not have met the objective of an easily readable and understandable document for watershed residents.

The available data specific to Cow Creek were limited. Where possible, SHN presented statewide data and opinions of professional scientists knowledgeable about the watershed. In some instances, these opinions vary. In these cases, we have attempted to provide both views. We felt this approach provided residents a better base of knowledge and issues. The conflict on certain topics displays that much work remains to be done to determine the ecosystem elements within the watershed that may require management or restoration.

The scope of the project did not include the verification of data, and errors may exist. In some instances, rounding errors resulted in certain columns not adding to a previous total. This is a function of the total number of polygons with the GIS databases.

Thank you again for the opportunity to work with the Cow Creek Watershed Management Group. We hope you will find the report enjoyable and informative.

SHN Consulting Engineers & Geologists, Inc.

COW CREEK WATERSHED ASSESSMENT
PUBLIC REVIEW DRAFT

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GLOSSARY

ACRONYMS

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AFRP	Anadromous Fish Restoration Program
AFRP	Anadromous Fish Restoration Plan
APCD	Air Pollution Control District
AQMD	Air Quality Management District
ARB	California Air Resources Board
ARD	Acid Rock Drainage
ATV	All-Terrain Vehicle
BLM	Bureau of Land Management
BMPs	Best Management Practices
BVWD	Bella Vista Water District
C	Centigrade
CalEPPC	California Exotic Pest Plant Council
CCR	California Code of Regulations
CDFA	California Department of Food and Agriculture
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
CLH	Crystal Lake Hatchery
CNPS	California Native Plant Society
CNWCPI	California Noxious Weed Control Project Inventory
COC	Constituents of Concern
CQA	Construction Quality Assurance
CVMP	California Vegetation Management Program (also VMP)
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWA	Clean Water Act
DAU	Cascade-North Sierra Nevada Deer Assessment Unit

DO	Dissolved Oxygen
DSH	Darrah Springs Hatchery
DSOD	California Division of Safety of Dams
DWA	Draft Watershed Assessment
DWR	California Department of Water Resources
EA	Environmental Assessment
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Federal Endangered Species Act
F	Fahrenheit
FGC	Fish & Game Code
FHWA	Federal Highway Administration
FONSI	Finding of No Significant Impact
FR	Federal Register
GAP	USGS Biological Resources Division Gap Analysis Program
General Plan	Shasta County General Land Use Plan
HCP	Habitat Conservation Plan
LAFCO	Local Agency Formation Council
MCL	Maximum Contaminate Level
mg/L	Micrograms per Liter
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MOU/MA	Memorandum of Understanding/Management Authorization
MSL	Mean Sea Level
NDDB	California Natural Diversity Database
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration

NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
PG&E	Pacific Gas and Electric Company
RB	Rural Residential B
RRLC	Red River Lumber Company
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SWP	State Water Project
SWRCB	California State Water Resources Control Board
SYP	Sustained Yield Plan
TPZ	Timber Production Zone
USACOE	U.S. Army Corps of Engineers
USBOR	U.S. Bureau of Reclamation
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
VMP	Vegetation Management Program
WCA	Whitmore Cattlemen's Association
WDR	Waste Discharge Requirement
WHR	Wildlife Habitat Relationships

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INTRODUCTION

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Section 1
INTRODUCTION

PROLOGUE

INTRODUCTION TO THE WATERSHED ASSESSMENT

The contract for the Cow Creek Watershed Assessment stated the scope as the following:

> The mission of the Cow Creek Watershed Assessment is to gather and integrate existing information on the physical, cultural and demographic variables that characterize the Cow Creek Watershed at present, and in the past. Where possible in the initial assessment, existing conditions that will be compared with earlier conditions in the time periods describe change through time. Data lacking for particular time periods should be noted. Any prior explanations or suggestions about causes of change, or effects of change, in any of these variables should be summarized and documented.
>
> The purpose of the Cow Creek Watershed Assessment is to inform interested individuals about the human, aquatic, riparian, and terrestrial features of the entire ecosystem, and to assist in identifying areas in which additional data are needed.
>
> Individuals, as well as public and private groups, need hard data for informed assessment of the effects of management decisions on the physical, commercial, and cultural environment of the Cow Creek Watershed. The Cow Creek Watershed Assessment will provide the beginning of a broad, landscape-scale description which, when combined with data from subsequent studies, will make possible such assessments.
>
> This watershed assessment can be considered the initial step in developing our knowledge of the physical, commercial, and cultural conditions within the Cow Creek Watershed ecosystem. It will be amended and extended as new information becomes available.
>
> The Cow Creek Watershed Assessment will follow a five-step process of analysis, which includes:
>
> 1. Characterization of the watershed in terms of defined variables and identification of the dominant physical, biological, and human processes and features of the watershed.
> 2. Descriptions of the current range, distribution and condition of ecosystem elements.
> 3. Descriptions of how these ecosystem elements have changed through time, where possible.
> 4. Synthesis of information, which compares existing and earlier ecosystem elements, and details studies and data needed to establish cause and effect relationships between change in one part of the ecosystem and another part.
> 5. Conclusion and suggestions, developed by the joint work of the Contractor and the Technical Team, responsive to watershed processes identified in the assessment.

BACKGROUND

Historic studies by the Regional Quality Water Control Board (RWQCB) in 1996 and Shasta College in May 2000 identified limiting elements in the watershed specific to anadromous fish resources. The 1996 study by the RWQCB found potential limiting factors of high temperature and low flow in the lower watersheds. In addition, the study identified high concentrations of fecal coliform in two of the five main tributaries.

A working paper on restoration needs, compiled by the Anadromous Fish Restoration Program Core Group in 1995, identified Cow Creek and its tributaries as in "relatively good condition" related to salmon and steelhead spawning habitat. The working group identified the primary limiting factors for Chinook salmon and steelhead as low fall and summer flows affecting attraction, migration, spawning, and rearing, caused in part by irrigation diversions. Irrigation diversions also affected steelhead by delaying or blocking adult upstream migration and entraining juvenile migrants. The report suggested that low flow conditions were a function of irrigation diversions.

The restoration report stated that, in general, agricultural diversions are unscreened, unladdered, and ditches unlined. It additionally stated that irrigation diversions typically operate from April through October and negatively affect stream flows important for all-run attraction, migration, and spawning. The same report suggested that livestock grazing has reduced riparian vegetation and eroded stream banks in the various tributary streams and in the main stem Cow Creek causing increased sedimentation and degradation of the quality of spawning gravel in Cow Creek. Increased demand for domestic water due to increased urbanization and development is reported to be affecting riparian habitat within the Cow Creek Watershed, especially in the vicinity of Palo Cedro, Millville, Oak Run and Bella Vista. The proposed restoration plan included provisions to provide additional flow, improve fish passages, reduce entrainment, and protect the riparian corridor.

The Central Valley Project Improvement Act Tributary Production Enhancement Report (CH2M HILL, 1998) states that:

> Loss of habitat from livestock grazing practices and agricultural diversion of water has reduced or degraded salmon and steelhead spawning and rearing habitats. Hydropower facilities also have altered instream flows. Agricultural diversions are unscreened resulting in the loss of juvenile fish emigrating from the watershed. Population growth in the communities of Palo Cedro, Bella Vista, Oak Run and Millville is increasing the demand for water and the associated development is impacting riparian areas within the lower watershed . . . .
>
> Water quality in Cow Creek has been significantly affected by siltation and erosion in the upper watershed. Streambanks have been eroded by excessive livestock grazing along Cow Creek and its principal tributaries. The resulting soil erosion and stream channel siltation have degraded salmon and steelhead spawning substrate in Cow Creek and its tributaries . . . .
>
> Elevated water temperatures in the summer, resulting from low stream flows and the lack of riparian cover resulting from livestock grazing, frequently reach levels that are detrimental or even lethal to salmon and steelhead.

The report identified six primary factors limiting anadromous fish production in Cow Creek:

1. Diversions decrease instream flows resulting in elevated spring, summer and fall water temperatures and reduced habitat availability.

2. Barriers limit upstream passage of adults.
3. Juveniles are entrained at irrigation and other unscreened diversions.
4. Livestock grazing results in sedimentation of substrate and the loss of riparian cover.
5. Urbanization and creekside development results in habitat loss and degradation.
6. Gravel mining removal of riparian vegetation and spawning gravel from the stream.

The report identified three action items, which included:

1. Screen all diversions to protect all life history stages of anadromous fish.
2. Improve passage at agricultural diversion dams.
3. Fence select riparian corridors within the watershed to exclude livestock.

The initial reports raised the awareness and concern of stakeholders in the Cow Creek Watershed, including the many landowners that are dependant upon the health of the watershed for their livelihood. In response to the many concerns, the Cow Creek Watershed Management Group was formed as a non-profit organization with the mission of using the resources in the Cow Creek Watershed in a way to meet the needs of today without infringing upon the needs of future generations. The first step for the watershed group included obtaining grant funding with assistance from the Western Shasta Resource Conservation District to conduct a preliminary watershed assessment/current conditions report for the watershed.

FUNDING SOURCES

Funding for this watershed assessment was provided by a 205j grant from the California State Water Quality Control Board administered through the California Regional Water Quality Control Board Central Valley Region, and a David and Lucille Packard Foundation grant. The funding was obtained through the Western Shasta Resource Conservation District.

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WATERSHED GENERAL CHARACTERIZATION

The Cow Creek Watershed is a generally uncontrolled tributary to the Sacramento River and is located in Shasta County on the eastern side of the Sacramento River downstream of Shasta Lake. No major water storage reservoir is located on Cow Creek. General vicinity of the watershed is included on Figure 1-1. Several tributaries, which include Little Cow Creek, Oak Run Creek, Clover Creek, Old Cow Creek, and South Cow Creek flow in a southwesterly direction and form the main stem of Cow Creek in Millville.

SUB-WATERSHEDS

The sub-watersheds of Cow Creek used for this report are summarized in Figure 1-2. These watersheds vary from the standard Calwater units as the latter did not appear to present a reasonable picture of the true boundaries. The boundaries used for this report include the same boundaries used by previous investigators in the watershed.

The watershed encompasses approximately 275,000 acres. Actual acreages calculated for each sub-watershed are included as Table 1-1.

TABLE 1-1
Sub-Watersheds Cow Creek

Sub-Watershed Classification	Acres	Percent	Basin Area (sq. miles)	Stream Length (miles)
Little Cow Creek	91,900	33	148	36.0
Oak Run Creek	30,138	11	42	24.5
Clover Creek	34,917	13	54	27.5
Old Cow Creek	54,420	20	80	32.9
South Cow Creek	50,479	18	78	28.5
Main Stem Cow Creek	12,830	05	29	15.0
Total	274,684	100	431	164.4

LAND OWNERSHIP

General ownership within the watershed is included on Figure 1-3. Land ownership in the Cow Creek Watershed consists of both public and private lands. Table 1-2 shows the number of acres that are in public and private ownership. The Latour State Forest is the predominant public owner, which is located in the southeastern corner of the watershed. Roseburg Resources Company owns the majority of the privately held land in the watershed.

TABLE 1-2
Land Ownership in Cow Creek Watershed

Ownership	Acres
Government Owned	**15,303**
BLM	3,201
Shasta-Trinity National Forest	481
Lassen National Forest	3,172
Latour State Forest	8,416
State Lands	33
Privately Owned	**259,381**
Sierra Pacific	5,410
Roseburg	41,885
Beaty Managed	24,395
Williamson Act	75,121
Other	112,570
TOTAL	**274,684**

TOPOGRAPHY

The topography of the Cow Creek Watershed varies significantly from the flat valley areas around the main stem to the mountainous upper reaches. Watershed topography is included as Figure 1-4. A summary of the USGS Quadrangle Maps within the watershed is included as Figure 1-5. The slope gradient and aspect of the watershed vary significantly and are discussed in detail later in this report.

ELEVATION

Elevation of the watershed varies from 340 feet above sea level at the valley floor to over 7300 feet at the upper reaches of the watershed. Elevational bands are shown on Figure 1-6. This steep elevational gradient results in a diverse mix of ecotypes throughout the watershed. The steep gradient and natural geologic barriers are key elements in determining the restorability of the anadromous fishery.

GEOLOGY

California Division of Mines and Geology has subdivided California into twelve geologic provinces, each with a different geologic history (California Division of Mines & Geology Bulletin 190). Due to the differences in geology, including rock type, structure and mineral deposits, each province is unique in its geography and topography. The Cow Creek Watershed encompasses portions of three geomorphic provinces including the Cascade Range, the Klamath Mountains and the Great Valley. The location of these geomorphic provinces within the Cow Creek Watershed, the history of each province and their individual geologic characteristics are discussed in this section. The geology of the Cow Creek Watershed is shown on Figure 1-7.

A summary of the geologic formations exposed in the Cow Creek Watershed is provided in Table 1-3. For reference, the relative age of these formations is shown in Figure 1-8.

TABLE 1-3
Geologic Summary

Principal Rock Type	Map Symbol	Description	Percent of Watershed
Intrusive dacite domes, basalt flows and pyroclastic deposits	Qrv	Volcanic rock	1
Tehama and Red Bluff Formations, river terrace deposits and alluvium	QP	Non-marine sedimentary and unconsolidated deposits	14
Tuscan Formation and Nomlaki Tuff Member of Tuscan and Tehama Formations	TQ_V	Cinder cones, andesitic and basaltic flows.	60
Montgomery Creek	Ec	Non-marine sedimentary rocks.	2
Chico Formation and similar units	K	Marine sedimentary rocks	11
Bully Hill Rhyolite and association complex	JT	Metamorphosed volcanic and sedimentary rock	12

Cascade Range Province

The Cascade Range geomorphic province occupies the eastern half of the Cow Creek Watershed, including the headwaters of the principal Cow Creek tributaries including South Cow Creek, Old Cow Creek, Clover Creek, Oak Run Creek and Little Cow Creek.

The Cascade Range extends from northern California northward through Oregon and Washington, and into British Columbia. The range consists of a chain of ancestral volcanic centers that began to erupt during Eocene time when the Farallon plate began to subduct beneath the North American plate. As a result, the Cascade Range is comprised of volcanic deposits associated with ancestral volcanism, and sedimentary deposits associated with depositional basins that were located adjacent to the ancient volcanic centers.

In Shasta County, the most widespread and continuous unit of the Cascade Range province is the Pliocene Tuscan Formation. The Tuscan Formation is exposed over approximately 60 percent of the assessment area, and it consists of resistant andesitic, dacitic and basaltic volcanic breccia, tuff breccia, and interlayered flows, sand, gravel, and tuff (Lydon and O'Brien, 1974). Locally, the Tuscan Formation lies unconformably over a weakly consolidated formation known as the Montgomery Creek Formation (Bailey, 1966). The Montgomery Creek Formation is Eocene in age and is composed predominantly of massive sandstone. Capping the Tuscan Formation is a complicated succession of Pleistocene basalt and andesite flows originating from eruptive centers located primarily to the east of the assessment area.

Rocks of the Montgomery Creek Formation are exposed primarily along portions of the incised drainage channels and/or tributaries of South Cow Creek, Old Cow Creek, Clover Creek, and Little

Cow Creek. These exposures are generally concentrated where the channels intersect a north-south trending lineation situated around 122^o West longitude. Due to the weak consolidation of the Montgomery Creek Formation, it is common to have extensive landsliding of overlying resistant rocks (i.e., the Tuscan Formation). This typically occurs where the stream channels have been incised into the Montgomery Creek Formation (Bailey, 1966).

Klamath Mountains Province

A portion of the Klamath Mountains physiographic province is situated in the northwest corner of the Cow Creek Watershed. The southern and eastern extent of the province is situated around 40^{o}40' North latitude and 122^{o}00' West longitude, respectively. The Klamath Mountains province occupies portions of the hydrologic basins of Clover Creek, Oak Run Creek, and Little Cow Creek.

The Klamath Mountains represent a complex, poorly understood region of very old bedrock materials that are the subject of on-going speculation regarding the area's depositional and tectonic history. The region is characterized by a series of Paleozoic to lower Mesozoic volcanic-arc sequences (i.e., paleo-volcanic chains similar to the modern Cascade Range) that were accreted to the North American continent during ancient subduction at the ancestral plate boundary (Potter et. al., 1990; Hacker and Peacock, 1990). The arc sequences contain both volcanic deposits associated with ancestral volcanic centers, and sedimentary deposits associated with depositional basins that were located adjacent to the ancient volcanic chains. The Klamath Mountains province is subdivided into three sub-provinces that include the Western Paleozoic Belt, the Central Metamorphic Belt, and the Eastern Paleozoic and Triassic Belt. The Cow Creek Watershed only occupies portions of the Eastern Paleozoic and Triassic Belt. No portion of the watershed drains rock made up of the Central Metamorphic Belt or the Western Paleozoic Belt.

The Eastern Paleozoic and Triassic Belt is comprised of interbedded metasedimentary and metavolcanic rocks, ranging in age from middle Devonian to Late Triassic and divided into 13 recognized formations. Included in the thirteen formations are the Bully Hill Rhyolite, the Pit Formation and the Hosselkus limestone. The Bully Hill formation is Triassic in age and outcrops in the vicinity of Ingot. Siliceous lava flows and pyroclastic rocks comprise the bulk of the Bully Hill Rhyolite. The Bully Hill Rhyolite is known as a being an economic source of sulfide deposits. Located stratographically higher then the Bully Hill Rhyolite is the Pit Formation. The Pit Formation is composed of shale, mudstone, and siltstone, with interlayers of tuff and tuff breccia (Lydon and O'Brien, 1974). Conformably overlying the Pit Formation is the Hosselkus Limestone of Late Triassic age. The Hosselkus Limestone outcrops along Highway 299 near Ingot. Overlying the principal bedrock of the Eastern Paleozoic and Triassic Belt are younger rocks composed of the aforementioned Tuscan Formation.

Great Valley Province

The Great Valley province occupies the southwest 1/3 of the Cow Creek Watershed. The Great Valley is a large elongate northwest-trending asymmetric structural trough that has been filled with a thick sequence of sediments ranging in age from Jurassic to Recent (Bailey, 1966). The assessment area occupies a portion of the northern Great Valley commonly referred to as the Sacramento Valley. In this area the principal rock types consist of marine and non-marine sedimentary rocks deposited by the erosion of the surrounding bedrock (e.g. rock composed of the Cascade Range and the Klamath Mountains). These deposits have been subdivided into the Chico formation, the Tehama Formation and the Red Bluff Formation.

As water flows out of the surrounding mountains of Cascade Range and Klamath Mountains, to the east and north respectively, it encounters marine deposits situated in the northeastern part of the Great

Valley geomorphic province. These rocks are composed primarily of marine sandstone, shale, and conglomerate, and are Early to Late Cretaceous in age. Some of these rocks are assigned to the Chico Formation. Principal exposures of the Chico Formation are located along the high-order segments of South Cow Creek, Old Cow Creek, Clover Creek, and Oak Run Creek, west of their intersection with 122^{o} North longitude. In this area, the Chico Formation is interfingered with deposits of the Tuscan Formation.

The southwestern portion of the Cow Creek Watershed is underlain by rocks composed of the Tehama and Red Bluff Formations, which consists of massive, uncemented, poorly sorted silt with conglomeratic lenses and clayey interbeds derived from tuffaceous material (Lydon and O'Brien, 1974). The sediments that lie within the watershed could be considered "Tuscan-Tehama sediments" which consists of pebbles and sand derived from the basement complex of the Klamath Mountains, intimately mixed with volcanic pebbles, sand, and ashy silt and clay derived from the eastern source. These sediments underlie mudflow deposits of the Tuscan Formation near and east of Bella Vista and Palo Cedro.

Mineral and Hydrologic Resources

The Cow Creek Watershed encompasses a geologic diverse region that varies in rock type. Consequently, the mineral and hydrologic resources of the region are also variable. The mineral and hydrologic resources identified within the Cow Creek Watershed are summarized by principal physiographic province in Table 1-4. Much of the information provided in these tables is adapted from Lydon and O'Brien, 1974, and Albers and Robertson, 1961.

TABLE 1-4
Mineral And Hydrologic Resources

Principal Rock Types	Potential and Actual Mineral Resources	Hydrologic Resources
Cascade Range		
Pleistocene and Holocene channel and terrace deposits	Sand and gravel, gold, and platinum	Limited groundwater
Pleistocene lava flows and intrusive rock	Dimension and crushed stone	N/A
Tuscan Formation	Dimension and crushed stone	Limited groundwater, hydroelectric generation
Montgomery Creek Formation	Coal, sand and gravel	Poor quality groundwater
Klamath Mountains		
Hosselkus Limestone	Limestone	N/A
Pit Formation	Limestone, crushed stone, massive sulfide ore (zinc, copper, silver, lead, gold, pyrite), manganese, barite, and graphite	N/A
Bully Hill Rhyolite	Massive sulfide ore (zinc, copper, silver, lead, gold, pyrite), mercury.	N/A
Great Valley		
Red Bluff Formation	Sand and Gravel, gold, brick clay	N/A
Tehama Formation	Natural gas (in the Corning area), sand and gravel, and clay	Principal groundwater producer for the region
Chico Formation	Dimension stone, natural gases	Poor quality groundwater

One of the more recognizable mines within the Cow Creek Watershed is the Afterthought Mine located approximately 25 miles northeast of Redding on Highway 299E in Sections 10 and 11, Township 33 North, Range 02 West, Mount Diablo Base and Meridian. The Afterthought Mine is located along Little Cow Creek, approximately one mile upstream from the town of Ingot. The Afterthought Mine was first patented in 1862 and the principal ore removed from the mine included zinc, copper, silver, lead, gold, pyrite, and mercury. In general, the mine workings are located in a massive sulfide deposit associated with the Bully Hill Rhyolite Formation. This sulfide deposit extends from the Afterthought Mine in the east to the Greenhorn Mine in the west. The more recognizable Iron Mountain Mine is located in the same massive sulfide deposit.

The main Afterthought ore bodies are located at the surface (Copper Hill ore body) and at a depth of between 450 and 600 feet. A tunnel used to transport the copper ore from the 400-foot level, intersects the surface near Little Cow Creek. Acid Rock Discharge (ARD) from this flows into Little Cow Creek. A cross-section of this tunnel and the underground workings is provided in Figure 1-9. The Afterthought Mine was operated off and on by different owners from 1862 to 1952. It has remained idle since.

Geologic Issues

Watershed geology and hydrogeology are foundations for much of what will occur in the watershed in the future. Key issues that will affect restoration, future land uses, and general watershed health associated with the watershed geology include:

- Poor water yields in the Little Cow sub basin with Bully Hill ryholite and associated complexes
- Poor water quality and yields in the areas of the center of the entire watershed underlain by Chico formation
- Physical barriers (waterfalls) located at the break in geology limit anadromous fish passage to upper reaches of four of five tributaries
- Tuscan/Montgomery Creek interface as source of numerous springs and water supply
- Unconsolidated nature of the Montgomery Creek formation has resulted in many historical rotational/transitional slides occurring next to streams. Additional slides are likely to occur in the future in these areas.

SOILS AND PRIMARY VEGETATION TYPES

Shasta County contains three major soil associations or soil groups. Soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern. All three associations are found in the Cow Creek Watershed and include soils of:

1. mountains;
2. foothills; and
3. terraces, valley bottoms, and flood plains.

One or more soil associations are in each part. The soil associations have been grouped mainly on the basis of soil differences that are related to their physiographic features and to differences in parent rock, slope, aspect precip itation, and vegetation potential. Dominant associations and associated soil series are summarized in Table 1-5 and discussed further in this section.

TABLE 1-5
Dominant Type Soil Summary*

Association	Soil Series	Acreage	Coverage Type	Description
Mountain	Cohasset-Windy-McCarthy	108,210	Ponderous pine, Douglas fir, white fire, sugar pine, black oak, manzanita	Well-drained very gravelly or very cobbly sandy loams and gravelly and very cobbly clay loams.
Mountain	Josephine-Marpa-Sheetiron	4,660	Conifer-hardwood (Douglas-fir, pine, oak)	Well-drained and somewhat excessively-drained gravelly and very gravelly loams and clay loams.
Foothill	Millsholm-Sehorn-Gaviota	15,000	Grasses, forbs, oaks, and gray pine	Well-drained and somewhat excessively-drained sandy loams to loams and silty clays to silty clay loams.
Foothill	Kilarc-Sites	31,740	Mixed conifers, oaks, shrubs, grasses	Moderately well-drained and well-drained clays and clay loams
Foothill	Auburn-Goulding-Neuns	15,290	Mixed conifers, oaks, shrubs	Well-drained gravelly loams and clay loams and very gravelly silty clay loams.
Foothill	Toomes-Guenoc-Supan	48,930	Oaks, gray pine, shrubs	Well-drained and somewhat excessively-drained stony loams and gravelly to very cobbly clay loams.
Terrace	Newton-Red Bluff	28,370	Grasses, oaks, shrubs and gray pine	Well-drained and moderately well-drained clays and clay loams.
Terrace	Churn-Perkins-Tehama	470	Oaks, gray pine, shrubs, grasses, forbs	Well-drained and moderately well-drained clay loams and silty clay loams.
Terrace	Tuscan-Igo	12,860	Grasses, forbs and scattered oaks	Well-drained cobbly clay loams and gravelly loams that contain hardpan.
Terrace	Reiff-Cobbly	110	Cottonwood, sycamore, willow, and oak trees-shrubs and annual grasses	Moderately well-drained and excessively-drained loamy fine sand to loams and frequently flooded cobbly land.

* Will not add to 274,684, as it is only dominant types.

There are four associations that make up the foothill soils. These cover 112,870 acres or approximately 42 percent of the watershed. Foothills soils are rolling to steep and occupy less rugged topography at lower elevations. Annual precipitation ranges from 25 to 70 inches. Vegetation on these less productive soils is generally grass, grass-oak, brush, and conifers.

The remainder of the watershed is considered terrace, valley bottom, or flood plain. This physiographic region consists of soils on dissected terraces that are nearly level or on broad tops with steep side slopes with nearly level soil in the valley bottoms and on flood plains. Elevation ranges from 350 to 1000 feet. The vegetation is grass-oak, brush, gray pine, cottonwood, and sycamore. This mixed alluvium, resulting from faulting, glacial activity, or deposition make up 15.8 percent of the watershed. Figure 1-10 shows the soils mapped for the Cow Creek Watershed under the US Department of Agriculture Soil Survey.

Mountain Soils

Cohasset-Windy-McCarthy. The most common soils found in the Cow Creek Watershed are those of the Cohasset-Windy-McCarthy series. This association generally grouped as a mountain soil, is derived from weathered volcanic rock of Tuscan formation. This association is generally level to very steep, rich well-drained loams to gravelly and very cobbly clay loams. The deep, rich well-drained soils of this association are exceptional timber producing soils and make up the majority of the soils owned by large timber companies. Limited areas have been converted to local irrigated pastures and apple orchards. Basic volcanic rocks of the Tuscan Formation underlie the association. The vegetation on these soils generally includes ponderosa pine, Douglas fir, white fir, red fir, sugar pine, and black oaks. In places, large brush fields of manzanita and chinquapin are mixed with young conifers. The annual precipitation is 35 to 70 inches. In the preliminary assessment of the area, Cohasset-Windy-McCarthy soils make up about 41 percent of the area.

The Cohasset series consists of well-drained soils that are underlain by volcanic rocks. Slopes range from 0 to 65 percent. Elevation ranges from 2500 to 5000 feet. Annual precipitation is generally 35 to 60 inches. The surface layer consists of dark reddish-brown and yellowish-red loam, about 18 inches thick. The subsoil is yellowish-red, gravelly clay loam that grades to a yellowish-red, very cobbly clay loam at a depth of about 53 inches. Parent material is andesite. Vegetation is mixed conifers.

The Windy series consists of well-drained soils that are underlain by basic volcanic rock. Slopes range from 0 to 75 percent. Elevation ranges from 4000 to 7000 feet. The annual precipitation is 40 to 50 inches. The surface layer is a very dark grayish-brown, stony sandy loam and loamy sand about 8 inches thick. The subsoil is light yellowish-brown, very gravelly sandy loam about 34 inches thick. Parent material is at a depth of 42 inches. Vegetation is mixed conifers and brush.

The McCarthy series consists of well-drained soils that are underlain by basalt. Slopes range from 0 to 85 percent. Elevation ranges from 2000 to 5000 feet. Annual precipitation is 35 to 70 inches. The surface layer is a dark-brown, stony sandy loam and gravelly sandy loam about 20 inches thick. The upper part of the subsoil is strong-brown, very cobbly sandy loam about 13 inches thick. The lower part of the subsoil is yellowish-red, very cobbly sandy loam. Hard basalt is found at a depth of about 44 inches. Vegetation is mixed conifers and brush.

Josephine-Marpa-Sheetiron. The Josphine-Marpa-Sheetiron association covers 4,660 acres in the Cow Creek Watershed. This association is considered mountain soils and consists on some of the most rugged topography in the area, on narrow ridge tops and deeply entrenched valleys. The soils in this association formed in material that weathered from sandstone, shale, and slate. Slopes are 50 percent in the majority of the area. Elevations range from 800 to 5000 feet, with an annual precipitation of 30 to 60 inches. The vegetation is generally conifer-hardwood type and included Douglas fir, pine, oak, and shrubs. This association is generally steep, well-drained and somewhat excessively-drained gravelly and very gravelly loams and clay loams. These soils are underlain by sedimentary and metamorphic rock. The productivity of this association is limited by the steepness of the terrain, which characterizes the association. The steep slopes result in sediment transport if disturbed. Although the soil types within this association can support timber stands, the productivity is lessened and harvest is difficult. The steep topography limits any additional uses.

The Josephine series consists of well-drained soils that are underlain by sedimentary or metasedimentary rock. Slopes range from 10 to 70 percent. Elevation ranges from 1000 to 5000 feet, with an annual precipitation of 30 to 60 inches. The surface layer is brown, slightly acid gravelly loam about 4 inches thick. The upper subsoil is light brown, medium and strongly acid gravelly clay loam. The lower part is at about 45 inches and is light reddish brown, strongly acid very stony clay loam. Shale and sandstone are at a depth of about 60 inches. The vegetation is mixed conifers, oaks, shrubs, and grasses.

The Marpa series consists of well-drained soils that are underlain by shale or slate. Slopes range from 30 to 75 percent. Elevation ranges from 800 to 4500 feet. The annual precipitation is 40 to 50 inches. The surface layer is brown, slightly acid gravelly loam about six inches thick. The upper part of the subsoil is brown, slightly acid gravelly loam about 7 inches thick. The lower part of the subsoil is light-brown, strongly acid very gravelly clay loam. Fractured shale is at a depth of about 26 inches. Vegetation is mixed conifers, oaks, and shrub.

The Sheetiron series consists of well-drained and somewhat excessively-drained soils that are underlain by sedimentary or metamorphic rock. Slopes range from 30 to 90 percent at elevations of 1000 to 5000 feet. In a representative profile, a gray to light gray very stony to gravelly loam exists to about 9 inches. The subsurface layer is light-gray gravelly loam and very pale brown very gravelly loam. Fractured slate is at about 22 inches. The vegetation is ponderosa pine, sugar pine, Douglas fir, white fir, incense cedar, canyon live oak, and black oak.

Foothills Soils

Millsholm-Sehorn-Gaviota. The Millsholm-Sehorn-Gaviota association covers 15,000 acres in the Cow Creek Watershed. This association is considered foothills soils and consists of very steep soils on short slopes of low rolling hills and of nearly level to sloping soils in broad valleys. The soils in this association formed in material that weathered from sandstone, shale, conglomerate and metamorphic rocks. This association is generally well-drained and somewhat excessively-drained sandy loams, to loams and silty clays to silty clay loams, underlain by sedimentary and metamorphic rocks. Slopes range from 0 to 75 percent, with elevations from 600 to 1800 feet. The annual precipitation is 25 to 40 inches. The vegetation on the Millsholm and Gaviota soils is grasses, forbs, oaks, and gray pine; and the vegetation on Sehorn soils is grasses. The soils of this association are well-drained to excessively well-drained and are generally used for range. Within the Cow Creek Watershed, a small acreage has been converted to irrigated pasture.

The Millsholm series consists of well-drained soils that are underlain by sedimentary and metasedimentary rock. Slopes range from 3 to 75 percent. Elevation ranges from 700 to 1880 feet. The annual precipitation is 30 to 40 inches. The surface layer is grayish-brown and light brownish – gray, slightly acid gravelly loam about 7 inches thick. The subsoil is brown, medium acid gravelly loam. Sandstone and conglomerate are at a depth of 16 inches. The vegetation is annual grasses and forbs, blue oak, gray pine, poison oak, and manzanita.

The Sehorn series consists of well-drained soils that are underlain by sedimentary rocks. Slopes range from 3 to 70 percent. Elevations range from 800 to 1600 feet. The annual precipitation is 25 to 35 inches. The surface layer is light olive-brown, slightly acid silty clay about 20 inches thick. The substratum is mottled, grayish-brown, light olive brown, and yellowish-brown, neutral silty clay loam. Weathered calcareous shale is at a depth of about 28 inches. Vegetation is grasses or, in a few places, grass-oak.

The Gaviota series consists of well-drained and somewhat excessively-drained soils that are underlain by sandstone or conglomerate. Slopes range from 0 to 50 percent. Elevation ranges from 600 to 1000 feet. The annual precipitation is 30 to 40 inches. The surface layer is yellowish-brown, medium acid and slightly acid sandy loam about 17 inches thick. It is underlain by hard sandstone. Vegetation is annual grasses, blue oak, interior live oak and gray pine.

Kilarc-Sites. This association occupies 31,740 acres of the Cow Creek Watershed, consisting of rolling soils on hills and in broad valleys at lower elevations. They are moderately well-drained and well-drained clays and clay loams underlain by sedimentary and metamorphic rock. Slopes range from 2 to 70 percent at elevations ranging from 600 to 4000 feet. The vegetation on Kilarc soils is oaks, gray pine, shrubs, and grasses. On Sites soils, vegetation consists of mixed conifers, oaks, shrubs, and grasses. The Kilarc-Sites association is a shallow moderately drained poor producing soil prone to landslides and mass movement. The timbered portions of the Kilarc–Sites series support sparse stands of lower site quality. The soils generally support oak woodland and scrub woodland communities.

The Kilarc series consists of moderately well-drained soils underlain by sandstone, shale, or conglomerate. Slopes range from 2 to 50 percent. Elevation ranges from 600 to 3000 feet. The annual precipitation is 35 to 70 inches. The surface soil is grayish-brown, slightly acid very stony light loam and sandy clay loam about 9 inches thick. The upper part of the subsoil is light brownish-gray and pale-brown, extremely acid clay about 12 inches thick. The substratum is light-gray, very strongly acid sandy clay loam. Unaltered weakly consolidated sandstone is at a depth of 44 inches. Vegetation is blue oak, Garry oak, interior live oak, gray pine, whiteleaf manzanita, poison oak, and annual and perennial grasses.

The Sites series consists of well-drained soils that are underlain by sedimentary or metamorphic rock. Slopes range from 5 to 70 percent. Elevation ranges from 1000 to 4000 feet. The annual precipitation is 30 to 40 inches. The surface layer is reddish-brown, medium acid loam about 14 inches thick. The subsoil is yellowish-red, very strongly acid clay loam and clay that grades, at a depth of about 41 inches, to strong-brown, very strongly acid clay loam. The underlying material, at a depth of 63 inches, is light yellowish-brown, very strongly acid sandy loam. Vegetation is mixed conifers, oaks, shrubs, and grasses.

Auburn-Goulding-Neuns. This association makes up 15,290 acres, consisting of very steep soils on sides of narrow valleys at higher elevations and smooth rolling soils in broad valleys at lower elevations. The soils in this association formed in material weathered from greenstone and other basic metavolcanic rock. It is well-drained gravelly loams and clay loams and very gravelly silty clay loams, underlain by partly metamorphosed volcanic rock. Slopes are generally 0 to 80 percent at elevations ranging from 700 to 5000 feet. The vegetation on Auburn and Goulding soils consists of shrubs, oaks, gray pine, and grasses. Shrubs are the main vegetation in many places. The shallow soils of the association have been removed in the northern portion of the Cow Creek Watershed to expose bedrock containing copper and zinc. Many abandoned mines within Shasta County are found within this association, including the Afterthought Mine.

The Auburn series consists of shallow well-drained clay loams that are underlain by basic metavolcanic rock, mainly greenstone. Slopes range from 0 to 70 percent. Elevation ranges from 700 to 1500 feet. The surface layer is yellowish-red, medium acid clay loam about 5 inches thick. The subsurface soil is yellowish-red, medium acid gravelly clay loam. Decomposed greenish-gray, slightly acid metavolcanic rock mixed with gravelly clay loam is at a depth of about 27 inches. Vegetation is manzanita, blue oak, interior live oak, annual grasses, and gray pine.

The Goulding series consists of well-drained soils that are underlain by greenstone. Slopes range from 10 to 70 percent. Elevation ranges from 700 to 1500 feet. The annual precipitation is 40 to 55 inches. The surface layer is brown, slightly acid very stony loam about 5 inches thick. The subsoil and substratum are pale-brown, medium acid gravelly loam. Fractured greenstone is at a depth of 16 inches. Vegetation is shrubs and grass-oak.

The Neuns series consists of well-drained soils that are underlain by basic metavolcanic rock, mainly greenstone. Slopes range from 8 to 80 percent. Elevation ranges from 1000 to 5000 feet. The annual precipitation is 30 to 60 inches. The surface layer is pale-brown, medium acid very stony loam about 5 inches thick. The substratum is very pale brown, strongly acid gravelly and very gravelly silty clay loam. Fractured greenstone is at a depth of about 23 inches. Vegetation is mixed conifers, oaks, and shrubs.

Toomes-Guenoc-Supan. This association makes up 48,930 acres, consisting of nearly level to sloping soils on broad ridges and moderately steep to steep soils on side slopes. The soils in this association are underlain by andesitic tuff breccia and lava flow rocks. They are well-drained and somewhat excessively-drained stony loams and gravelly to very cobbly clay loams. Slopes are generally 0 to 50 percent at elevations ranging from 800 to 2000 feet. The vegetation on Toomes soils is grasses, forbs, and an open stand of oaks, shrubs, and gray pine. The vegetation on Guenoc and Supan soils is grasses, forbs, and an open dense a stand of woody vegetation consisting of oaks, gray pine, and shrubs.

The Toomes series consists of well-drained and somewhat excessively-drained soils that are underlain by lava or tuff breccia. Slopes range from 0 to 50 percent. Elevations range from 800 to 2000 feet. The annual precipitation is 30 to 40 inches. The subsurface layer is brown, slightly acid very stony and stony loam. Tuff breccia is at a depth of about 11 inches. Vegetation is annual grasses and scattered blue oak, interior live oak, wedgeleaf ceanothus, manzanita, and gray pine.

The Guenoc series consists of well-drained soils that are underlain by volcanic rocks. Slopes range from 0 to 50 percent. Elevations range from 800 to 1500 feet. The annual precipitation is 30 to 40 inches. The surface layer is reddish-brown, slightly acid very stony loam about 5 inches thick. The subsoil is dark-red, slightly acid cobbly clay loam and dark-red, medium acid very cobbly heavy clay loam. Andesite bedrock is at a depth of about 23 inches. Vegetation consists of annual grasses, blue oak, interior live oak, manzanita, and gray pine.

The Supan series consists of well-drained soils that are underlain by tuffaceous breccia. Slopes range from 0 to 50 percent. Elevation ranges from 800 to 2000 feet. The annual precipitation is 30 to 40 inches. The surface layer is dark grayish-brown, mildly alkaline and neutral very stony loam and loam about 10 inches thick. The subsoil is dark-brown, neutral and slightly acid gravelly clay loam. Tuff breccia is at a depth of about 33 inches. Vegetation is annual grasses, oaks, gray pine, and shrubs.

Terraces, Valley Bottoms, and Flood Plains

Newtown-Red Bluff. This association makes up 28,370 acres, consisting of sloping to steep soils on side slopes of terraces and of nearly level soils on broad terrace tops. Red Bluff soils are nearly level to gently sloping. Newtown soils are moderately sloping to steep and are on the sides of terraces. The soils in this association were formed in weathered gravelly alluvium from mixed sources; they are well-drained and moderately well-drained clays and clay loams. Slopes are generally 0 to 50 percent at elevations ranging from 500 to 1000 feet. The vegetation on these soils is grasses, oaks, shrubs, and gray pine.

The Newtown series consists of well-drained soils that formed in old alluvium from mixed sources. Slopes range from 8 to 50 percent. Elevation ranges from 500 to 1000 feet. The annual precipitation is 28 to 40 inches. The surface layer is brown, slightly acid gravelly loam and mixed very pale brown and brown, slightly acid very gravelly clay loam about 18 inches thick. The subsoil is brown, strongly acid clay and pale-brown, slightly acid silty clay loam. At a depth of about 65 inches, the substratum is pale-brown, neutral cobbly silty clay loam. Vegetation is grasses, forbs, oaks, shrubs, and gray pine.

The Red Bluff series consists of well-drained and moderately well-drained soils that formed in gravelly old alluvium from mixed sources. Slopes are 0 to 8 percent. Elevation ranges from 600 to 900 feet. The annual precipitation is 25 to 35 inches. The surface layer brown, very strong acid loam about 6 inches thick. The upper 22 inches of the subsoil is yellowish-red, very strongly acid and strongly acid clay loam. The lower 29 inches of the subsoil is red, strongly acid heavy clay loam and light clay. A light-brown, medium acid clay loam substratum that extends to a depth of more than 60 inches is at a depth of about 57 inches. Vegetation is blue oak, interior live oak, manzanita, gray pine, and natural grasses and forbs.

Churn-Perkins-Tehama. This association makes up 470 acres, and is part of the terrace, valley bottom and flood plain physiographic region. It mostly consists of nearly level soils in narrow to broad valleys on terraces. Perkins and Tehama soils are on higher areas of intermediate terraces, and Churn soils are on lower areas. The soils in this association formed in mixed alluvium. They are well-drained and moderately well-drained clay loams and silty clay loams formed in recent alluvium in low terraces. Slopes are generally 0 to 30 percent at elevations ranging from 500 to 1000 feet. The native vegetation composed of oaks, gray pine, shrubs, grasses, and forbs, has been removed in most areas of the soils.

The Churn series consists of well-drained and moderately well-drained soils that formed in alluvium from mixed sources. Slopes range from 0 to 8 percent. Elevation ranges from 500 to 1000 feet. The annual precipitation is 30 to 40 inches. The surface layer is light yellowish-brown, medium acid gravelly loam about 9 inches thick. The upper part of the subsoil is light yellowish-brown, medium acid gravelly loam about 4 inches thick. The lower part of the subsoil is light yellowish-brown and strong-brown, medium acid gravelly clay loam that extends to a depth of more than 60 inches. Vegetation is blue oak, valley oak, interior live oak, gray pine, and annual grasses and forbs.

The Perkins series consists of well-drained and moderately well-drained soils that formed in mixed alluvium. Slopes range from 0 to 30 percent. Elevation ranges from 600 to 800 feet. The surface layer is brown, slightly acid gravelly loam about 10 inches thick. The subsoil is yellowish-red and reddish brown, slightly acid gravelly clay loam about 44 inches thick. The substratum is slightly acid, yellowish-red gravelly clay loam that extends to depth of more than 60 inches. Vegetation is blue oak, valley oak, interior live oak, poison oak, manzanita, gray pine, and annual grasses and forbs.

Tehama series consists of well-drained soils that formed in mixed alluvium. Slopes range from 0 to 15 percent at elevations that range from 500 to 600 feet. A representative profile shows the surface layer to be pale-brown loam about 30 inches thick. The upper part of the subsoil is pale-brown and light yellowish-brown silty clay loam to a depth of about 45 inches. It is underlain by a yellowish-brown, very gravelly clay loam.

Tusca-Igo. This association makes up 12,860 acres, and is part of the terrace, valley bottom and flood plain physiographic region. It mostly consists of nearly level soils on tops of dissecting high terraces. The soils in this association formed in old basic alluvium. They are well-drained cobbly clay loams and gravelly loams that contain hardpan. Slopes are generally 0 to 8 percent at elevations ranging from 600 to 1000 feet. The vegetation on the Igo soils is a sparse cover of annual grasses and forbs, and the vegetation on Tuscan soils is grasses and forbs and scattered oaks and shrubs. This association consists of level to undulating hummocky soils on top of dissected high terraces.

The Tuscan series consists of well-drained soils that have a hardpan. Slopes are 0 to 8 percent. Elevation ranges from 700 to 1000 feet. The surface layer is brown, strongly acid cobbly loam about 3 inches thick. The subsoil is reddish-brown, medium acid cobbly clay loam that extends to depth of about 16 inches. Below the subsoil is an indurated hardpan about 10 inches thick. Below the hardpan is semi consolidated, gravelly and cobbly alluvium. Vegetation consists of annual grasses, forbs and scattered blue oak.

The Igo series consists of well-drained soils that have an indurated hardpan. These soils formed mainly in old alluvium from basic rock sources. Slopes are 0 to 8 percent. Elevation ranges from 600 to 800 feet. The surface layer is yellowish-red, strongly acid gravelly loam about 3 inches thick. The subsoil is yellowish-red, slightly acid gravelly heavy loam about 4 inches thick. Below this layer is an indurated gravelly layer about 15 inches thick. Below the hardpan, to a depth of more than 60 inches, is a substratum of stratified mixed alluvium of sand to clay in texture. Vegetation is annual grasses and forbs.

Reiff-Cobbly. This association makes up 110 acres, and is part of the terrace, bottomlands and flood plains. The soils are generally moderately well-drained to excessively-drained loamy fine sands to loams and frequently flooded cobbly land on valley bottoms and flood plains. Reiff soils are generally in large, nearly level to gently sloping tracts in the highest part of the association and cobbly alluvial land is in smaller, narrow tracts along the stream course and in old channels. The soils in this association formed in very deep deposits of recent mixed alluvium. Slopes are generally 0 to 8 percent at elevations ranging from 250 to 275 feet. Most areas of Reiff soils have been cleared of natural vegetation and are farmed. The vegetation on the cobbly alluvial land consists of open to dense stand of cottonwood, sycamore, willow, and oak trees and an understory of shrubs, vines, and annual grasses.

The Reiff series consists of well-drained and moderately well-drained soils that formed in recent alluvium from mixed sources. Slopes are 0 to 8 percent at elevations ranging from 350 to 500 feet. Annual precipitation is 25 to 40 inches. In a representative profile the surface layer is grayish-brown and brown fine sandy loam about 18 inches thick. The substratum is brown fine sandy loam to about a depth of about 43 inches, covering brown loamy fine sand. The vegetation on this series is a fairly dense cover of valley oak, canyon live oak, gray pine, annual and perennial grasses, forbs, vines, and shrubs.

Cobbly alluvial land consists of very gravelly, very cobbly, or very stony coarse-textured alluvium. This land type is excessively-drained and has very rapid permeability. Runoff is slow, and erosion and deposition hazards are moderate. The vegetation consists of willow, alder, ceanothus, manzanita, annual grasses, and gray pine.

CLIMATE

Temperature and Growing Seasons

The average annual temperature is about 63 degrees F in the Sacramento Valley, 45 to 50 degrees F in the eastern plateau area, and 50 to 60 degrees F in the rest of the area. Temperatures are warm in the summer months. The average maximum temperature in July is near 100 degrees F in the Sacramento Valley and in the 80s in the eastern plateau. Maximum temperatures of 105 degrees F or higher are common, and a record high of 119 degrees F has been recorded in Shasta County. Temperatures at night are comfortably cool most of the time. Minimum temperatures in July average in the middle 60s in the Sacramento Valley and in the middle 40s in the eastern plateau.

Temperatures in winter are cool. The average minimum temperature in January is in the middle 30s. Extreme low temperature readings are near 20 degrees F in the Sacramento Valley and maximum temperatures in January are in the 50s. Average daily temperatures are included on Table 1-6

TABLE 1-6
Average Daily Temperatures*

Month	Average Daily Maximum	Average Daily Minimum	Average Temp
January	57.1	37.8	46.2
February	61.4	40.5	50.1
March	66.1	43.0	54.3
April	73.2	47.0	60.2
May	83.6	54.9	68.3
June	92.8	62.8	76.2
July	99.7	68.1	83.3
August	97.9	66.7	81.2
September	91.2	61.0	76.0
October	80.1	53.5	65.9
November	61.8	42.8	54.5
December	55.7	38.1	47.3
* Redding Station	76.9	51.5	63.6

The average date of the last 32 degree freeze in the spring is mid-June for plateau areas and as early as the latter part of February in the Sacramento Valley. The first freeze in fall averages as early as the middle of September in colder areas of the plateau, but it is in December in the Sacramento Valley. The growing season based on the freezing dates, is 90 days in the east and as much as 250 to 300 days in the Sacramento Valley.

Precipitation

Current precipitation patterns were generated from three precipitation stations; two within the watershed, the other near enough to its periphery to reflect conditions within the watershed. The stations are Redding (60+ years of records), Cow Creek (13 years of records), and Round Mountain (18 & 31 years of records).

Annual precipitation within the watershed ranges from about 25 inches in the Sacramento Valley to about 65 inches in the northeastern portion of the watershed. Average annual precipitation at Cow Creek, which is near Whitmore, at an elevation of about 2840 feet, is 51.13 inches. By comparison, the Round Mountain station, which is near the northern boundary of the watershed, at an elevation of about 1800 feet, has an annual average of 63.35 inches. Precipitation is generally correlated to elevation (MSI) as shown in Figure 1-11, displaying precipitation contours for the watershed.

Most of the precipitation falls in winter. Seventy-five to 90 percent of the annual total precipitation is received between November 1 and April 30. Thundershowers in summer occur on about 5 to 10 days a year, particularly in the mountains, but they account for only a small percentage of the total annual supply of moisture. This is displayed on Figure 1-12.

Rainfall intensities are greatest in the mountains. Short period precipitation totals are likely to be greatest during thundershowers in fall or in the spring, and the long-period totals reach a maximum during winter storms. Thunderstorms generally are limited to 3 to 5 days a year at lower elevations, but they occur as frequently as 10 to 12 days a year in the mountains in places.

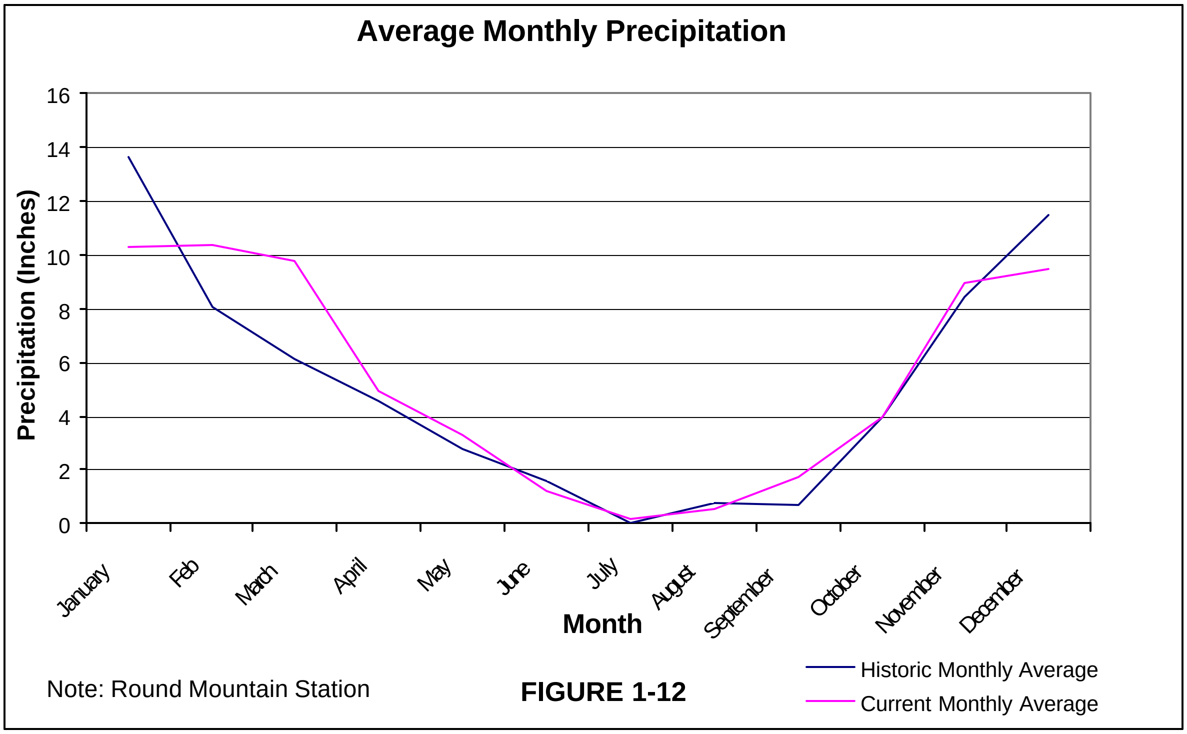

FIGURE 1-12

The technical advisory committee requested that SHN evaluate possible trends in precipitation over time. Historical and current precipitation data from the Round Mountain station, years of record from 1952-1970 and 1970-1984 including recent data 1984-present from PGE show that trends have remained the same, with slight variation in March and September. Information is presented on Figure 1-12

A similar trend analysis was completed using City of Redding climate data, which, with 70 years of record, are the most complete local data. No significant historical trends were observed. Slight trends of an increase in spring precipitation (March) since 1972 with a coincidental decrease in April precipitation during the same period were noted. In the same time period, 1972 to present, there has been a slight increase in September precipitation. Annual precipitation in inches by month for ten-year increments is included as Figure 1-13A to Figure 1-13C.

Snowfall

Snowfall is very light at low elevations within the watershed and only a few inches are recorded in an average year. The annual total exceeds 100 inches in the mountainous areas of the eastern watershed. Mid elevations in the watershed average 30 to 40 inches of snowfall per year.

In Cow Creek the snow zone is believed to be above 6000 feet. The rain-on-snow zone can be defined as an area where a snow pack may or may not last through the winter, and where rain occurs several times a year that may melt all the snow. In Cow Creek, the rain-on-snow zone was identified from 2500 feet to 6200 feet in elevation. In the Cow Creek watershed, much of the precipitation above 3500 feet occurs as snow. The transient snow zone within the rain-on-snow zone is the elevational zone where snow falls, but melts away without forming a snowpack. In Cow Creek this is from 2500 to 4500 feet. The seasonal snow pack zone within the rain-on-snow zone is the area where most of the precipitation falls as snow and contributes to a snowpack that lasts throughout the winter. In Cow Creek, this is generally 4500 to 6200 feet (McGurk and Cafferata, 1991).

Many of the major floods in the Cow Creek basin have resulted from rain-on-snow events. In general, snowmelt is more sensitive to increased winds that accompany a rainfall event than the magnitude and intensity of precipitation itself. This can cause more rapid melting to occur than terrain or timber management methods (McDonald, et al., 1995). Timber management can effect snow accumulation and melting. Even-aged systems tend to accumulate more snow (Harr, 1986), but may allow increased wind. Uneven-aged methods, which provide “roughness” to slow wind speeds, retard accelerated melt that leads increased peak flows.

Large openings, such as those caused by wildfire, can significantly increase peak flow, especially in the transient rain-on-snow zone. In general, the more immature the forest canopy (such as historic burns), the higher potential for elevated peak flows due to storm rain-on-snow events (McDonald, et. al., 1995).

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DRI-NOAA Redding (1934-1998)
DRI-NOAA Round Mountain STN 947580 (1952-70 and 1970-84)
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FIGURE 1-1
GENERAL VICINITY
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

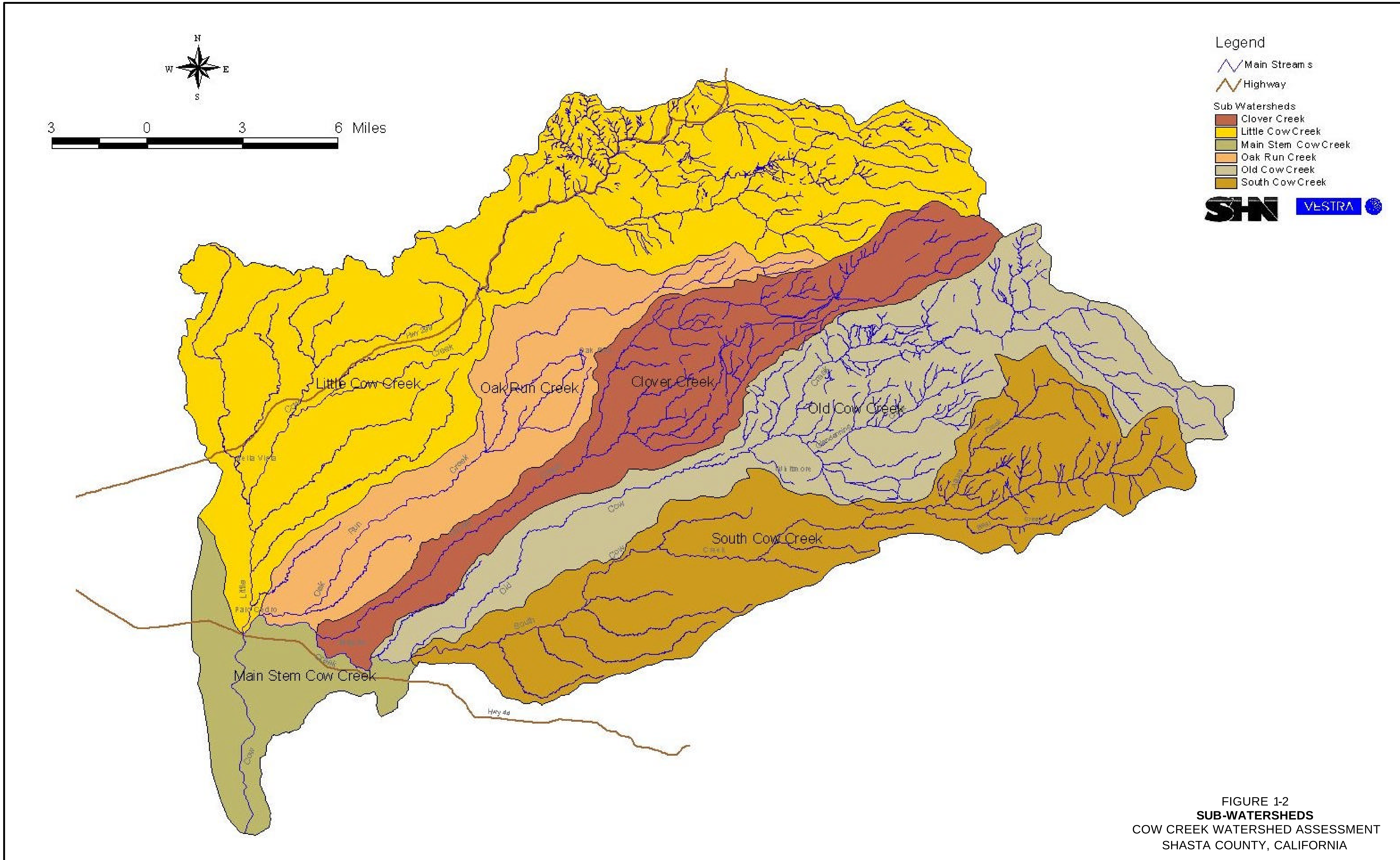
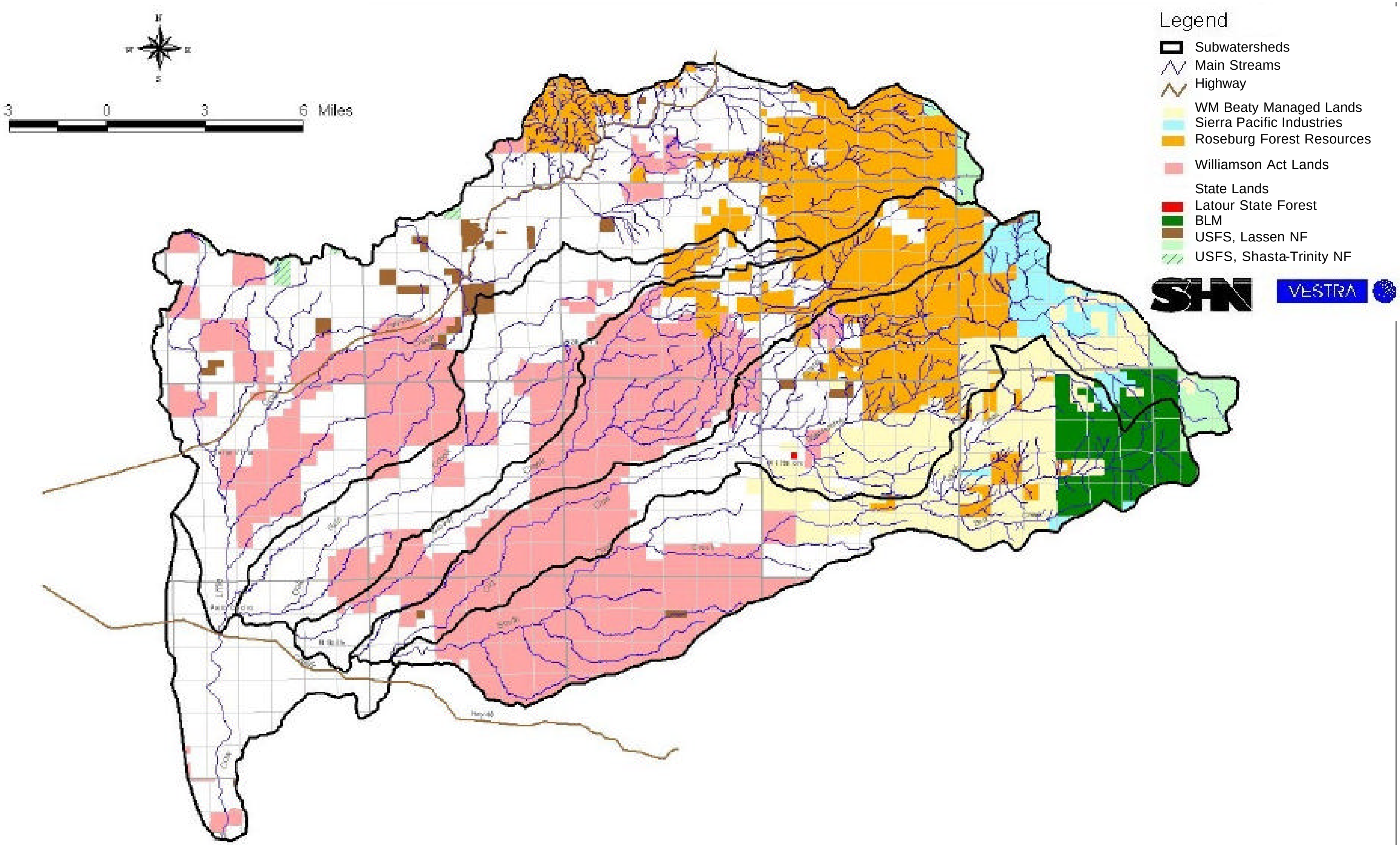
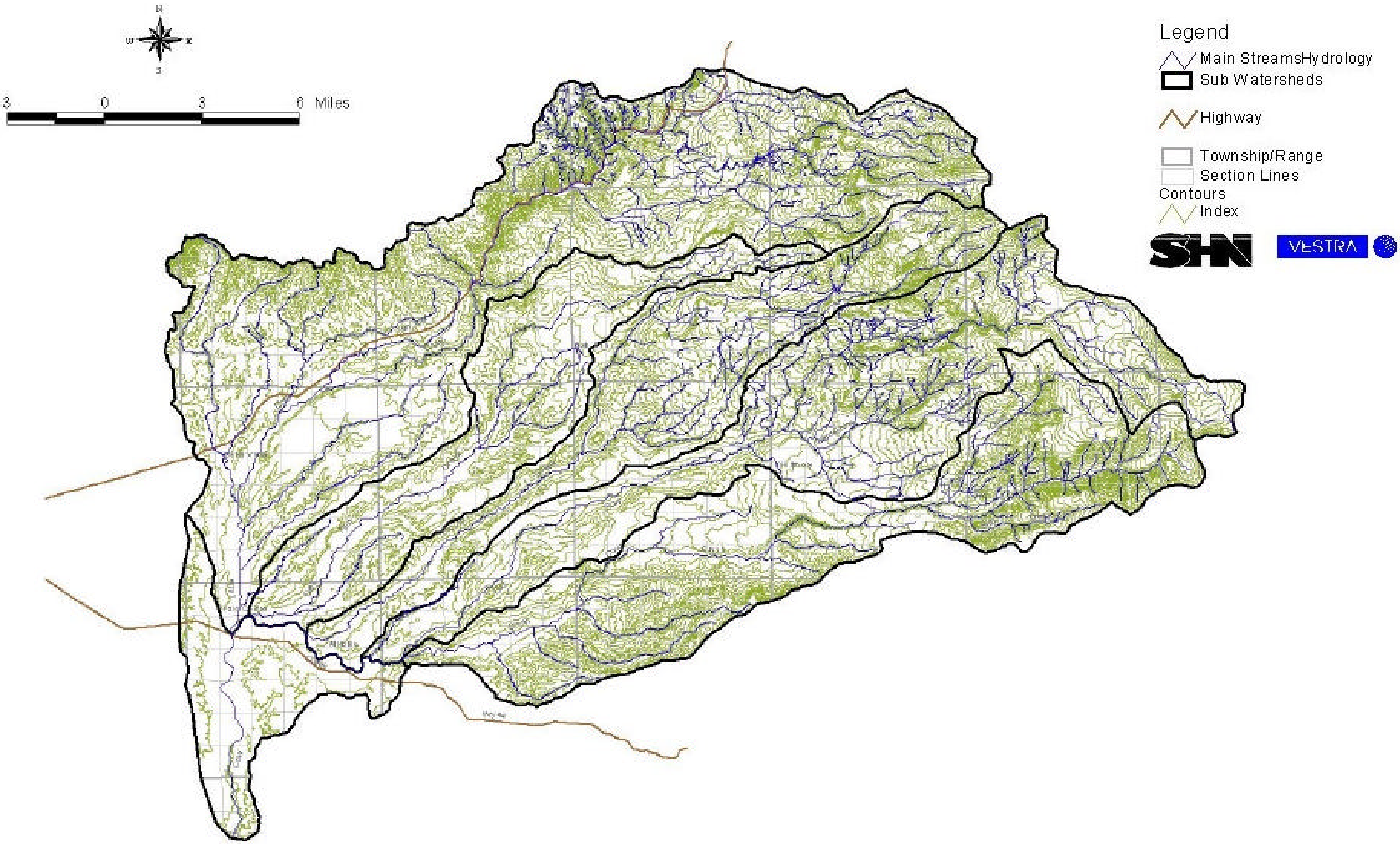


FIGURE 1-2
SUB-WATERSHEDS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA



Reference: Roseburg, Beaty, SPI, USBR, Williamson Act

FIGURE 1-3
OWNERSHIP
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA



Reference: DEMs, CDF Roads, Roseburg Streams, CDF PLS

FIGURE 1-4
TOPOGRAPHY
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

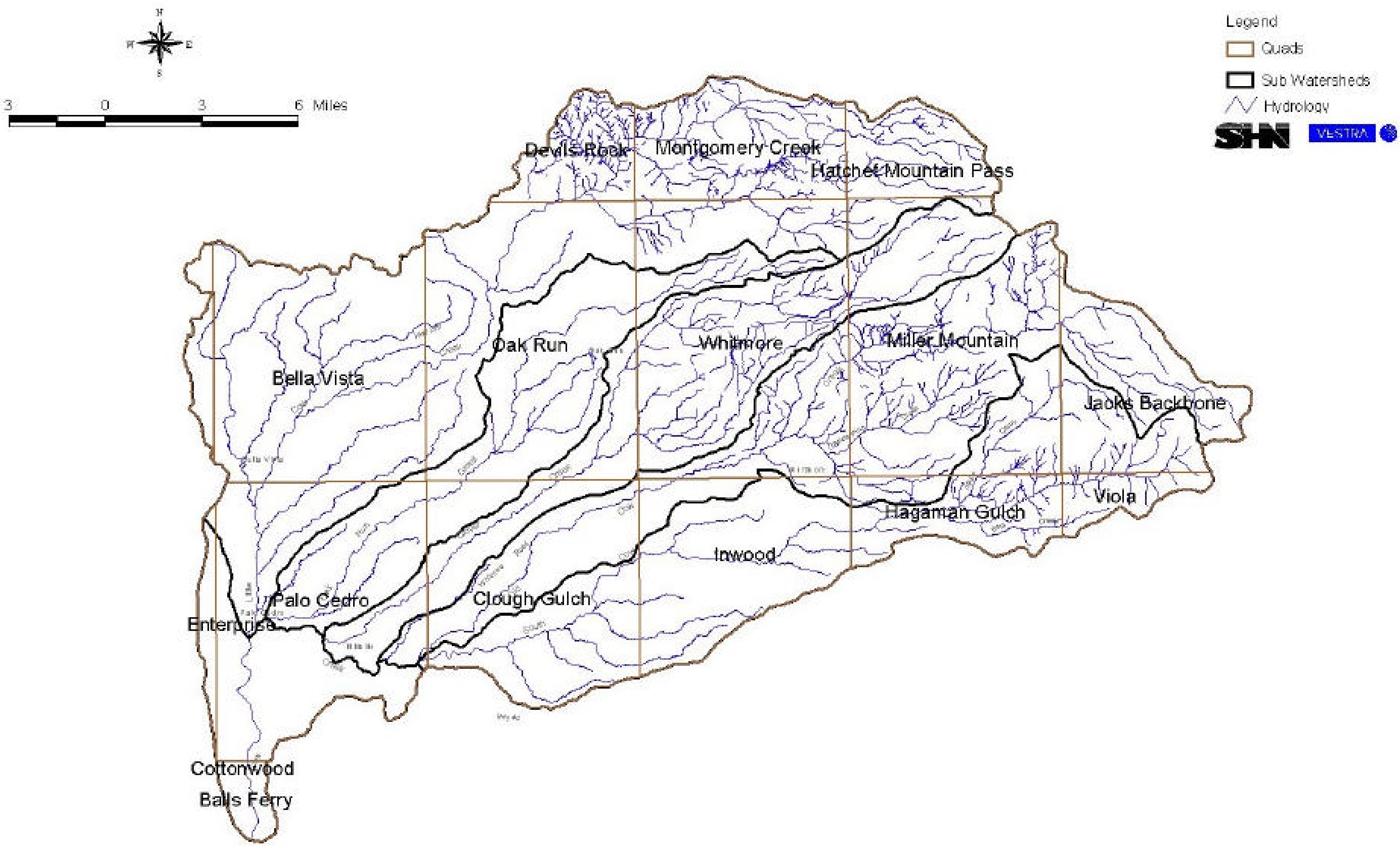
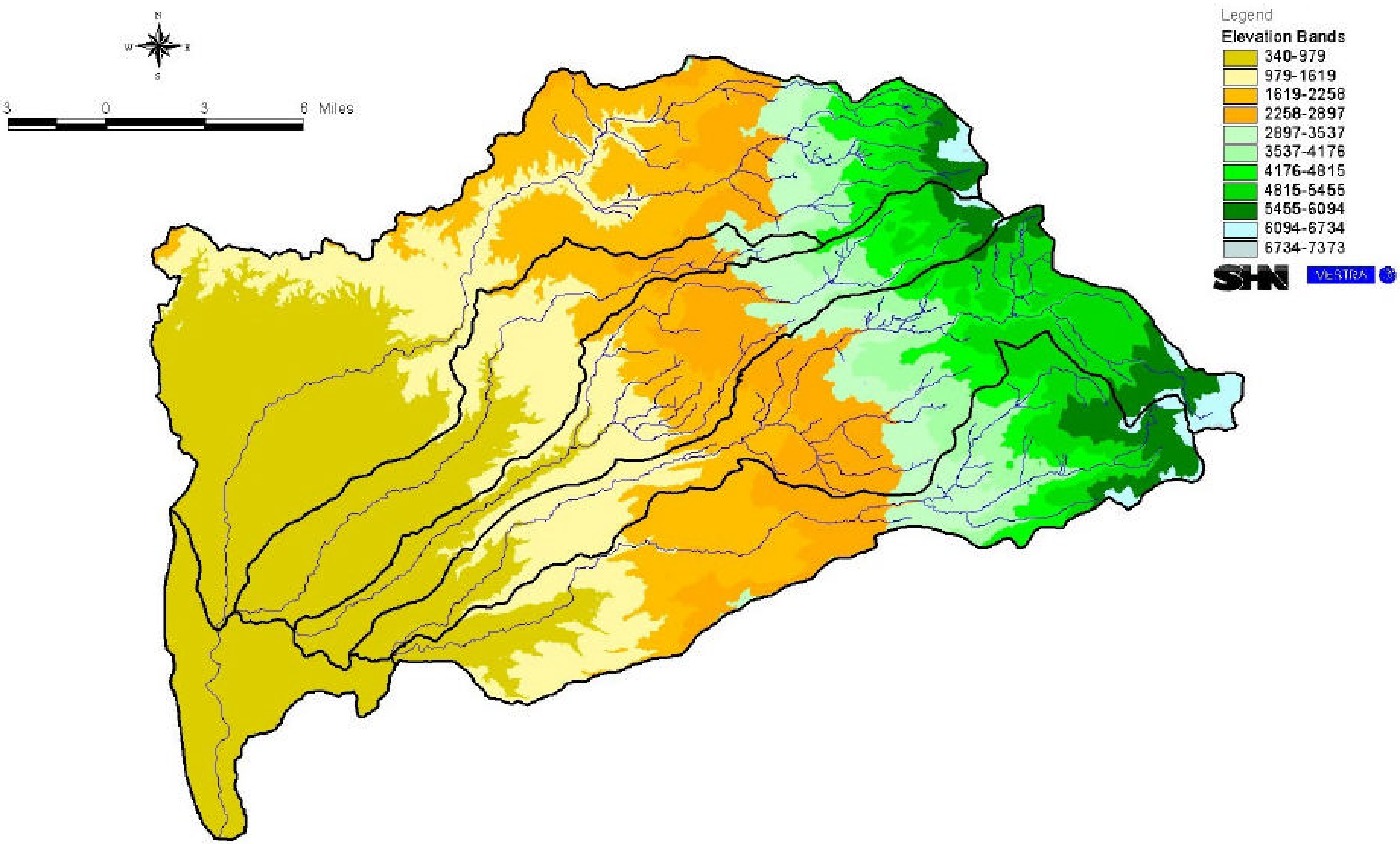


FIGURE 1-5
USGS QUADRANGLES
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: USGS 7-1/2 Minute Quadrangles



Reference: USGS DEMs

FIGURE 1-6
ELEVATION BANDS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

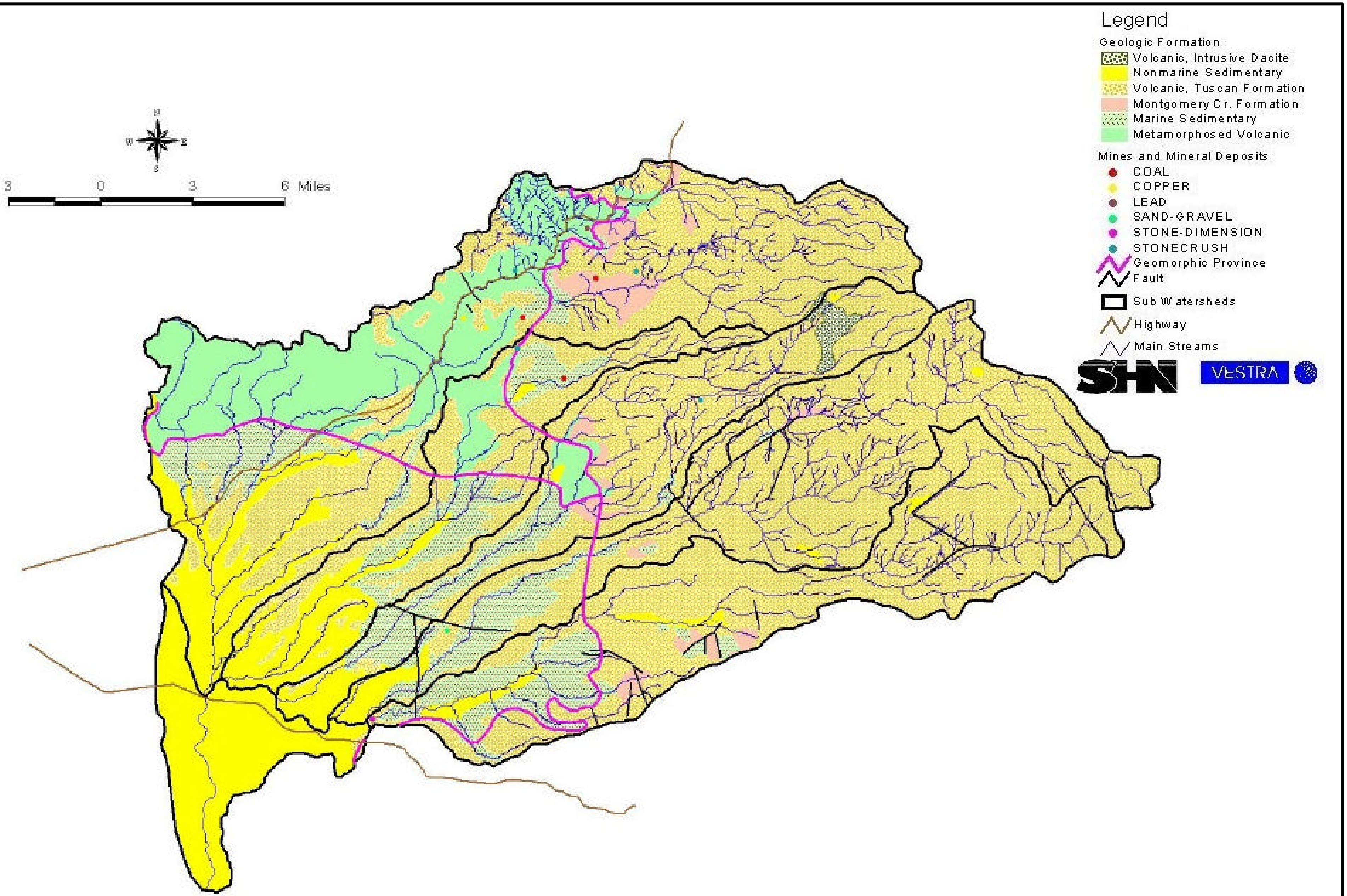


FIGURE 1-7
GEOLOGY
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: CA Dept Mines & Geology, County Report #6

ERA	MILLION YEARS AGO	PERIOD	
CENOZOIC	2	QUATERNARY	Volcanic Intrusive Rocks Tehama & Red Bluff Formations
	65	TERTIARY	Tuscan Formation Montgomery Creek Formation
MESOZOIC	140	CRETACEOUS	
	210	JURASSIC	Chico Formation
	250	TRIASSIC	Pit Formation Bully Hill Rhyolite
PALEOZOIC	280	PERMIAN	
	320	CARBONIFEROUS	
	360		
	400	DEVONIAN	
	440	SILURIAN	
	500	ORDOVICIAN	
	570	CAMBRIAN	
PRECAMBRIAN			

FIGURE 1-8
AGE OF COW CREEK FORMATION
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

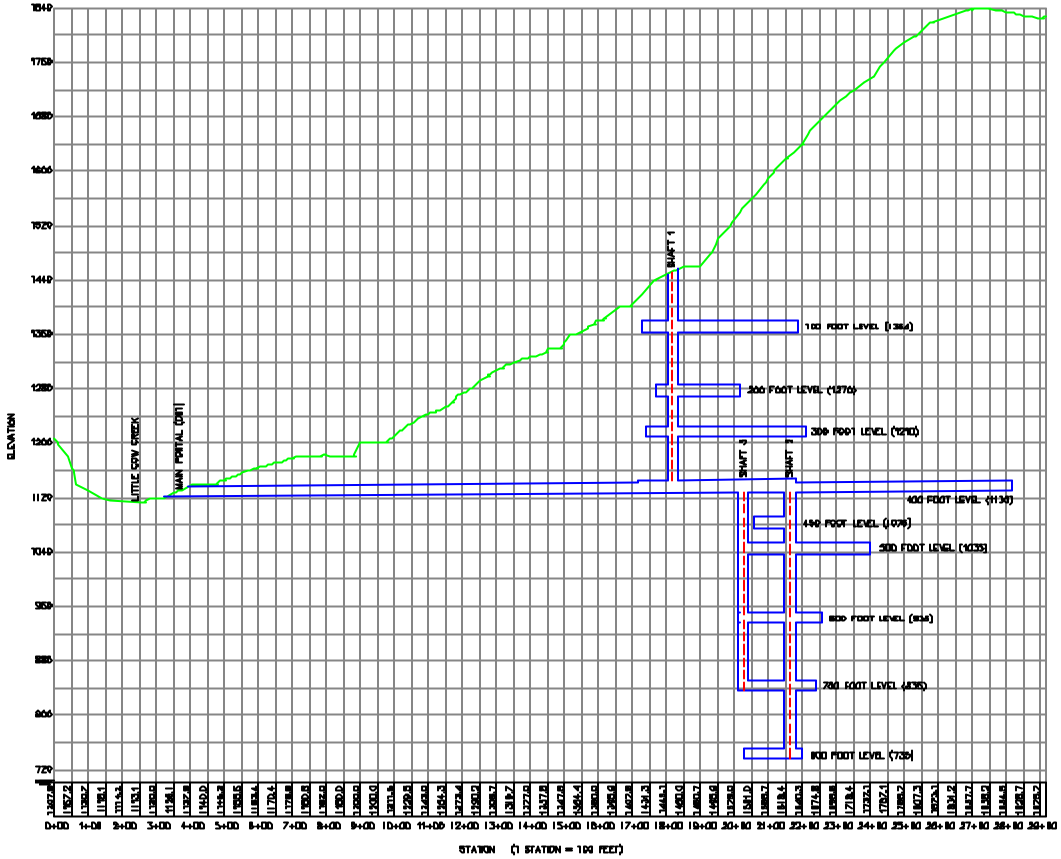
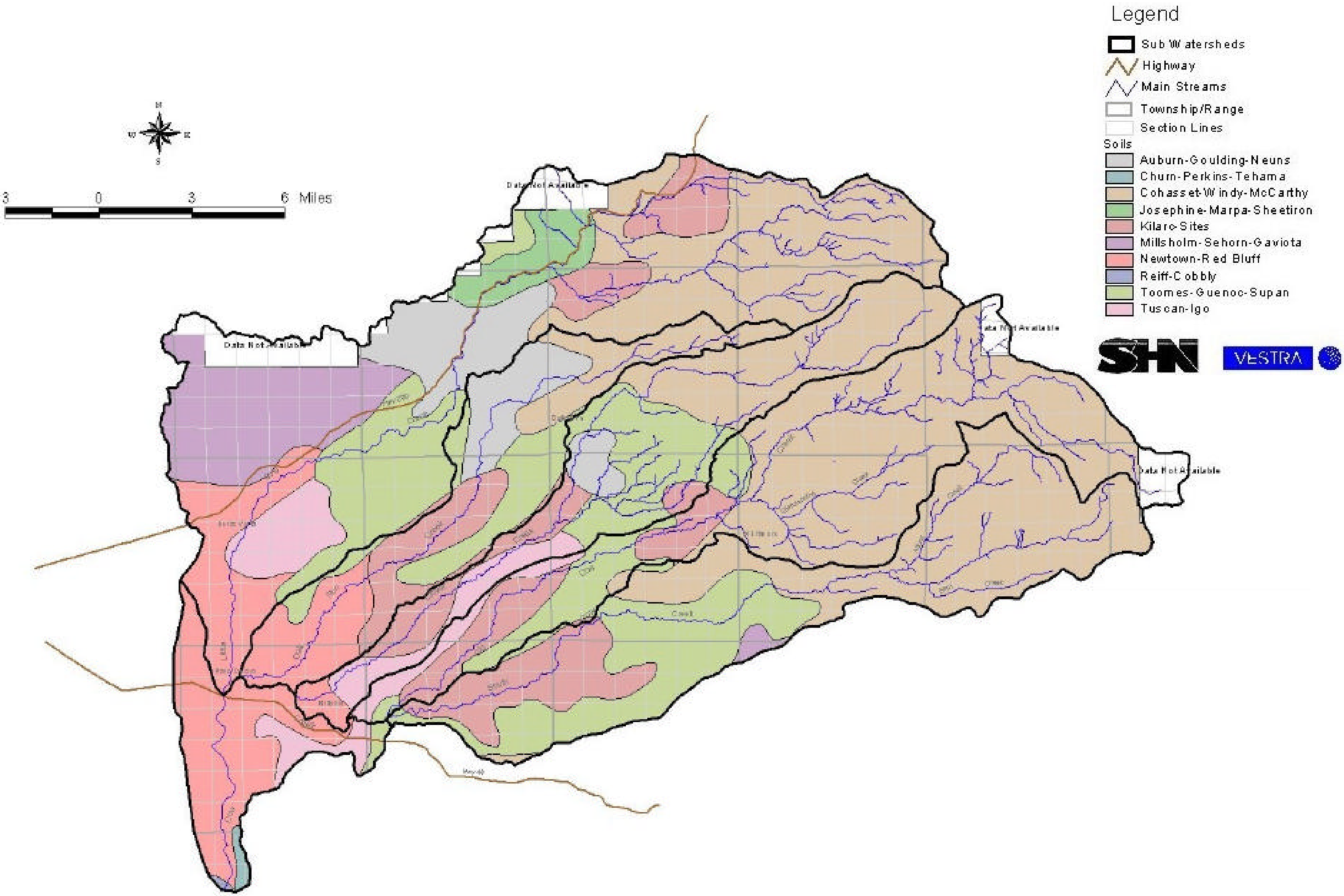


FIGURE 1-9

COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

SHN 500062 NOV'01

SHN CONSULTING ENGINEERS & GEOLOGISTS



Reference: USGS General Soils of Shasta Area

FIGURE 1-10
SOIL SUMMARY
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

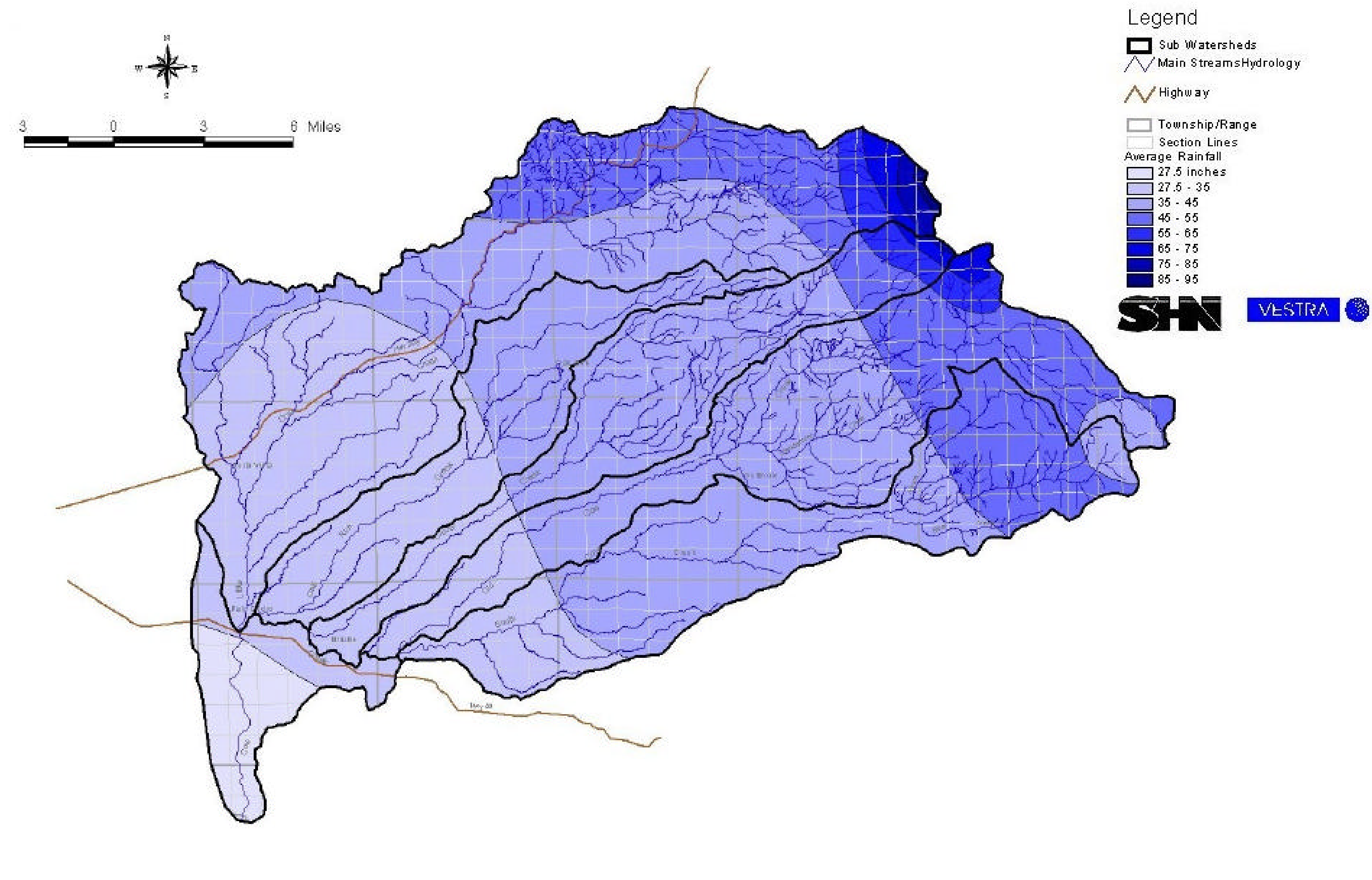


FIGURE 1-11
AVERAGE PRECIPITATION
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: CDF 1900-1960 Average Annual Precipitation Zones

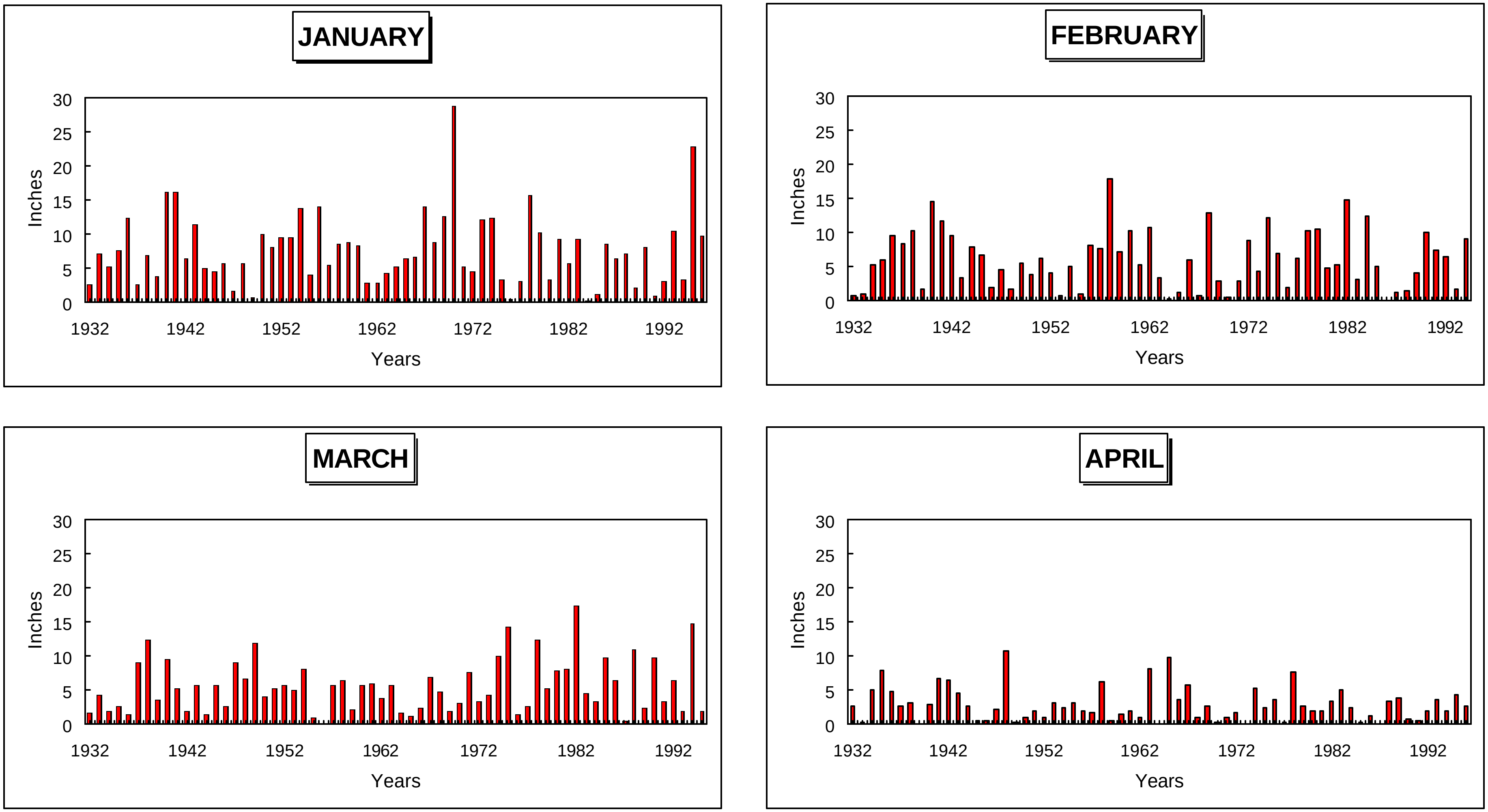
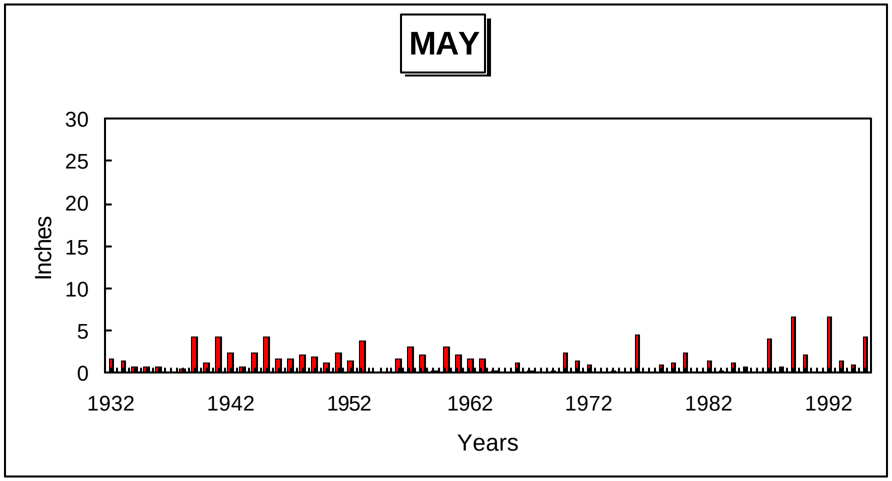
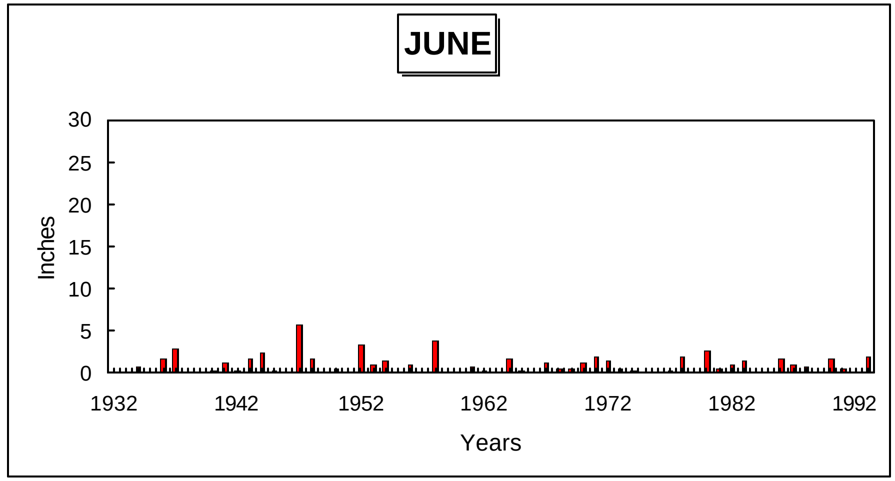
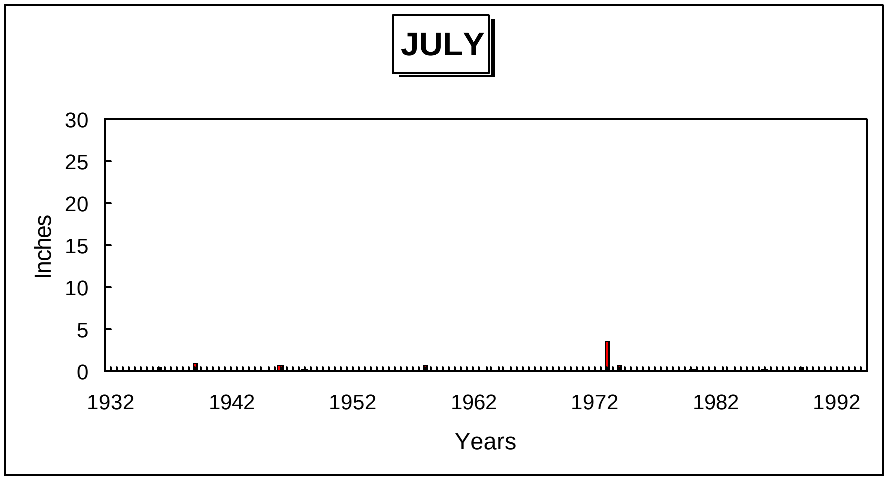


FIGURE 1-13A
ANNUAL PRECIPITATION BY MONTH
FOR 10-YEAR INCREMENTS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA







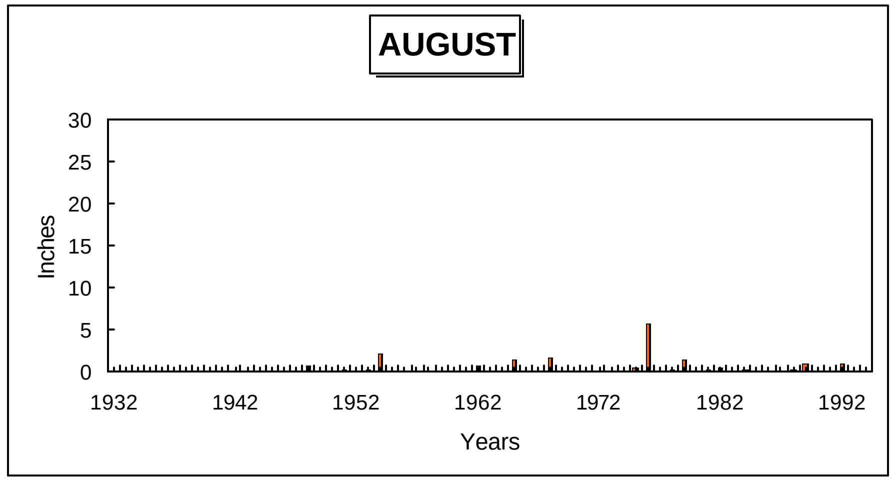


FIGURE 1-13B
ANNUAL PRECIPITATION BY MONTH
FOR 10-YEAR INCREMENTS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

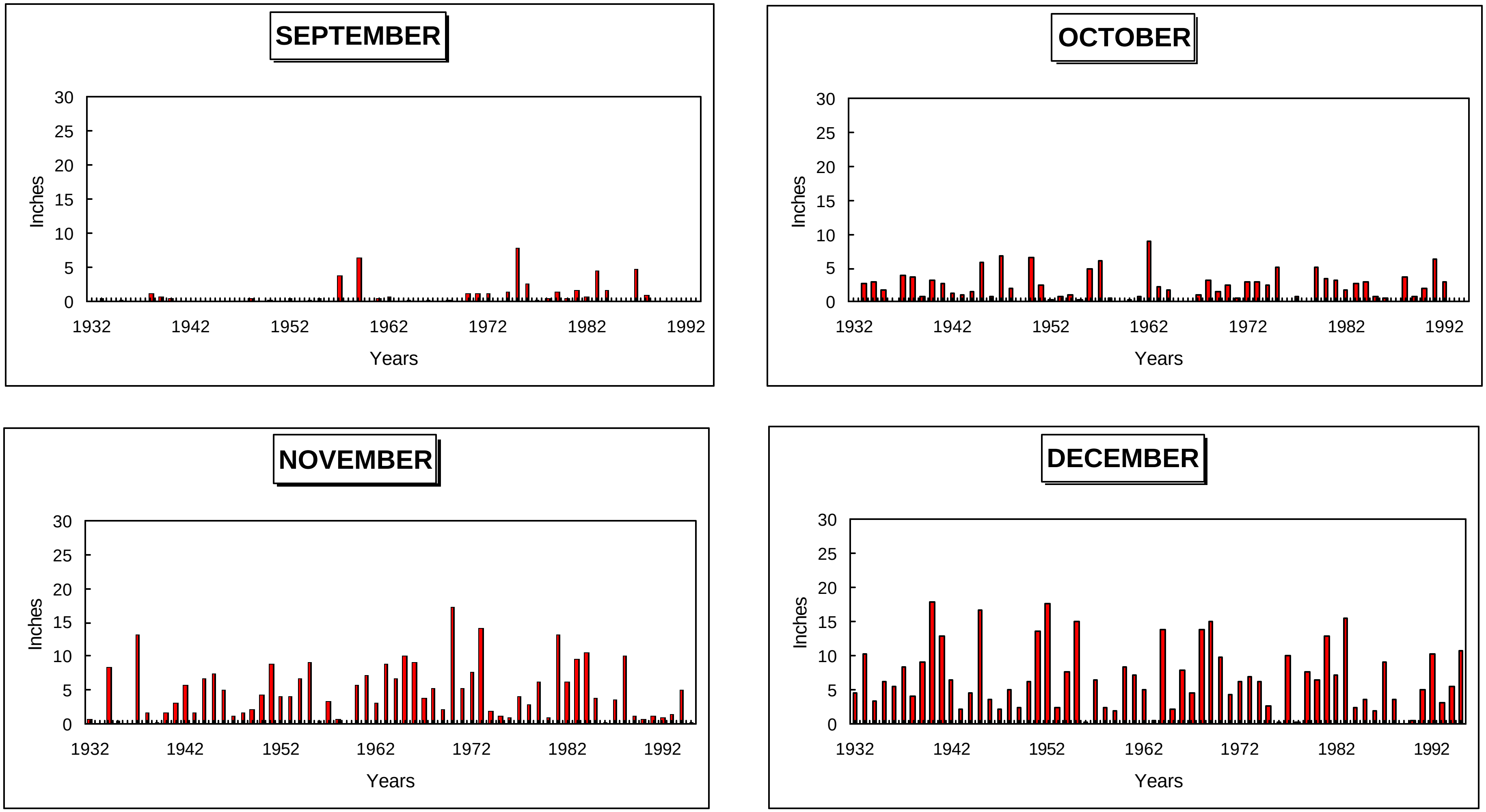


FIGURE 1-13C
ANNUAL PRECIPITATION BY MONTH
FOR 10-YEAR INCREMENTS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Section 2
GENERAL WATERSHED HISTORY

Section 2
TABLE OF CONTENTS

Section 2
GENERAL WATERSHED HISTORY

The Cow Creek Watershed has been influenced and changed by input from both man and nature. The most recent period of influence and change has been in response to the arrival of European man beginning in the middle of the last century. In the last 150 years, European man has molded the watershed environment to fit his needs. The most significant impacts are related to the exclusion of fire, introduction of non-native grasses and brush species, mining and development. Prior to the arrival of European man, Native people also managed the landscape to meet their specific needs.

NATIVE PEOPLES

The Cow Creek watershed was inhabited by the Northern Yana at the time of historic contact. It is believed the watershed area supported between 300 and 500 individuals; however, by 1887 less than 100 individuals remained. The Yana were hunters and gatherers. They preferred to live independently in their own small family groups and outsiders were discouraged. Villages were generally family units of 20 to 50 persons. Often communal hunts and gatherings combined villages. They are believed to have traded with the Achumawi people to the north for obsidian, although two local source of obsidian have been identified; one on Little Backbone Ridge along the northern boundary of the watershed and one on Bullskin Ridge (Jenkins, 2001, pers. comm.).

Camps are reported to have been moved to meet the seasons. Horse use is not documented by the Yana. Materials were carried by family members or cached until the return in spring or fall. Travel was via footpath and trail. No active farming was documented. It is assumed, however, that the Yana used fire to manage the resources available to them. The Yana subsisted on the native plants and game that were abundant prior to white contact.

The Yana depended heavily on the salmon of the Sacramento River and its tributaries as a primary food source. They also depended on the oak trees of the valley and foothills for acorns and on the large deer herds that roamed the valleys and foothills of the Sacramento Valley. They were hearty warriors and fought often with the Achumawi to the north and Wintu to the west and northwest. The Yana were not reported to have been friendly to the white settlers, whereas the Wintu were initially amicable, but later joined with the Yana against the European settlements.

Acorns, pine nuts, and young shoots constituted the bulk of available food for Native American peoples of the watershed. Large and small mammals and fish constituted seasonal importance. Large amounts of herbaceous plants were also taken as food (Blackburn and Anderson, 1993) Grass seeds, bulbs and shoots were the primary sources of food, especially in the spring, which was the most difficult time for native residents. Grasses, bulbs and sprouts were all most productive in the presence of reoccurring fire. Literature does not specifically document burning of forests or grassland for range improvement, game management or hunting by the Yana. Archeologists generally agree, however, that California Native peoples used fire to "manage" the ecosystems they inhabited (Jenkins, 2001, pers. comm.).

Stewart (1955) maintains that there is evidence for almost every tribe in the western Unites States having used fire to modify their respective environments. Within California, Reynolds (1959) shows that at least 35 tribes used fire to increase the yield of desired seeds; 33 used fire to drive game; 22 groups used it to stimulate the growth of wild tobacco; while other reasons included making vegetable food available, facilitating the collection of seeds, improving visibility, protection from snakes, and "other reasons" (Blackburn and Anderson, 1993). While the use of fire is noted for almost every Native American group in California, little is known about the timing or method of fire.

For example, the Wintu are reported to have burned the valley and hill slopes to improve basket materials and habitat for deer and other animals. Fire was also used as a tool to move mammalian game and insects to be collected for food.

Wintu are reported to have collected grasshoppers "by burning off large grass patches" in chaparral, woodland grass, and coniferous forest areas, similar to those inhabited by the Yana (DuBois, 1935). Unfortunately, neither the specific vegetational cover nor the time of year in which the burning took place is mentioned. Holt (1946) discusses the use of fire by the Shasta people:

> The second method was used on the more open hills of the north side of the river, where the white oak grew. When the oak leaves began to fall fires were set on the hills. Then they came down…in the late fall… It was at this time they had the big drive, encircling the deer with fire.

Achumawi are reported to have burned in the spring to encourage sprouting species and to prevent growth of dense underbrush (Kniffen, 1928). Karuk, Wintu and Shasta people burned grass, brush and riparian areas to improve basket making raw materials. Hazel sticks were required for ribs for baskets with prime shoots being one to two years after fire (Blackburn and Anderson, 1993). Many tribes apparently used fire to drive game, which was especially common in the fall. Deer were driven into snares or circled by fire and killed.

Blackburn and Anderson (1993) document general features of Native American patterns of burning. Fall, and secondarily spring, burning involved not simply an intensification of the natural pattern of fires, but a pronounced departure from the seasonal distribution of natural fires. The pattern previously shown for the woodland, grassland, and coniferous forest involved the intensification of the natural pattern. In the chaparral areas, the strategy of fall and spring burnings involved a quite different kind of management, shifting both intensification and seasonality of natural fires. This idea implies that early Native American people played a fundamental role in the evolution of California's chaparral. Ethnographic data strongly indicate that such a pattern of environmental manipulation and control did exist. Most important, by creating and/or maintaining openings within the chaparral, the Native Americans increased the overall resource potential of an area and created the enclosures, or "yarding areas," where these resources could be more readily exploited.

In many cases, Native American groups that exploited woodland-grass and chaparral also hunted animals and collected plants within portions of the coniferous forest belt, particularly the ponderosa pine regions of the Sierra Nevada and the redwood-Douglas fir areas of the northern Coast Range. The evidence indicates that the impact of the Native Americans was significant in the maintenance and evolution of vegetation types. Although ethnographic data is lacking, field studies in fires ecology show that frequent burns were common throughout the coniferous belt and foothills of the Sierra Nevada.

The ethnographic and field references to the time of burning indicates that Native American burning occurred in the coniferous forests during the late summer or early fall. Discussing the Southern Maidu, in the foothills and mountains east of Marysville and Sacramento, Beals (1933) notes the overall effect of burning:

> The land was apparently burned over with considerable regularity, primarily for the purpose of driving game. As a result, there were few young trees and all informants were agreed that in the area of permanent settlement, even so far up in the mountains as Placerville, the timber stand was much lighter than at present… The Indians insist that before the practice of burning was stopped by the whites, it was often a mile or more between trees on the ridges, although the canyons and damp spots held thickets of timber.

EARLY CONTACT

Trappers and early explorers of Spanish, Russian and American descent were the first Europeans to enter the watershed. The first contact between Native people and European man is documented to have occurred in the 1820s as Hudson Bay Company trappers traveled down the Pit River from the north. It has been estimated that malaria, introduced by trappers, reduced the population of the Native People in the northern Sacramento Valley by more than 75 percent between 1830 and 1833.

Pierson B. Reading established his rancho in the area in 1845 as the northern-most Mexican land grant in California. As word spread, more prospectors and trappers moved north to explore the new lands. Sheep are reported to have been introduced from the southern portion of California in the late 1840s. The discovery of gold along Clear Creek in 1846 brought many more miners, herders and settlers to the area. One of the primary routes of migration into the new region was via the Nobles Trail established in 1851. This trail followed the ridge between the south fork of Cow Creek and the north fork of Battle Creek, and continued to be one of the main migration routes into and out of Northern California for the next 40 years.

Hydraulic gold mining in Clear Creek and the Sacramento River destroyed salmon habitat and spawning areas. In addition, sheep and cattle reduced the forage for wildlife. Available game became scarce due to over-hunting and over-grazing of resources by livestock. As a result, by 1851, confrontations between whites and the native peoples were common.

Widespread starvation and desperation of the Wintu and Yana tribes led to numerous skirmishes beginning in the 1850s. The most notable was that of Bloody Island in which a band of Yana and Wintu engaged Captain John Fremont near the mouth of Cottonwood Creek. This engagement began a series of encounters later known as the Salmon Wars. Tension continued and Fort Reading was constructed on Cow Creek in 1852 in response to increasing tension. The Fort was active for only five years and was abandoned in 1857. The remains burned in a brush fire in 1866. The battle of Bauncombes Mill (later Millville) was fought between 150 natives, believed to be Wintu and Yana, and 30 settlers in approximately 1854. In 1864, a band of natives attacked the William Allen Family homestead, killing all but William Allen and one son. Allen was a rancher. A posse of friends and family from Millville, Oak Run, and Balls Ferry pursued and retaliated with the death of 80 to 100 natives.

In 1866, Marie Dersch, wife of George Dersch, was shot in a raid on their homestead. Although blamed by some on Captain Jack, a Modoc, Mr. Dersch relentlessly pursued the remaining Yana and Wintu in the region. Murder, starvation and disease resulted in the decline of remaining Native American populations in the watershed.

TABLE 2-1 Key Dates of Early Contact	
1820	Trappers and explorers.
1845	Reading establishes Rancho.
1846	Gold discovered on Clear Creek.
1852-1855	Large wave of immigrants.
1855	North Star Mill established making Millville, the second largest city in the county.
1872-1873	Railroad to Shasta County.
1876	The railroad extended to Redding, and was extended on to Portland in 1887.
1914-1920	Numerous eruptions of Lassen.
1896-1919	Copper primary resource of the county.
1911-1920	Smelters close.
1920	Deep recession – 30% of county residents leave.

MINING

Copper, coal, gravel and dimension stone have been mined from the Cow Creek Watershed. By far, the most important mineral and mining that had the most significant impact on the local biosocial element was copper.

The early miners of the Cow Creek watershed were independent men who mined for surface gold and moved on. The gold rush in Shasta County began in 1847. Although gold was not discovered on the eastside of the Sacramento River, the available timber and grazing lands on the eastern lands became primary supply areas for the initial gold miners and copper miners that followed.

Copper was discovered in Shasta County in the mid 1860s and the copper mining era began. Copper mining required significant investments in smelters and transportation systems and manpower. The change in industrialized society of the late 1800s created a huge demand for copper due to its high electrical conductivity, ductility, toughness and use as an alloy agent. Between 1896 and 1919, Shasta County developed into one of the largest copper mining and smelting regions of the United States. Numerous mines throughout the region supported five copper smelters. The Afterthought and Donkey Mines, and the Ingot smelter were located in the Cow Creek Watershed.

The Afterthought Mine was first patented in 1862 when seven claims of the Copper Hill group were mined for gold and silver. The furthest east of the copper mines in the Copper Crescent is located in the Cow Creek Watershed. The Afterthought Mine operated from 1872 until 1950. It was originally exploited as a gold mine, but copper surpassed gold in value in early 1890. A reverberating furnace was constructed at the site in 1875. A 250-ton smelter was constructed approximately one mile downstream from the mine in 1905.

The sulfur emissions from the smelters damaged vegetation as far south as Tehama County and denuded the local hillsides of vegetation. The smelters created sulfur fumes from the combustion of sulfide ores. The fumes damaged or eliminated vegetation over an area of greater than 153,000 acres, extending from the Sacramento Canyon to below Red Bluff. Little evidence of controversy over the Ingot smelter was found in the literature, probably due to its small size and isolated location. Reporting to the state legislature in 1921, State Forester E. Munns estimated that in excess of five cubic yards of soil and rock were eroded per acre annually in areas impacted by smelter fumes. Maps prepared for the Munns report and other reports do not specifically address the Ingot area; however, rough terrain and poor vegetative cover in the vicinity of the smelter indicate at least some impact on the vegetation and soils of Little Cow Creek.

The smelter was closed in 1910 due to legal challenges from farmers and the United States Forest Service. The Afterthought smelter was the first of five local smelters to close due to legal challenges. Prior to closure of the smelter, the town of Ingot was home to more than 2,000 miners and their families and boasted a store, hotel, several bars and a post office. The mine operated sporadically until 1952, when it was closed permanently.

Today, drainage from Afterthought Mine has impacted a portion of Little Cow Creek. As water contacts the sulfide mineral deposits exposed to the air inside the mine workings, a chemical reaction causes the formation of sulfuric acid. The sulfuric acid dissolves metals such as copper, zinc and cadmium. High metal concentrations in discharge water from the mine can impede the ability of fish to draw oxygen into their gills causing them to suffocate and die. Although no fish kills associated with discharge from Afterthought Mine have been documented in Little Cow Creek, a portion of Little Cow Creek is listed as impaired under Section 303 of the Clean Water Act.

Gravel was mined in Little Cow Creek near Bella Vista (at Dry Creek and at Salt Creek), near Palo Cedro (Graystone Court and near Bloomingdale Road), and in the lower reaches of the main stem of Cow Creek. Mining of gravel in active floodways has likely reduced available spawning gravel in Little Cow Creek and the main stem of Cow Creek. Gravel removal may also contribute to channel incisement.

TIMBER AND MILLING

Open air roasting of ore created a huge demand for cordwood and rail lines with steam locomotives also required considerable wood for fuel. Historic accounts document that the oak trees were removed "for some distance" on either side of the tracks, having been used for fuel. The mines also generated needs for lumber for housing, and fuel for locomotives. Much of the wood was floated down the Pit and Sacramento Rivers. The completion of the railroad into Redding in the 1870s significantly increased the demand for wood products for fuel wood and the expanding commercial centers.

Beginning in the late 1860s, mills were constructed throughout the Cow Creek watershed to feed the growing development. The mills were located throughout the timber belt in the county. Most were small mills that moved as the timber was depleted. The largest problem facing the early lumber companies was the transportation of the product to developing centers.

The most famous of the early mills was Terry Mill with its associated 32-mile flume and separate railway. The mill operated from 1872 until 1922, and by 1915 was the leading producer of lumber in the county. The mill itself was located on Hatchet Mountain outside of the Cow Creek watershed. However, the flume and box factory were located within the watershed. The flume generally followed what is now Highway 299 to the planing mill and box factory, which were located on what had been the Gibson Ranch in Bella Vista (now Meyers Ranch). Originally constructed by Orison Morse and later purchased by J. Enright, the mill and timberlands soon were known as the Shasta Lumber Company. Enright purchased and constructed the railroad in 1889. In June 1897, the mill was sold to Joe Terry. Mr. Terry expanded milling activities and increased timber harvest. The mill employed over 200 men in 1890 and, at the time, the town of Bella Vista boasted a population of over 2,000. The box factory burned in 1910 and was moved to Anderson. The timberlands of the Shasta Lumber Company were harvested heavily, removing all large trees and leaving smaller and less healthy trees.

The Shasta Lumber Company was sold to the Red River Lumber Company in 1922. In 1945, the railway from Bella Vista to Anderson was deeded to Shasta County. This later became Deschutes Road (south of Palo Cedro), which allowed for improved access to the area and encouraged residential development of the corridor.

With the advent of a better road system and large internal combustion engines, the logs were hauled from the woods for processing. The original lumber company lands transferred ownership many times, but generally remain managed for production of timber. See ownership summary in Section 1.

Pete Hufford and Roy Atkins provided an overview of some of the early mill sites in the Whitmore area.

> The earliest mill was located on Mill Creek at the Bullard place. In the 1870s the Mott Mill was located along South Cow Creek (by the Ponderosa Way bridge). The mill provided the lumber for the Hufford place. It was a sash mill. Q.N. Atkins established the Atkins Mill in the 1880s. It contained a turbine located in the creek that ran a circular saw in the mill. The sawdust was deposited in the creek. George Hufford had a mill right below the Atkins mill. Maxwell's Mill in the 1920s was located in Oak Run at the Bibben's place. The Thatcher Mill was located at the current Brady place and was steam powered. Elbert Miller had a mill at Mill Creek by the South Cow Creek Road bridge. It was then located south of the CDF station and ran until 1947.
>
> Roy Atkins worked for Elbert Miller at the mill on Ponderosa Way in the 1930s as a boy cleaning the flume. They used to select cut Sugar Pine first, then Ponderosa Pine and Doug Fir. Frank Atkins and his brother had a mill along Tamarack that milled all the lumber for the Kilarc Powerhouse. It only operated for 1-2 years. Latour Butte Mill was located along South Cow Creek by Rough Diamond Ranch. They are reported to have dumped sawdust into the creek, but Roy Atkins remembers still catching fish in the area. The mill went out of business, but still had cut lumber stacked there. The employees had not been paid when the mill went out of business, so the employees took possession of the lumber and shipped it to Anderson via horse and wagon. It took the entire summer to move all of the lumber from the mill (Atkins & Hufford, 2000, pers. comm.).

In the Oak Run area there were a few small mills that operated, but did not have a substantial effect on the timberlands. They were the Phillips Mill, which is still in operation, two mills on Bullskin Ridge, and one by the Twin Valley School.

The Red River Lumber Company (Walker family) owned the majority of timberland in the watershed at the turn of the century. Red River Lumber Company divided and sold in the early 1940s. The largest portions of the lands were sold or leased to Ralph L. Smith.

In 1947 R.L. Smith Lumber Company made a number of acquisitions. The first was for undivided interests in the Third Party lands of the Red River Lumber Company, which were partitioned. About 40,000 acres of timber went to R.L. Smith. The second acquisition was two cutting contracts on 15,000 acres of land east of Oak Run. The initial 375 million board feet was with the IVth Parties and the balance of the timber was with US Plywood. The third acquisition was the purchase of the Deschutes Lumber Company, which included the sawmill in Anderson and 12,000 acres of cutover and virgin timber located immediately south of the lands in the Whitmore area. The land was virgin timber until the 1950s, with the exception of the land immediately around Whitmore, in close proximity to the small local mills. The lower foothill tract was originally logged between 1930 and 1940 to feed the Miller Mill. The logging was a high-grade pine operation and removed only the pine in excess of 32 inches.

The R.L. Smith cutting contract included trees over 20 inches in diameter with a three percent reserve of trees 20 to 28 inches. The contract included two 10-year cutting cycles, in which half of the volume was to have been removed in the first cycle and half of the volume in the second cycle. The first cycle was from 1947-1958, with the second cycle from 1957-1968.

Some members of the Walker family retained interest in portions of the timberlands. Beaty and Associates have managed these lands for the last 50 years. In general, these were lands that were acquired by patent, railroad lands, or homestead claims.

The Ralph L. Smith fee lands and undivided interest in certain Red River Lumber Company lands were eventually sold to Kimberly Clark and, hence, to Roseburg Lumber Company. The timberlands managed currently by Sierra Pacific Industries were originally the timberlands of the Scott Lumber Company, which sold to Publishers Company and, hence, to Sierra Pacific Industries. (See ownership in Section 1.)

The lands of the Latour State Forest were acquired through a trade with the California State Land Commission in 1946.

California historically taxed the total value of a parcel. In the case of timber this included the value of the land and the appraised value of the standing timber. Laws stated that a landowner had to cut 70 percent of the standing timber volume to be taxed on land value only. The taxes encouraged heavy cutting on many private parcels. In 1978 California tax law concerning timber was modified such that timber value was taxed only when cut – a yield tax. The goal was to encourage conservation and stewardship of forest property.

Early logging practices were not regulated. Logs were removed from the woods as cheaply and quickly as possible. Most roads and skid roads were located near creeks and draws to allow skidding downhill. Replanting was not required. During the 1950s most forests were managed using selective cutting techniques. These techniques cut the large trees and left the smaller trees, which is a reasonable practice assuming smaller trees were also younger. In general practice, California's timberlands consisted of even-aged (same-aged) stands of variable sizes so that early practices actually removed the better, stronger individuals from the gene pool, while preserving the less vigorous smaller individuals for breeding purposes.

The 1970s brought many changes to forest management in California besides changes in tax law. Stricter forest practice rules were enacted requiring replanting or residual stocking retention. The new rules prohibited logging in and near streams and initiated significant sediment and erosion control practices. The changes in tax laws allowed forest managers to retain larger, healthier trees, and numerous genetic conservation programs were established.

Currently, forests in the Cow Creek Watershed are managed on a sustained yield basis (only cutting that amount of timber which can be grown over a given harvest cycle) and for conservation of diversity and quality.

VEGETATION

The type of vegetation in the watershed has changed dramatically in the last 150 years. Vegetation change is discussed in detail in the Chapter dedicated to vegetation in this report.

Prior to white settlers, Native Americans used fire to manage and control the landscape in which they lived. Their management objectives were simply to use fire to produce the resources necessary for survival from the native vegetation of the time. Significant change in the original vegetation of the Cow Creek Watershed began in the 1840s with the arrival of the first ruminate. In the stomachs of the cattle and sheep, imported to help feed the growing number of white settlers, miners and adventurers, were the seeds of non-native grasses and other plants. Deposited by cattle and sheep, these seeds soon flourished and, in the absence of pests or disease, began to encroach on the native vegetation.

Many non-native plants have been introduced to the watershed. These include many annual grasses, forbs and brush species. Many of these are now recognized as typical garden weeds and generally are not known to be non-native. A list of most common non-native invaders include:

TABLE 2-2
Common Non-Native Weeds

Forbs	
Pigweed (all sp)	*Amaranthus albus, A. blitoides, A. palmeri, A. retroflexus.*
Wild Caraway	*Carum carvi*
Poison Hemlock	*Conium maculatum*
Knapweed (all sp)	*Acroptilon repens; Centaurea diffusa, C. maculosa, C. pratensis, C. virgata*
Chamomile	*Anthemis cotula*
Thistles	
Musk	*Carduus nutans*
Italian	*Carduus pycnocephalus*
Yellow Starthistle	*Centaurea solstitialis*
Bachelors Button	*Centaurea cyanus*
Oxeye Daisy	*Chrysanthemum leucanthemum*
Chicory	*Cichorium intybus*
Fleabane	*Conyza bonariensis*
Hawksbeard	*Crepis setosa*
False Dandelion	*Hypochaeris radicata*
Dandelion	*Taraxacum officinale*
Prickly Lettuce	*Lactuca serriola*
Sowthistle	*Sonchus arvensis, S. uliginosus, S. asper, S. oleraceus*
Wild and Black Mustard	*Brassica kaber, B. nigra*
Perennial Pepperweed	*Lepidium latifolium*
Field Pennycress	*Thlaspi arvense*
Teasel	*Dipsacus fullonum*
Klamath Weed	*Hypericum perforatum*
Nettleleaf Goosefoot	*Chenopodium murale*
Scotch Broom	*Cytisus scoparius*
Peavine	*Lathyrus latifolius*
Sweetclovers (all)	*Melilotus officinalis*
Hairy Vetch	*Vicia villosa*

Horehound	*Marrubium vulgare*
Mallow (all sp)	*Hibiscus tronum, Malva neglecta*
Creeping Woodsorrel	*Oxalis corniculata*
Buckhorn Plantain	*Plantago lanceolata*
Curly Dock	*Rumex crispus*
Buttercup	*Ranunculus acris, R. repens, R. testiculatus*
Common and Mouth Mullein	*Verbascum blattaria, V. thapsus*
Puncturevine	*Tribulus terrestris*
Himalayan Berry (Blackberry)	*Rubus discolor*
Grasses	
Goat Grass	*Aegilops cylindrical*
Wild Oat	*Avena fatua*
Rescue Grass	*Bromus catharticus*
Japanease Brome	*Bromus japonicus*
Soft Brome	*Bromus mollis*
Ripgut Brome.	*Bromus rigidus*
Cheat Grass	*Bromus secalinus*
Downy Brome	*Bromus tectorum*
Bermuda Grass	*Cynodon dactylon*
Quack Grass	*Elytrigia repens*
Velvet Grass	*Holcus lanatus*
Foxtail Barley	*Hordeum jubatum*
Hare Barley (Common Foxtail)	*Hordeum leporinum*
Italian Ryegrass	*Lolium multiflorum*
Littleseed Canarygrass	*Phalaris minor*
Rabbitfoot Polypogon	*Polypogon monspeliensis*
Common Rye	*Secale cereale*
Johnsongrass	*Sorghum halepense*
Medusahead	*Taeniatherum caputmedusae*

Over the years, blackberries (non-native) have increased in number and line the creek banks in many areas within the watershed. Joe Crowe relayed information that Tobe Hufford had told him that blackberries (non-native) used to only grow in the garden where they were watered and cultivated (Crowe, Joe, 2000, pers. comm.). At the Crowe Ranch in Whitmore, blackberries (non-native) run the entire length of South Cow Creek on both sides. While this keeps cattle out of the creek, they have to constantly spray the blackberries to keep them at bay.

Observations of long-time residents state that in the late 1800s until the 1920s, fires were used in the high country to eliminate the underbrush. The vegetation consisted of large trees with little underbrush. In the 1930s the fir thickets encroached on the previously burned areas and choked off the grasses. The only good areas for grazing were in the existing meadows. Long-time residents noted that cows pulled out any new trees, so the meadows stayed in good condition (Hufford, 2001, pers. comm.). In the 1940-50s, logging was initiated in areas that had never been logged before. After logging operations were completed the grasses began to grow again in areas that had contained numerous fir thickets. The cattle spread out and didn't stay in the meadows, so willows and alders took over some of the meadows (Hufford, 2001, pers. comm.). In 1950, the white fir regeneration had already begun beneath the large pines in the absence of fire. There were still lots of openings and the pine only regenerated on bare dirt. At the Gardens, where Roy Atkins summers his cattle, the lodgepole pines have come in and taken over the meadows within the last 20 years. He says wherever the ground is disturbed, the trees start to grow and take over (Atkins, 2001, pers. comm.).

There is a large quantity of literature on the positive and negative effects of cattle grazing on meadow ecosystems similar to those found in Cow Creek. Uncontrolled or excessive livestock use in meadows has been documented to mechanically alter the form, structure, and porosity of soils, and change the composition of the plant community. Overgrazing and livestock concentration in riparian zones has, in some cases, altered stream morphology and vegetative composition.

Joe Crowe remembers talking with Tobe Hufford about traveling to Burney around 1924-25 (Crowe, 2001, pers. comm.). According to Tobe, Tamarack Road was a wide gravel road that went through large trees. There was no underbrush and the trees were spaced apart so a person could see into the forest.

Hal Bowman recalls that the vegetation in the Whitmore/Oak Run area in the early 1950s contained significant brush, and was no longer made up of open stands of trees. He also recalls less fir and cedar in the species mix (Bowman, 2001, pers. comm.).

In general, all longtime residents agree that since the 1950s, the trees have encroached into the meadows in the absence of fire and grazing, with the exception of the marshy areas, as trees do not establish well in the marshy areas. Mr. Bowman recalls that the ceanothus came back strongly after the initial harvest in 1950. Manzanita has always been present in the watershed and has taken over in many areas due to lack of fire (Bowman, 2001, pers. comm.).

In the South Cow Creek basin around Blue Mountain, the vegetation in the 1870s is reported to have consisted of scattered blue oaks and gray pines with ceanothus and grasses (Hufford, 2001, pers. comm.). By the 1920s the ridge was heavily vegetated with thick brush, and after the 1924 drought the brush died off. The area was burned and the brush has not returned. Now the ridge consists of dense oaks and gray pines. Mr. Pete Hufford observed that blue oaks are regenerating on most of his range, with some places having “too many little oaks for their own good.” He has seen some areas where oaks are not regenerating, mostly very low-rainfall, low-elevation sites.

Starthistle, medusahead and other non-native weeds have also increased over time. These grow in the drier areas and choke off the native grasses. They tend to grow in new areas after the ground has been disturbed.

DFG also wishes to clarify that in non-degraded meadow ecosystems, the conversion from meadow to coniferous stands is part of natural succession. It is natural, therefore, for trees to encroach upon a meadow system over time. However, this process can be dramatically accelerated if the meadow is negatively impacted by overgrazing, recreation, roads, etc.; (i.e., if land use causes the water table to drop). In addition, literature suggests that frequent, pre-suppression fire regimes helped maintain meadows, often not so much by burning meadows but by maintaining the surrounding ‘non-meadow’ habitat (e.g., mixed conifer). Literature also suggests that fire suppression has accelerated successional processes. The author requests the reader to please understand that science differs on its evaluation of the impact of fire and grazing on meadow ecosystems and that a complete discussion of the subject is outside the scope of this project. There are no documented effects of degraded meadows in the Cow Creek Watershed.

RANCHING

Over one third of the area of the Cow Creek Watershed is currently managed for the production of livestock. Many of the original ranchers in the watershed moved west under land grant provisions during the Grant presidency. Additional railroad ground was eventually sold and added to many of the ranches. The sheepherders were the first to graze the rich grasslands of the Cow Creek Watershed. Most of the early ranches of California ran joint herds of sheep and cattle and horses. The original herds of sheep and cattle entered Shasta County and the Cow Creek area in the 1840s. Early herds are reported to have been predominately sheep, as California remained the largest sheep producing state in the nation until later in the 19th century. Early ranches raised hogs, lamb and cattle, often concurrently. Range was open, with fences documented only along main roads. The majority of the livestock production is now attributable to cattle. The Atkins family reportedly ran over 6,000 sheep at one point in the Old Cow and Cow Creek drainage (Atkins, 2001, pers. comm.).

The plentiful water in the Cow Creek Watershed presented an attractive area for livestock production. Although reported to have been "too high to be good winter range and too low to be good summer range", production flourished. The early cattlemen and women successfully diverted water from natural channels to create acres of lush summer pasture for livestock. Water struggles began in the late 1880s, and by 1925, many ditch rights were adjudicated. Lack of groundwater in the lower oak woodland portion of the watershed helped to reduce the pressure of development to sustain the ranching activities.

The Whitmore Cattlemen's Association (WCA) formed at the turn of the century in response to increasing controls over open grazing, agency fire suppression, and Red River Lumber Company (RRLC) land purchases. The WCA negotiated leases with RRLC and R.L. Smith for grazing rights on approximately 26,000 acres of timberland located in the southeast portion of the watershed. The leases were for the period from May to October. In general, the cattle used four main areas, which included Cow Creek meadow, Cutter Meadows, Sheridan Flat and Miller Mountain Meadows. Beaty and Associates continues to permit lease grazing on portions of the RRLC and Smith properties. It is Beaty's position that the cattle contribute to perpetuation of open meadow and maintaining the health of riparian communities in the absence of fire. Historically, Hufford's had about 300 of the approximately 2000 cattle that utilized the leased grazing lands. Currently, Hufford's have the only substantial grazing lease within the watershed.

FIRE

Years of aggressive fire protection and timber management have dramatically changed the character of all of California's foothill and forest ecological communities, including those of the Cow Creek watershed. Evidence suggests that pre-European forests were open, park-like pine and fir forests subject to frequent low-intensity fires. These forests consisted of large mature individuals with only a grass understory. Undergrowth was minimal and consisted of small aggregations of individual regeneration. Frequent fires rejuvenated the meadow and riparian areas (Kozlowski, 1974). The fires were low intensity, creeping fires that consumed only dead, down materials. Fast moving crown fires, common today, rarely occurred. Only infrequently did fire consume mature individuals. See Section 7 for a more detailed discussion of the impact of fire on ecosystems.

Prior to suppression efforts in the 20th century, lightning and native peoples ignited forests. Pre-settlement fire return intervals were generally less than 20 years throughout a broad zone extending from the foothills though the mixed conifer forests (McKelvey et al., 1996).

Over a century of wildfire control, prevention, and other management techniques have created forests that are smaller, younger, and denser. These new forests have undergone significant changes in species composition and structure. They are now multi-level stands with a ladder fuel structure. Fires that occur today can be carried into the tree crowns by the ladder fuels. Once in the tree crowns the fires move quickly with great intensity and are all but impossible to control. Fires that do occur have become larger and more devastating.

WILDFIRE HISTORY

Ranchers and timber managers first documented fuel increases. As late as the 1920s ranchers continued to ignite understory vegetation as herds were driven from the high country in the fall. In addition, foothill grassland communities were burned to reduce encroaching brush and non-native species.

Several large wildfires have occurred in the Cow Creek Watershed in the last seventy years that records have been maintained. CDF Fire history records indicate a total of 42 wildfires within the Cow Creek Watershed. Of these fires, nine have been in excess of 3000 acres in size. The most recent large fire that occurred in the Cow Creek Watershed was the Jones Fire that burned 26,020 acres in the northeastern portion of the watershed in October of 1999. The largest fire of record is the Fountain Fire that burned a total of 65,300 acres, of which only 9 percent or 9,300 acres was located in the Cow Creek Watershed. The Fountain Fire occurred in August 1992. Fire size and intensity have increased steadily. Historic fire acreage is included in Table 2-3.

TABLE 2-3
Fire Acreage

Date	Fire Type		% Watershed Burned
	VMP Acres	Wildfire Acres	
1850 - 1900	None Noted	None noted	n/a
1900 - 1950	None Noted	10,209	4
1951 - 1975	4,079	11,119	6
1976 - present	23,934	45,365	25
TOTAL	**28,013**	**66,693**	**35%**

Figure 2-1 displays recorded fire history in the Cow Creek Watershed. CDF began keeping records of wildfires in the 1920s.

CONTROLLED BURNING

In the late 1800s, cattlemen would ignite the underbrush as they were bringing their cattle down from the mountains. Native Americans were still living in the area at that time, and they too burned the brush in the high country. All burning had stopped by the 1920s and the cattlemen had approximately 10 years of feed after the last fire before the brush and fir thickets choked of the grasses.

In the 1940-50s control burning in the watershed was started. In the 1940s, an area of Oak Run from Fender Mountain to Highway 299 was burned. According to Roy Atkins, they had to burn the area three times at two-year intervals to get all the brush. Hal Nixon and Joe Caporusso set up and managed these burns. The large burning programs stopped in the 1960s (Atkins, 2001, pers. comm.).

Large control burns in Whitmore began in the 1950s. Pete Hufford stated that the first control burn in the Blue Mountain area consisted of 10,000 acres between Bear Creek, South Cow Creek, Morelli Ranch on the east, and Hufford and Wagoner Ranches on the west. Half of the manzanita in this area was burned off with this first control burn. They conducted four burns total, with the last one taking place in the 1970s (Hufford, 2001, pers. comm.). Bill Beaty reports that these burns did the best job of brush conversion, ridding the grassland of encroaching brush chaparral (Beaty, 2000, pers. comm.). The Strawn Ranch started conducting small control burns on their property in 1946, to eliminate the brush and allow for livestock grazing (Strawn, 2001, pers. comm.). The last fire took place in 1996

and included approximately 200 acres. These vegetation management burning programs were successful not only in reducing the invasion of brush species and non-native weeds, but increasing water and spring yield. (See Table 2-4.)

Quantitative studies of the hydrologic responses of watersheds where dense vegetative cover has been replaced with range and forage grasses have consistently shown increases up to 50 percent or more (equivalent to 3 to 5 acre-inches per acre) in annual runoff over long periods of measurement (Burgy, undated). These runoff studies cover the variety of conditions found in Northern California. About half the yield increase occurs in the latter portion of the season, giving usable flow in dry periods. The balance of the increase is produced as increased outflow during the post-storm periods (Burgy, undated).

Specific spring measurements were obtained during a 1950 burn with the Cow Creek Watershed, and significant changes in water yield were obtained (UC Coop Extension Data Files, 1950). These resulted in an average increase in water yield in two springs of over 170%. Data is included in Table 2-4.

TABLE 2-4
Spring Data

	Measurement Date	Gallons/Hr.	% Change
Bastain Spring			
	Pre-burn 8/9/50	9.4	
	Burn date 8/10/50	--	--
	Post-burn 8/11/50	20.2	215%
Last Chance Gulch Spring			
	Pre-burn 8/9/50	31.5	
	Burn date 8/10/50	--	--
	Post-burn 8/21/50	40.3	128%
	Post-burn 8/23/50	75.6	240%

Ranchers in the watershed that were interviewed have conducted control burns on their ranches consisting of a few hundred acres to thousands of acres since the 1940s. Most of these ranchers have abandoned this practice due to the difficulty in obtaining permits and problems adhering to the air quality regulations. In addition, complaints from neighboring houses, which have moved in to recently divided parcels, make burning difficult.

DEMOGRAPHICS AND SETTLEMENT

The County boundaries of Northern California were not delineated formally until after 1870. Prior to that time, Shasta and Siskiyou and what is now Tehama County were lumped together in a variety of differing divisions. Retrieval of historic demographic information is further hampered by the ever-changing names and location of many of the settlements in the watershed. A summary of settlements and their respective dates of establishment are summarized by original name in Table 2-5.

TABLE 2-5
Settlements Summary

Town/Settlement	Date Founded	Comments
Afterthought	1870s	Near Ingot
Albertson	1883	At Palo Cedro
Basin Hollow	1857	Near Whitmore
Bella Vista	1887	What is now Meyer Ranch, approx. one mile south and east of current town
Buncombe		Now Millville
Calkins	Pre-1901	East of Bella Vista
Dry Creek		Oak Run
Eilers	1895	SW of Round Mountain
Estep	Pre-1901	North of Oak Run
Euclora	1885	German colony east of Whitmore
Fern	1898	Near Whitmore
Furnaceville	1875	Near Ingot or Ingot depending on reference
Goodhope	1895	SW of Round Mountain
Heryford	Pre-1901	East of Palo Cedro
Ingot	1904	Also Silverton or Furnaceville, east of Bella Vista
Kendon	1900	Near Ingot
Loomis Corners	1861	West of Bella Vista
Millville	1860	Formerly Buncombe
Oak Run	1852	Dry Creek, mining area east of Redding
Osborne	Pre-1901	North of Oak Run
Palo Cedro	1891	East of Redding
Paronee	1894	Between Millville and Whitmore
Roberts	1885	At Palo Cedro
Silver City	1862	Ingot, near Ingot or also Silverton?
Tamarac	Pre-1860	Now Whitmore
Whitmore	1860	aka Tamarac

The demographics of the watershed have changed over time with the movement of people and consolidation of industrial centers in the valley area close to transportation corridors of railroads, highways and waterways. A 1901 historic map of the western portion of the watershed is included as reference, Figure 2-2. Prior to the 1920s, the population of the watershed was concentrated around the resource industries that supplied the raw materials needed for the expanding economy. These included the milling, mining and agricultural areas. Although many of the road locations remain the same, the population centers have relocated from the uplands resource areas to the valley areas.

Population estimates for Shasta County, 1850 – 1990, and Millville are shown in Figure 2-3 and presented in Tables 2-6 and 2-7.

TABLE 2-6 Shasta County Decennial Census Data	
Decade	**Population**
1850	378
1860	4351
1870	4173
1880	9492
1890	12133
1900	17318
1910	18920
1920	13361
1930	13927
1940	28800
1950	36413
1960	59468
1970	92100
1980	115715
1990	147036

TABLE 2-7 Historic Population in Cow Creek Watershed		
City	**Year**	**Population**
Millville	1860	780
	1870	968
	1880	1680
	1900	426
	1920	600
Round Mountain	1900	806
	1920	800
Whitmore	1900	213
Bella Vista	1915	2000
	1980	5458
	1990	6979
Palo Cedro	1980	3804
	1990	4198

WILDLIFE

Wildlife populations are dependant on the vegetation and related habitat conditions of the ecosystem. The changing vegetation and ecosystem dynamics in the Cow Creek Watershed are likely to have resulted in a change in the wildlife populations. (See Section 8 for additional information on wildlife.)

Population dynamics and trends are included in detail in the Wildlife section. No detailed information was located on the early populations of Cow Creek wildlife. The following information has been obtained from interviews with long-time residents, and is mostly associated with game animals. It is provided to present their recollection of historic conditions.

All sources interviewed including the DFG note that deer populations in the watershed have decreased dramatically in the last 60 years. Local residents recall that in the 1940s, there was a huge deer herd on Clover Mountain in Oak Run, which supported 30-40 bucks and a total of 200-300 does (Atkins, 2001, pers. comm.). There were also great numbers of deer in the 1950-60s. Most sources agree that the increase in the deer herds in the 1960s was in response to an increase in early successional habitat as a result of the RL Smith logging. The logging opened the tree canopy and disturbed the duff, which allowed the seeds of forbs and browse plants to sprout and prosper.

Bill Beaty remembers significantly more deer in the 1950s after the first cycle of logging in the area. He recalls paying for numerous truck repairs on foresters' trucks after hitting deer on Whitmore Road and Highway 44 during migratory time (Beaty, 2000, pers. comm.). Beaty & Associates has maintained a hunting lease on a portion of the land they manage. Review of the lease records show that the lessee used to kill 25-30 bucks a year; now they kill less than five.

Pete Hufford recalled his father telling him the deer were scarce in 1913. His father saw no deer on a hunting trip to Magee Peak that year. Once at Magee, he saw one doe, one buck and a mountain lion. He was not sure why the deer were so scarce that year, however this period was before logging in the watershed and may have been due to severe winter or draught in previous years (Hufford, 2001, pers. comm.). Mr. Hufford recounts that his father recalls that deer were scarce in the early 1900s. He attributed this to lion predation, as he added that after a local man began trapping lions, the deer population increased (Hufford DWA comments, Sept., 2001).

The deer use the Strawn Ranch in Oak Run as a migration route. Historically they used the ridge above the ranch, but because of the increased numbers of people that have moved into the area, the deer have moved down the canyon to the ranch (Strawn, 2001, pers. comm.). Blue Mountain is also a migratory route. Mary Crowe remembers the deer always using this route. (Crowe, Mary, 2001, pers. comm.) There are trails up on the ridge that are cut into the ground due to use year after year.

Interviewees and DFG gave several reasons for the decline of the deer population. These include less logging in the high country allowing the tree and manzanita thickets to take over, closing of the canopy that prevents the grasses and ceanothus from growing, increased mountain lion populations, dogs from the increase in people, poaching, and road kill. The lack of habitat is likely the primary cause for declines in deer herd numbers. Many studies over time have correlated the decline in habitat quality with fire suppression activities.

The significance of the lower edges of the chaparral belt where woodland-oak forest and grasslands meet have been identified as areas of special abundance for game animals during the early historic period of California.

> Prior to settlement, deer seem to have occurred principally along “edges” where forest and grassland met or on recent burns in the forest. Neither dense timber nor extensive prairie supported many deer. The woody shrubs and/or tree reproduction which constitute staple items of deer diet are characteristic of sub-climax ecological conditions (in other words, of early stages in a forest successional cycle), such as occur even today on prairie borders where woody plants encroach on the grass only to be pushed back periodically by drought or fire…the borders of the Sacramento Valley were maintained in young brush by recurrent fires, some of them probably set by Indians for the specific purpose of producing more game (Leopold, 1950).

Studies in California wildlife management have shown the significance of various relationships between animal populations and environments subject to fire succession (Biswell and Gilman 1961, Biswell 1952, Komarek 1963, Leopold 1950). Depending upon local environmental factors and the conditions under which fire takes place, it has been shown that deer in recently burned-over cover show marked increases in numbers, size, and improvement of health:

> An area of prescribe-burned chamise and chaparral was compared with a similar unburned area as a control. Counts of deer in the burned area showed a summer population density of about 98 per square mile after the initial burning treatment. This rose to 131 in the second year, and dropped to 84 in the fifth and sixth years. In the dense, untreated brush the summer density was only 30 deer per square mile. Ovulation rate in adult deer was 175 percent in treated brush and only 82 percent in untreated brush. Deer weights were higher in prescribed-burned brush than in the untreated area” (Biswell, 1967; 81).

Small game populations are similarly affected. Research in the chaparral regions (Biswell, et al., 1952) has shown that valley quail are found in numbers two-and-a-half times greater in burned areas than in unburned areas, jackrabbits two to four-and-a-half times as great, with the number of doves simply noted as having increased.

Recent regulations prohibiting the hunting of mountain lion and trapping of coyote has also likely had a significant effect on local deer and wildlife populations. During the time the state had a bounty for the mountain lions, they were rarely seen, but they were plentiful. The lions had a large range, passing by the same area in about 7-10 days. After they became protected, their numbers increased. Many of the cattle ranchers loose calves each year to mountain lions. Atkins typically looses 2-3 calves per year, Morelli lost 6-8 percent of her calves and some sheep recently, and Aldridge lost 8-10 calves last year (Atkins, 2001, pers. comm.).

Feral pigs were introduced into the ecosystem in the early century as domestic hogs escaped into forestlands. Although not as prevalent in Cow Creek as in other areas of the State, the pigs compete for available forage, damage wetlands, and provide alternate food sources to maintain lion populations at increased levels.

FISHERIES

The decline of salmon populations is widely documented in the literature available. Decline is attributed to historic mining, reduced water flows, and increased temperatures due to diversions and the construction of the Red Bluff diversion dam. A discussion of fishery resources reference conditions is included in the Fishery Resources section of this report.

The following information was obtained from interviews with long-time residents. Although undocumented technically, the information is included to present local historic perspective. The actual runs of, or species of, anadromous fish referenced are not specified.

Historically, there were large numbers of salmon in Old Cow Creek. Roy Atkins lived in Millville from 1929-1937 and remembers lots of salmon in the creek if there was a good rain in October that would raise the flows enough for the fish to come up. He has seen salmon at the old Hufford place in the 1930s. They used to spear salmon in the Sacramento River at the junction with Cow Creek. They could wade or swim across the Sacramento River, as it was warmer and used to run less (prior to the construction of Shasta Dam) (Atkins, 2001, pers. comm.). Pete Hufford also told of wading out into the Sacramento River at the junction of Cow Creek to get salmon during low water years. Pete also recalled that his father's family used to fish at the fork of South Cow Creek and Cow Creek and they would fill up the wagon box with 20-30 fish. He recalls they had many good salmon runs years ago with more irrigation diversion and grazing than today (Hufford, 2001, pers. comm.). In the 1940s-50s, Joe Crowe remembers watching the salmon jump the small waterfalls in Old Cow Creek on the ranch when he was a kid. He recalls that there were enough salmon that ranchers would come and get 1-2 at a time and pick good fish, not beat up ones (Crowe, 2001, pers. comm.). Virginia Strawn remembers swimming in Old Cow Creek and pushing the salmon up to the pool below the falls, so they could catch them during the war (Strawn, 2001, pers. comm.).

No one interviewed recalls salmon in Old Cow Creek above the falls, but all interviewed mentioned the abundant trout. Pete Hufford remembers that the fishing was better after the logging of the area in the 1940-50s. In the late 1950s, DFG asked R.L. Smith Lumber Company to use a crawler tractor in the creek to remove all logs and debris. The operator is rumored to have "run the cat right down Old Cow Creek above Kilarc" (Hufford, 2001, pers. comm.). Some say the fishing was worse after clearing, some say it was better. Bill Beaty conducted a study (1955-58) that showed in the year following logging there were more fish in the logged area than in the un-logged area (Beaty, 2000, pers. comm.).

There were salmon in Clover Creek, but not as many as Old Cow Creek. Most of those interviewed attribute this to lower water levels in Clover Creek. V. Strawn recalls that the Native Americans used to camp at the Clover Creek falls and catch enough salmon for the entire winter (Strawn, 2001, pers. comm.). Roy Atkins remembers catching 100 fish (trout) in Clover Creek in the late 1930s and early 1940s (Atkins, 2001, pers. comm.). Bill Beaty recalls the fishing on Clover Creek was good, as well as in the other Cow Creek tributaries, if you were willing to plow through the brush to get to the creeks (Beaty, 2000, pers. comm.).

Salmon in South Cow Creek above the Wagoner Canyon have always been scarce (Hufford, 2001, pers. comm.). In 1908, PG&E constructed a dam at South Cow Creek. There used to be a natural barrier in Wagoner Canyon, but the Department of Fish and Game blasted the rocks to allow the salmon access upstream during higher flows in the 1970s. P. Hufford recalls that his uncle in 1894 killed two salmon with a rifle and sometime between 1902-08 they killed one with a rifle at the ranch on South Cow Creek above the dam. He says it is exceptional to see salmon that far up the creek (Hufford, 2001, pers. comm.). John and Mary Crowe, as well as Joe Crowe, all say that there are very few salmon in South Cow Creek where it flows through their ranches (Crowe, 2001, pers. comm.). PG&E installed a fish ladder at the dam on South Cow Creek in the 1970s, but local residents state that there has been no significant increase in the number of salmon in the creek above the dam. There are trout in the creek, and DFG continues to plant fish in South Cow Creek.

Many local ranchers attribute problems with salmon and fish population to the otters. Otters are likely to have been eliminated from the watershed by early trappers and hunters. Numerous local residents recall that the otters returned to South Cow Creek in large number in the 1960s. The otters enjoyed the numerous fish and had a negative effect on the fishery near the Hufford Ranch and all but eliminated the fish (Hufford, 2001, pers. comm.). The otters are reported to still come up the creek system, but they are fewer in numbers and thin out the fish, but do not eliminate them. "The sucker fish disappeared with the appearance of the otters," according to Pete Hufford. There used to be 18-inch suckers in the creek, now there are none (Hufford, 2001, pers. comm.).

In Mill Creek, tributary to South Cow Creek, Pete Hufford says there were fish in the creek in 1924 (Hufford, 2001, pers. comm.). Roy Atkins remembers lots of 7-8 inch trout. Now he says he sees a few 4-5 inch trout in the creek. (PG&E diverts the entire flow of Mill Creek in the summer just upstream from the junction with South Cow Creek (Atkins, 2001, pers. comm.)).

No one commented on salmon in Oak Run Creek. Virginia Strawn stated that Oak Run Creek dried up around 1977 during the drought. Their ranch was the end of the water rights at that time, and they took the last of the water in the creek for irrigation (Strawn, 2001, pers. comm.). The trout died off at that time and have not come back to the populations that existed prior to the drought. There are a few trout, but they migrate upstream during the summer to the cooler water. There are now bass in the creek that were not there before. When R. L. Smith was logging in the area there was a lot of water in Oak Run Creek. After the 1956 fire, the water in the creek increased tremendously (Strawn, 2001, pers. comm.). Now there is less water in the creek than in the past. There are algae in the creek now and the temperature of the creek has increased. The spring inflow to the creek has decreased due to an increase in the number of people in the area that are using the springs and an increase in the amount of brush.

Numerous parties mentioned that many springs have dried up since the 1920s (Strawn, Atkins, Hufford, Palmer, 2001, pers. comm.). Most attribute this to the increased transpiration of the trees and brush. Strawn noted that after burning or clearing removes the brush, the spring flows come back (Strawn, 2001, pers. comm.). Roy Atkins noted the springs located on his summer pasture in the high country have diminished with the intrusion of brush and trees (Atkins, 2001, pers. comm.). Ron Palmer also noted that the springs rejuvenate when the trees and brush are gone (Palmer, 2000, pers. comm.).

Numerous interviews noted that the salmon have decreased since the construction of the Red Bluff Diversion Dam in the Sacramento River system.

IRRIGATION

The abundant water and steep terrain of the Cow Creek Watershed provided the early settlers with great opportunities for irrigation, diversion and power generation. The first ditches and diversions were established in the early 1840s. Most were adjudicated between 1925 – 1965.

A detailed discussion and summary of diversions in the watershed is included in the Hydrology section of this report. Interesting stories associated with ditch construction and other information obtained from interviews with long-time residents follows in the section.

Pete Hufford provided a brief history of the establishment of the early irrigation ditches. In 1859 Wagoner had the Native Americans dig the ditch to his ranch. In 1868, George and Pete Hufford established rights for property where the current Cascade School is located outside Whitmore. Bob Hufford established the 1868 ditch (Pete Hufford DWA comments, Sept., 2001). In the 1880s Aldridge, Gimblin and St. Vain dug a ditch in Section 32, each with 1/3 interest. While digging the ditch, they made a mistake in the grade/location so it couldn't make it to the Aldridge place. Aldridge then sold his interest to Gimblin.

The Harris Ditch was established in the 1880s before the German Ditch (1886-1887). The downstream users were worried about the amount of water the Germans were taking. There was a reported meeting at Pete Hufford's grandfather's house with the Germans and the other downstream users, over concerns that the German allotment would take the full flow of the creek. They came to an agreement that everyone would get their share of the water. In low water years the Germans would back off on the amount of water they were taking (Hufford, 2001, pers. comm.).

By the 1900s most of the diversions and ditches were in place. In the late 1930s PG&E owned above the Morelli's place and dug a ditch from their property that collected surplus flows from Mill Creek. This diverted the water that went back into South Cow Creek, used by downstream parties. The private owners retained a lawyer to keep PG&E from diverting the water. The case went to court and the judge felt adjudication was the appropriate action. That case was dropped but problems continued, and eventually all diversions were adjudicated. John Crowe and Jesse Hufford worked to get the adjudication in 1969. The adjudication reflected the new name "Atkins Creek" for what used to be known as the "North Fork of South Cow Creek". Because of this some of the newer people researching their water claims could not find them, as they were looking for Atkins Creek references. The adjudication allocated three levels of diversion rights: domestic, old existing rights, and power new rights.

The Bassett Ditch served the Crowe Hereford Ranch at the time of the adjudication. According to Joe Crowe, they constructed concrete boxes at each tributary point so they would not have to monitor each user (Crowe, 2001, pers. comm.). The concrete boxes were constructed in such as way as they would distribute the correct allotments to each user. There is no watermaster service for this adjudication.

During the few times where there hasn't been enough water to meet all the allotments on South Cow Creek, PG&E has had to cut back on the amount they are diverting to the power house because they are a lower priority class than the domestic and historic irrigation users.

At the Crowe Ranch on South Cow Creek, Joe Crowe remembers very minimal fish loss in the irrigation ditches (Crowe, 2001, pers. comm.). The pond on the ranch contains some trout that have entered via the irrigation ditch.

The Strawn diversion on Oak Run Creek has two gages to monitor the diverted flows. They are the only people on Oak Run Creek that have a gage. The ditches have been screened (non-DFG approved) for the last few years to prevent fish from entering the ditches. Previously, fish would get carried into the ditches and out into the fields. Strawn's leveled their fields in 1950 to be more efficient with the irrigation water. The water goes a lot further now. The neighboring property leveled their fields after that (Strawn, 2001, pers. comm.).

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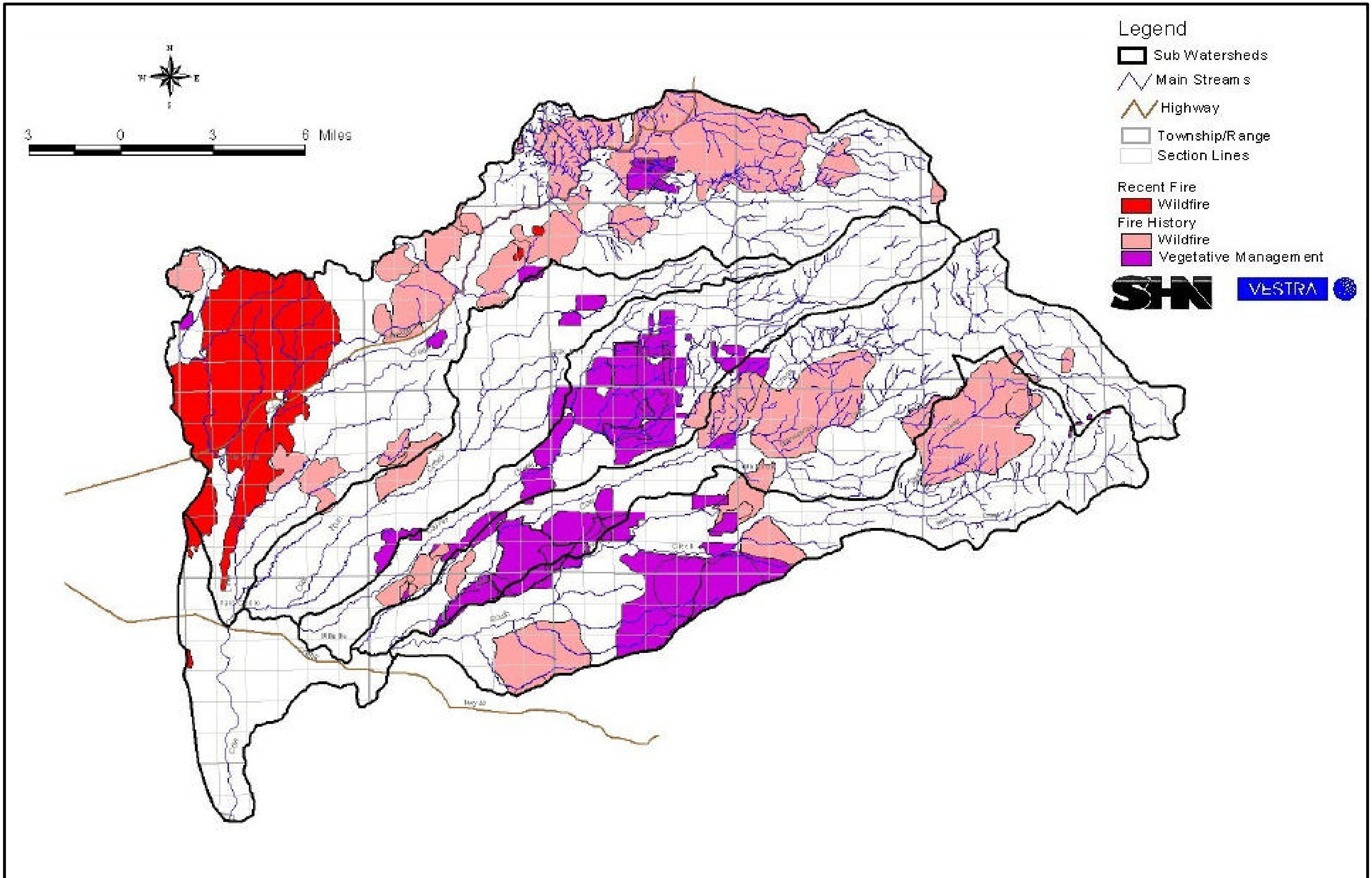


Reference: CDF

FIGURE 2-1
FIRE HISTORY
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

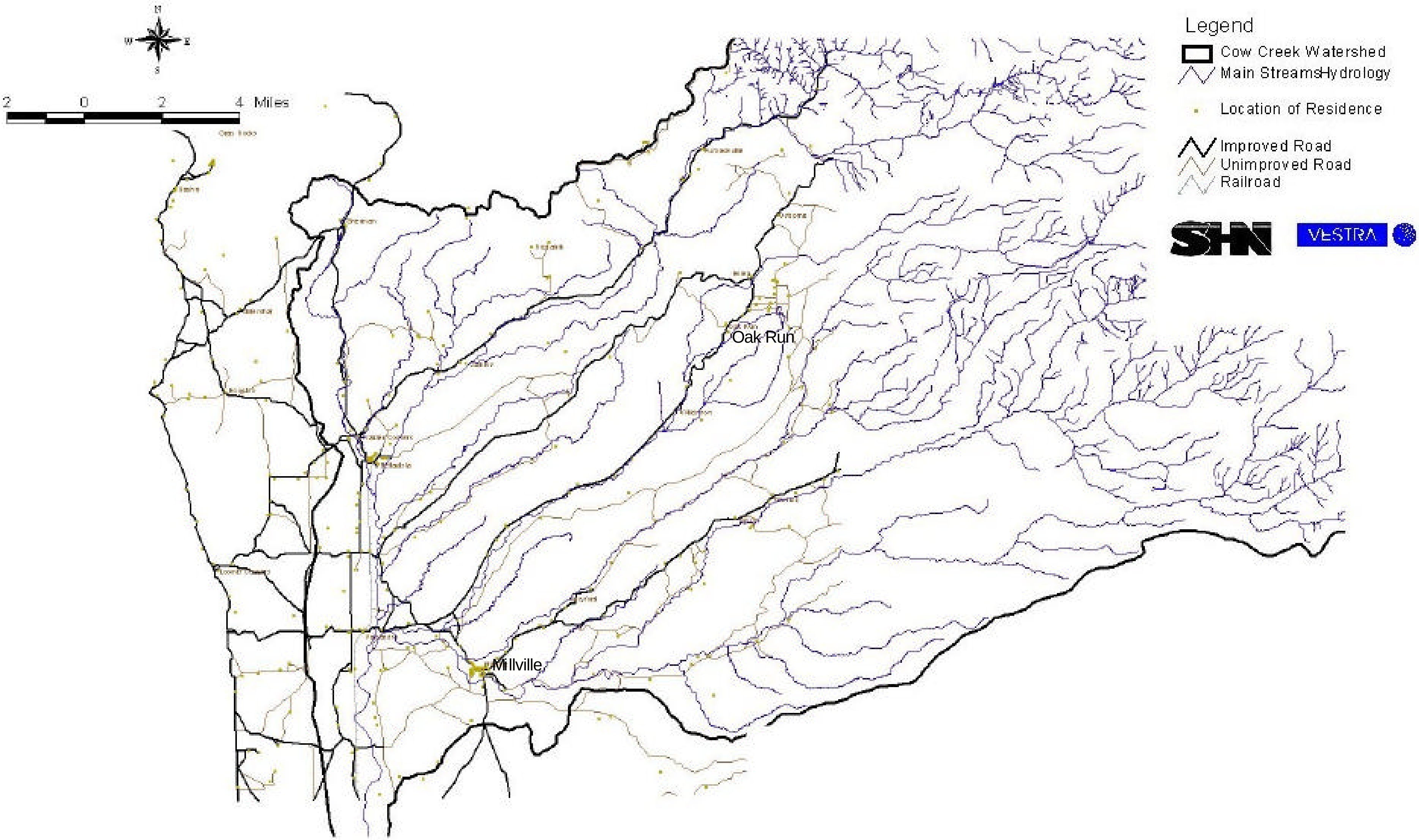
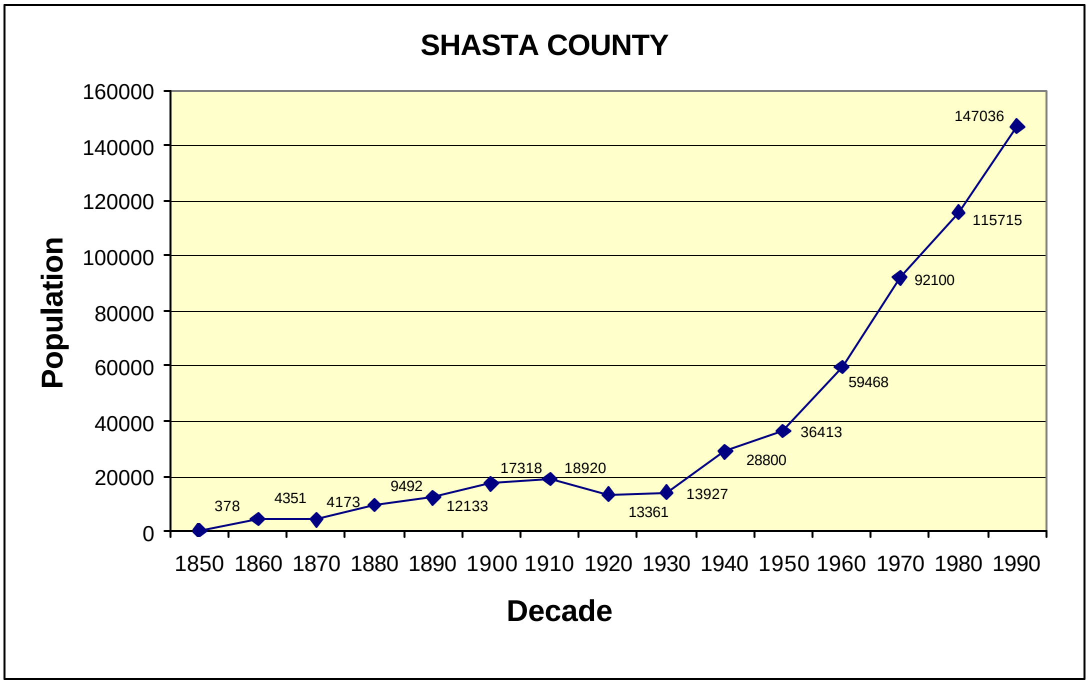
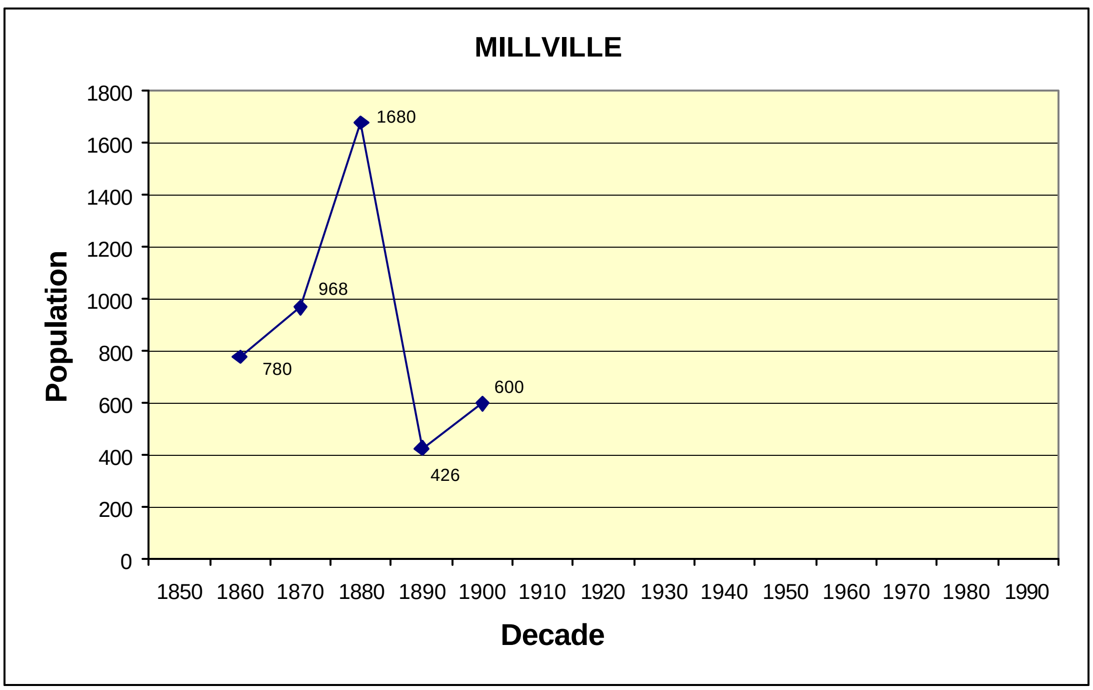


FIGURE 2-2
1901 HISTORICAL MAP
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: USGS 1901 Quadrangle

FIGURE 2-3
Population Estimates
1850-1990





Section 3
LAND USE AND DEMOGRAPHICS

Section 3
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Section 3
LAND USE AND DEMOGRAPHICS

INTRODUCTION

Land use in the watershed is heavily influenced by its ownership. While most of the low and mid-elevation lands are held by private individuals who utilize these areas for agriculture (ranching, farming) and residential uses, the upper elevations are held by commercial timber companies, the State of California and to a limited extent the US Forest Service. This section will discuss the predominant land uses in the watershed, primarily focusing on private lands.

LAND USE

Land use in the watershed is mixed. This section will discuss the various land uses in the watershed, providing a brief overview of public and commercial forestlands and focusing specifically on private lands.

PUBLIC LANDS

Land ownership is included was included on Figure 1-3. The State of California and the federal government hold limited public lands in the watershed. Located in the South Cow Creek sub-basin, the Latour State Forest is the largest public ownership in the watershed. This land, managed by CDF, emphasizes multiple uses including sustained yields of timber harvest, recreation and wildlife management. The Sustained Yield Plan (SYP) prepared by CDF guides specific land management within the Latour State Forest. The SYP breaks up Latour into management units in five watersheds within the forest. Three of the management units are within the Cow Creek watershed: Old Cow Creek, Atkins Creek, and South Cow Creek. Resource management within the state forest is designated to:

- maximize timber production on all productive acres and improve the quality of forest products, including pest management activities;
- emphasize an ongoing experimental and demonstration program to improve timber production;
- provide and expand recreational experience for the public;
- improve and maintain watershed protection through forest practices and erosion control, emphasizing the prevention of site degradation by erosion control methods and soil conservation practices;
- continue fire prevention and hazard reduction programs; and,
- manage wildlife habitat to increase populations.

In addition to the Latour State Forest, the other major public ownership is held by the federal government and includes lands administered by the US Forest Service (Shasta-Trinity and Lassen National Forests) and the BLM. At about 2 percent of the total watershed land base, public lands are not a significant portion of the watershed.

Forest Service lands are located at the eastern extreme of the watershed, while BLM lands are generally isolated blocks scattered throughout the watershed. Land management activities on these federal lands have traditionally focused on timber management, livestock grazing, mining and management of lands for production of water. In recent years, the various land management plans for these public agencies have de-emphasized timber and livestock production and focused more on watershed management and preservation of wildlife habitats. This "ecosystem" approach to management has significantly reduced the amounts of timber harvested from these public lands, increased scrutiny on livestock grazing and put more emphasis on research and development of conservation techniques.

COMMERCIAL TIMBERLANDS

At just over 30-percent of the land base in the watershed, commercial timberlands are a significant commercial activity in Cow Creek. The three landowners (Roseburg Resources Co., Beaty and Associates, Sierra Pacific Industries) have individual land management planning documents for their lands that outline goals and objectives for the various properties. These specify timber harvest levels, vegetation and stocking plans, wildlife management plans and limited public uses. While these plans vary by owner/manager, all must conform to requirements for commercial timberlands outlined by the State Board of Forestry, administered through CDF.

PRIVATE LANDS

Privately held lands dominate the watershed. The uses of these lands vary from commercial and residential to agriculture and grazing. While individuals hold these properties, development and use is overseen by Shasta County through the Board of Supervisors and the County General Plan. The following section will describe the overall private land uses as described in the Shasta County General Plan. For a complete and definitive overview of private land uses, detailed objectives and specific land use designations in the Cow Creek Watershed, refer to the Shasta County General Plan.

SHASTA COUNTY GENERAL PLAN

The primary regulatory agency and policy making body for private land use in the Cow Creek Watershed is the Shasta County Board of Supervisors. All discretionary decisions regarding land use, resource management, development approvals, environmental impact assessment and related matters must be considered by the Board of Supervisors in the context of the current Shasta County General Plan.

The Shasta County General Land Use Plan (General Plan) is the official document adopted by Shasta County, which makes general, long-range policies of how future development within the county should take place, addressing both private and public owned land resources. There are four components that form the framework for the development and utilization of the General Plan. These components define basic planning opportunities and constraints that must be addressed for public safety, resources, and community development. The components are:

- the natural environment (landforms, water, climate, minerals, soils, vegetation and wildlife);
- the man-made or built environment (residential areas, transportation networks, water impoundments, cultivated areas);

- the institutional environment (social, economic, governmental); and,

- the potential for environmental change (changes of the above due to population growth).

The General Plan looks beyond the present and immediate future, reflecting a 20-year time period of development; in this regard the General Plan may not always reflect the existing land use patterns of the area, but rather if the land can support a use, with regards to the components natural, man-made or institutional environments. Additionally, the General Plan should not be confused with the zoning ordinance map, which specifies how individual land parcels may be utilized.

GENERAL PLAN OBJECTIVES

The objectives of the General Plan are basic statements of the values regarding the future growth, development, and quality of life within Shasta County. These objectives were formulated through a broad-based citizen participation effort, representing the wide range of perspectives and interests present in the County. The General Plan incorporates a review, evaluation and revisions of these objectives, to account for changing priorities and potential land uses. The County objectives that generally pertain to the Cow Creek Watershed, with regards to resource management, are listed below in broad categories. Specific objectives and detailed descriptions for these areas can be found in the General Plan.

- ***Agriculture –*** focuses on lands dedicated to full-time and part-time agricultural operations that provide a local and regional food supply, provide open space, and facilitate a rural lifestyle.
- ***Timberlands*** - focuses on the preservation of timberlands for sustainable forest management and production, and protection from adjacent adverse land uses.
- ***Minerals –*** emphasizes the identification, conservation, and development and reclamation of mineral resources while protecting adjacent land uses.
- ***Water –*** focuses on protection of surface and groundwater resources for the benefit of all County residents.
- ***Historic/Archaeological –*** preserves and protects historic and archaeological resources for education, aesthetic and recreational uses.
- ***Open Space –*** protects open space for the use and enjoyment of County residents while protecting private property rights.
- ***Fish and Wildlife –*** protects fish and wildlife habitats and vegetation resources so that wildlife species will continue to flourish in the County.
- ***Flood Protection –*** restricts new development in the 100-year floodplain.
- ***Fire Protection –*** protects developments from both wildland and non-wildland fires by requiring development standards.
- ***Erosion –*** protects property from development on highly erodible soils.

GENERAL PLAN DESIGNATIONS

There are eight General Plan land use designations in the Cow Creek Watershed: Agriculture, Commercial, Habitat Resource, Mixed Use, Public Lands, Recreation, Residential, and Timber. Land use maps provided by County Planning were used to determine planned land uses within the watershed, and Table 3-1 shows a summary of those land use designations with acreages.

In the Cow Creek Watershed, as well as throughout the county, some of the land use designations outlined in the General Plan do not coincide with the existing land uses. This is because the General Plan looks at not only what the land is currently used for today, but also what the long-range use of the land should be. Currently, agricultural land held as Williamson Act Lands are designated in the General Plan as agricultural grazing or cropland. These lands currently are being utilized for agriculture and due to their designation as Williamson Act lands, it can reasonably be presumed that they will retain this use in the future. By the same token, areas designated as timberlands are being managed for long-term timber production and can also be predicted to be maintained as timberlands in the future.

TABLE 3-1
Land Uses by Acres[1]
Cow Creek Watershed

Categories	Acres[2]
Agricultural	
Croplands	970
Grazing Land	73,610
Grazing/Croplands	2,910
Commercial	230
Habitat Resource	33,700
Mixed Use	350
Public Land	16,280
Recreation	
Recreation Resource	80
Commercial Recreation	30
Residential	
Rural Residential-A	18,580
Rural Residential-B	43,280
Suburban Residential	60
Timberland	84,620

1-Figures taken from Shasta County Planning
2-Acres are rounded for ease of use.

Unlike the designations above, the other General Plan designations do not necessarily reflect the *current* uses of the area, but what the *development trends* of these areas indicate. For example, the Residential designation has been developed for areas that should or can be utilized for residential purposes, with restrictions. However, because the area is designated as such for future use does not mean that the area is not utilized for some other purpose today, such as timber or agricultural production. Land use designations are included on Figure 3-1.

Agricultural Lands

Agricultural land uses are a major component of the resource land base, in Shasta County, as well as the Cow Creek Watershed. They are also a major element in defining the quality of life available to the residents of Shasta County. Were agriculture to lose its land-based prominence in the County, the rural character and country living, so valued by its residents and so important to its economy, would decline and eventually vanish. This element encompasses portions of three mandatory elements: land use, conservation, and open space. These elements are generally defined as:

> ***Land Use*** **-** The proposed general distribution, location and extent of the use of land for agriculture.
>
> ***Conservation Element*** **-** The conservation, development, and utilization of natural resources including soils.
>
> ***Open Space*** **-** The managed production of resources, including rangeland, agricultural lands, and areas of economic importance for the production of food or fiber.

History. Farming and ranching began in Shasta County when the first settlers arrived. By 1858 almost 6,500 acres were cultivated in Shasta County. The raising of cattle had become an important source of income by 1858, as well as the breeding of hogs, sheep, and horses; wheat and barley were the major field crops. The importance of farming was overshadowed by the gold rush and subsequent mining activities. In later years, lumbering and construction overtook farming and ranching.

While farming has continued to have a stabilizing influence on the economy, only a small percentage of soils are suitable for cultivation and the availability of water for irrigation has always been a problem. Before the arrival of the railroad in 1872, local miners consumed much of the crop yield. Wheat was ground into flour at a mill in Millville and ranching has been the cornerstone for the Whitmore area since the mid-eighteen hundreds. When Shasta County opened for homesteading, some of these settlers were the first ranchers in Cow Creek. Other settlers were the men who came to California for the gold rush, but found ranching and farming more profitable.

In 1885, about twenty-nine German families were enticed into the area, by promises of established farms and farmland. The land they had purchased was virgin timber, so they had to clear the land and build farms. With little developed water on their property, they began building irrigation ditches to redirect streams for irrigation. Dry beans, hops, and apples were early cash crops as well as raising sheep, hogs, and cattle.

During the post-World War II period, California's agricultural and open space lands began to dwindle, due in part to population growth, new commercial enterprises, and rising property taxes. Valuable farmland began disappearing at alarming rates, as urban conversion became a viable financial alternative for landowners. In 1965, Assembly Bill 2117, authored by John Williamson, was generated, proposing contracts between local governments and landowners to voluntarily restrict development on parcels for a minimum of ten years. The passage of the Land Conservation Act, commonly known as the Williamson Act, enabled local governments to enter into contracts with private landowners for the purpose of restricting specific parcels of land to agricultural or related open space use. The landowners received property tax assessments, which were much lower than normal, because they were based upon farming and open space uses as opposed to full market value. The local government receives the lost property tax revenues from the state via the Open Space Subvention Act of 1971.

The Williamson Act recognizes the importance of agricultural land as an economic resource, which is vital to the general welfare of society. The enacting legislation declares that the preservation of a maximum amount of the limited supply of agricultural land is necessary to the conservation of the State's economic resources and the assurance of providing adequate, healthful, and nutritious food for future residents of California and the nation. The majority of the land held by the Act within the Cow Creek Watershed is considered Grazing Land, and while the per acre production potential of these lands are not as high as irrigated areas, they support a valuable economic resource. The sale of cattle and calves rank third among dollar values for all California agricultural commodities.

The Williamson Act also recognizes the importance of preserving land for open space purposes. The Act declares that in a rapidly urbanizing society, agricultural lands have a definite public value as open space, and the preservation in agricultural production of such lands constitutes an important physical, social, esthetic, and economic asset to existing or pending urban or metropolitan development. Open space lands form portions of upland watersheds whose protection from unnecessary subdivision and development is important to water and stream quality, wildlife habitat, downstream flood management, and provision of buffers between agricultural and other uses.

Current Use. Today, the majority of the agricultural land in the Cow Creek Watershed is designated Grazing Land (as defined by the General Plan). According to the Shasta County Important Farmland Map (1998), the definition of Grazing Land is land on which the existing vegetation is suitable for grazing of livestock. The County has established a minimum parcel size of 760 acres for Grazing Land, 120-160 acres for Irrigated Pasture Land, and 40 acres for Croplands (General Plan, 6.1 Agricultural Lands, page 6.1.08). These were based on the amount of land required to maintain a full-time operator in an economically worthwhile endeavor. There are also dispersed areas of "Prime Farmland" and "Farmland of Local Importance". Most of the Prime Farmland, land with the best combination of physical and chemical characteristics able to sustain long-term production of agricultural irrigated crops, are along Oak Run Creek, Old Cow Creek, and South Cow Creek. Farmland of Local Importance, defined as dry land grain producing lands, are scattered throughout the Cow Creek Watershed. The General Plan does not breakout irrigated pasture from its broader Agricultural Grazing mapping unit.

Additionally, the Williamson Act has remained a stable and effective mechanism for protecting agricultural and open space land from unnecessary urban development. About 16 million acres have enrolled under contract statewide since the early 1980s. Currently, there is a 100-acre minimum limit in effect for Williamson Act contracts in Shasta County. About 75,120 acres are held within the Cow Creek Watershed, which is about 96 percent of the total designated agricultural lands. Most of the lands are in the center to southern portion of the watershed.

Use Designation. The agricultural lands, which are currently enrolled in the Williamson Act, are also designated agricultural lands for future development in the General Plan. There are about 77,500 acres of designated agricultural lands for future use. Of this future designation, 75,120 acres are currently enrolled in the Williamson Act, so the majority of the land used for agricultural purposes is not expected to change drastically in the future.

Agricultural lands in the watershed are designated as one of three types: croplands, grazing, or grazing/cropland. Approximately 970 acres are defined as land capable of producing agricultural products, which are planted, cultivated, and harvested by either mechanical means or by hand or both. These can include field and row crops, orchards and vineyards, nursery crops and food and fiber crops.

The largest of the three agricultural lands is grazing, comprising approximately 73,600 acres of land defined as being used primarily for grazing and which relies exclusively on rain and snowfall for production of forage.

Lastly, the designation of grazing/cropland occupies about 2,900 acres and consists of mixed agricultural uses predominantly found adjacent to rural residential areas where agriculture may not necessarily be the main income source for the owners.

Commercial

History. Historically, commercial operations consisted of ranches, farms and logging within the watershed, with "commercial centers" to support these activities found generally outside the watershed in Redding. As activities increased, so did the population with the need to provide limited commercial support services within the watershed in the small communities that developed. Typically, small general stores, equipment repair facilities, gas stations, and restaurants emerged.

Current Use. As with the residential development in the Cow Creek Watershed, most of the commercial development is currently located within community centers, specifically the Palo Cedro area. Palo Cedro is a full-service community, with several restaurants, gas stations, and banks, as well as grocery and hardware stores. Palo Cedro is about 12 miles from Redding and is the closest source for many goods and services for the residents of the Cow Creek Watershed. There are also small general stores in the rural communities of Whitmore, Oak Run, Millville, and Bella Vista.

Use Designations. Future commercial development will remain in areas of future residential growth centers. The General Plan designates 230 acres for commercial use in the Palo Cedro area, this is the only area planned for future commercial development in the watershed.

Habitat Resource

History. Natural resources and habitat for wildlife have been an integral part of the watershed and the lifestyles of people who live there and use these resources. Forests, oak woodlands and lowland areas of the watershed have provided habitat for significant numbers of wildlife species, especially deer, elk, and anadromous and resident fish populations. These resources have historically provided food for native peoples and loggers, miners and ranchers who developed the Cow Creek Watershed.

Current Use. The relatively undeveloped nature of the Cow Creek Watershed lends to its use by fish and wildlife both seasonally and year-round. The Cow Creek Deer Herd utilizes a significant portion of the watershed (estimated at over 90,000 acres) in the form of winter range from November to April each year. This winter range occurs at mid- and low-elevation agricultural and residential lands that offer forage (acorns, brush, grass), water and cover for hiding and resting. Migration out of winter range to higher elevations for fawning and summering is also significant, and is highlighted by the Whitmore-Oak Run Critical Wildlife Area that provides a corridor for migrating deer.

As well as deer use, local streams provide habitat for native species of trout as well as anadromous fish. Habitat occurs throughout the watershed, with various stream reaches providing differing types of habitat, from spawning and rearing for anadromous fish to summer holding water for native trout and juvenile steelhead and salmon.

Use Designations. The General Plan designates approximately 32,140 acres as Habitat Resource use. This designation encompasses agricultural lands designated under the Williamson Act as well as other privately owned lands.

Mixed Use

History. Historically, mixed use has traditionally occurred in or adjacent to population centers, towns, communities and groups of residences. As a formal designation, mixed use was not historically applied to the watershed and was developed under the General Plan.

Current Use. The Mixed Use designation refers to those lands that are located within commercially designated lands, predominantly in the western edge of the watershed near the communities of Bella Vista and Palo Cedro, with smaller uses occurring near rural communities such as Oak Run and Whitmore. This designation permits a mixture of uses in the rural community environment that include limited industrial, commercial and a higher density of residential development. Uses in these areas must not detract from the rural environment and generally do not produce adverse impacts such as excessive noise, light or odors.

Use Designations. The General Plan has designated approximately 345 acres for Mixed Uses in the watershed. As previously noted, these mixed-use designations are found near community centers to facilitate community development. The most rapid growth is anticipated in the western edge of the watershed where the communities of Palo Cedro and Bella Vista are located. Some minor growth can be expected in the outlying rural communities of Oak Run and Whitmore.

Public Lands

History. Historically, public lands within the watershed have been limited, as homesteading, patented mining claims, and acquisition by the railroad took lands out of public ownership.

Current Use. As previously discussed, public lands administered by the State of California, US Forest Service and BLM, consist of approximately 16,300 acres within the watershed. These lands are currently used for a variety of activities, including commercial timber development, open space, general recreation, hunting, fishing, camping, protection of wildlife habitat, and production of water supplies. Public use is managed by various resource management plans that describe appropriate outputs and uses. The Latour State Forest is managed under its SYP while the US Forest Service and BLM lands are managed according to local, regional and national Land and Resource Management Plans.

Use Designations. Designation of these lands as public lands in the General Plan is important because it sets the tone for adjacent land designations and future developments. Adjacent land uses compatible with timberland activities are designated so as not to interfere with the development and management of these lands. These lands are set aside by the various entities for long-term public ownership, and it is anticipated that the designation will not change.

Recreation

History. The Cow Creek Watershed provides a wide variety of outdoor recreation opportunities, including sightseeing, camping, hiking, fishing, whitewater boating, horseback riding and nature appreciation. Most of this recreation occurs on private timberlands, Kilarc Reservoir, and Latour State Forest lands in the upper watershed. Except at a few limited points, recreational access is extremely limited in the lower watershed due to the predominance of private land.

Tourism and outdoor recreation are important industries in Shasta County. Residents of California's metropolitan areas migrate to the County for outdoor recreation opportunities during the summer months. Interstate Highway 5 links the County with these areas. California State Route 44, a major highway from Redding, passes through the Cow Creek Watershed and the Cascade and Sierra Ranges to connect with U.S. Highway 395 east of Susanville, California. An estimate of 6,766,700 visitor days of recreation occurred in Shasta County in 1998.

Current Use. Shasta County residents use most of the recreational resources within the Cow Creek Watershed. Pacific Gas and Electric (PG&E) estimates that 1,120 visitor days per year are spent at the Kilarc Forebay. The usage of the other developed and undeveloped recreational resources within the watershed is unknown. There are also areas within the Beaty and Associates and Roseburg Resources Co. properties that are frequently used by the public. The logging roads are used for all-terrain vehicles (ATVs) and horseback riding. Cleared areas, near creeks, are known as undeveloped campsites and picnic areas. A major unassessed recreational resource within the watershed is Buckhorn Lake and its surrounding area. This is a popular summer destination for local residents to swim, fish, and picnic.

Camping and Picnicking. The upper watershed has seven developed public campsites, and one developed day use area, managed by Latour State Forest. There are two sites: South Cow Creek campground and at Old Station campground, located in the South Cow Creek Watershed. There are two developed sites at Old Cow Creek campground and one site at Butcher Gulch campground on Atkinson Creek. The developed campsites all have vault toilets (some will be installed in Summer 2001), barbeques, picnic tables, and fire rings; the sites do not have potable water sources. South Cow and Old Cow campgrounds have continuous weekend occupancy from June through October, and Butcher Gulch campground is primarily used during hunting season.

A public picnic area was developed by PG&E on the northeastern side of Kilarc Forebay in 1965 and improved in 1971. This area serves local communities as a day-use recreation resource, from May through October. The facilities include eight picnic tables, four Klamath stoves, two water faucets, two vault toilets and a parking area. PG&E plans on re-designating the existing eight-unit picnic facility at the forebay to four group picnic units. Five additional family picnic units will be constructed in an expansion area. A footbridge will be constructed across the entrance of Kilarc Main Canal to provide unrestricted public access around the forebay.

Fishing. Fishing for catchable (hatchery) trout is a recreational activity at many of the campgrounds within the watershed. The DFG plants trout in the summer at the Ponderosa Way bridges on Old Cow and South Cow Creeks and at South Cow campground. Planting also takes place at the Kilarc Reservoir and connecting canals. Fishing does occur in upper reaches of the Cow Creek Watershed, but access is very limited, due to steep slopes and thick brush, so angling use is limited in these areas.

Hunting. Hunting for deer, dove, quail, and turkey is a popular seasonal activity in portions of the Cow Creek Watershed. Much of the hunting is done on privately held timberlands or in the Latour State Forest. Since 1970 there has been a hunting lease, covering a gated area from South Cow Creek to Bear Creek, on timberland managed by WM Beaty & Associates. This lease is on a year-to-year permit, and is patrolled by the leaser. The members are charged a fee and the landowners receive a percentage of that fee. In the last eight to ten years, membership has declined, as well as the take. There is also hunting in the Latour State Forest, which is regulated by the DFG, with restrictions within one-quarter mile from the State Forest Headquarters and all campgrounds.

Winter Sports. Snowmobiling is a popular winter activity within the watershed, particularly on Latour State Forest lands. In an agreement with Lassen National Forest, the use of green sticker money (State off-road vehicle taxes) is used to groom 30 miles of snowmobile trails throughout Latour State Forest. Lassen National Forest estimates 3,500 visitor days will be spent on these groomed trails. Cross-country/backcountry skiing is also popular in the winter.

Whitewater Boating. This is one of the few recreational activities in the lower portion of the watershed. Mainstem and Little Cow Creek present a gentle five-mile, Class I-II spring season boating run for Kayaks and canoes. Boaters will usually begin their run at Old Highway 44 and go down to Highway 44 or Deschutes Road. This is a short easy run and in the summer people have been seen inner-tubing in this section. More adventurous whitewater enthusiasts use other sections on Cedar Creek and Little Cow Creek in winter during high flows. Low flows during summer limit other opportunities throughout the watershed.

Use Designations. In the General Plan there are two recreation designations, commercial recreation use and recreation resource use, totaling 106 acres. However, as described above, there are other areas under different land use designations, which are currently used by the public for recreation purposes, such as: habitat resource, public lands, timberlands and mixed-use lands.

Residential

History. Residential use within the watershed has historically been tied to ranching, farming, timber production, or other commercial/development uses that required people to live on the land. No formal residential development was established, and people living in the watershed generally worked there. Commuting to an office or business was not contemplated or even an option with limited roads and modes of transportation.

Current Use. Residential use in the watershed is divided into three categories, totaling 61,915 acres. These residential uses are defined as:

- ***Rural Residential-A***, defined as one dwelling per two acres and occupying a total of 18,580 acres of the watershed;
- ***Rural Residential-B***, defined as one dwelling per five to twenty acres and occupying a total of 43,280 acres;
- ***Suburban Residential***, defined as three dwelling per acre, on 60 acres in the watershed.

The majority of current residential development is in the westernmost portion of the Cow Creek Watershed, west of Little Cow Creek to the watershed boundary. According to the 1990 Census data, the Palo Cedro area has the greatest population density, at 312.5 people per square mile. The Palo Cedro and Millville area is considered the most valuable residential area of Shasta County. Millville is in Rural Residential B zoning district; maximum density for this designation is one dwelling per five acres. According to the Shasta County General Plan, the reasons for the larger lot density range is to focus growth in rural community centers by decreasing population densities in rural areas outside them.

Decreasing population densities in these outlying rural areas has reduced conflicts between residential and the agricultural uses found in the watershed. The central portion of the watershed is designated as agricultural land. The populations are isolated in the central watershed, except for very small rural community centers at Whitmore and Oak Run. The areas of least population density remain in the eastern and northern portions of the watershed, where lands remain under timber and/or land management contracts, with the large commercial timberland owners.

Use Designations. When designating lands for future residential use, water supply is a critical limiting factor. The zoning districts require a proven reliable water supply for the permissible size of the parcel. According to the Eastern Shasta County Groundwater Study, there is good potential for groundwater development in the Millville area, where the aquifer is found in the semi-consolidated sand and gravel of the Tuscan Formation. East of Millville, groundwater potential is poor and streams and creeks supply water.

Timberlands

History. Timber harvest has been one of Shasta County's most valuable resources. Providing the early settlers with raw materials for development of homes and ranches, timber was a main economic commodity in Shasta County for most of the 20th Century. Raw and semi processed wood products have been exported from Shasta County and the Cow Creek Watershed for decades. In 1979, the timber harvest from various lands within the County was 248 million board feet valued at over $43 million. By 1988, the value of timber had dropped, and while the County's timber production increased to 267 million board feet, the value fell to $40.2 million.

A major timberland reform was enacted in the form of the Timber Yield Tax, passed in 1976. Prior to this, the value of timber was added to the value of land and then taxed, requiring landowners who did not harvest their timber to pay huge tax burdens. This "disadvantage" of owning timber gave property owners an incentive to harvest vast areas of the state. After 1976, taxes were paid on timber after it was harvested, reducing the need to harvest timber to escape taxes.

Current Use and Designations. Current timberland use and future designation in the Cow Creek Watershed amounts to 83,200 acres or about 30 percent of the area. All timberland uses are located in the upper reaches of the Cow Creek Watershed, the northeast portion of the area. Roseburg Resources holds the largest amount of the privately owned timberland, followed by Beaty and Associates and Sierra Pacific Industries. While public lands are not part of the timberlands element, they do provide commercial timber products.

Land dedicated to commercial forest management provides not only building materials, energy for industrial processes, firewood, County revenue for roads and schools, and employment opportunities, but also wildlife habitat, recreational opportunities, aesthetic enjoyment, and watershed protection. Maintaining timber operations and preservation of valuable timberlands are important to the economic base and the natural resource values of Shasta County, as well as the Cow Creek Watershed. The Timberlands Element, therefore, relates present and future uses of timberlands to the natural resource, economic, and community development plans for Shasta County.

DEMOGRAPHICS

Historic Shasta County demographics were discussed in Section 2. Census information for 2000 was not available for completion of this section. Census data from 1990 is included on Figure 3-2. As displayed, the highest population densities are found in the western portion of the watershed and are concentrated along Deschutes Road and Little Cow Creek drainage. In general, these reflect 3-acre to 10-acre minimum parcel sizes with single-family homes.

As discussed previously, the General Plan has designated significant areas within the watershed as Rural Residential-B. Over the last decade, significant "rural sprawl" has occurred in the watershed. Individuals and families seeking a less crowded, rural setting/lifestyle have left urban areas for rural residential parcels. The development of these parcels reflects a mixture of people from local urban centers and those from larger metropolitan areas. The ability of these people to make the transition from urban to rural has been made possible by several factors, including transportation development (improved highways and local roads), telecommuting, increased urban pressure, and affluence.

With this increased rural development comes the impact to natural resources. As rural areas are developed, their very nature is impacted. Open tracts of land are divided with homes, fences, gardens and features of domestic life. This impacts the ability of wildlife to utilize these areas and natural ecosystems to flourish. Often, people are at odds with the wildlife that historically utilized undeveloped land upon which yards and gardens are now developed. Predators such as bobcats, coyotes and mountain lions find easy prey of domestic animals, and are attracted in greater numbers to these areas.

Additionally, impacts to plant communities increases as residential construction replaces the oak-woodland community. Impacts to the blue oak community has been discussed for several years and has drawn attention from several state and local agencies to minimize the loss of California native oaks. In 1995, the Shasta County Board of Supervisors adopted the Oak Woodland Management Guidelines to encourage local landowners to protect oak woodland habitats. While not a permitting process, the guidelines offer landowners valuable suggestions for oak woodland management, publications and contacts for local assistance.

Increased development also puts pressure on local agencies to provide timely and adequate fire protection and other emergency services. This becomes increasingly difficult with more and more residences in the ubrban/wildland interface. Not only do local fire protection agencies have to contend with residential fires, they must also contend with wildland fires and the effects on residences located in the "wildland areas". As development increases, fire protection and suppression efforts become not only more difficult, but more costly, possibly resulting in higher local and state taxes. While these factors will most likely affect the development of rural residential areas within the watershed, the primary limiting factor to future growth will be the availability of water. Limited coordination in the delivery of public drinking water occurs in the watershed.

Currently, the Bella Vista Water District (BVWD) is the only community service district providing public water supplies to customers. BVWD boundary is included on Figure 3-3. As a sanctioned community service district under Local Agency Formation Committee (LAFCO), the BVWD provides water to customers in an area from Bella Vista to Palo Cedro, in the western portion of the watershed. Areas within the BVWD are most likely to be subjected to development pressure due to reliable water supply. Currently BVWD is allotted 24,000 acre feet from the Bureau of Reclamation contract and obtains an additional 2,000 acre feet from five wells. The district used only 14,826 acre-feet in 2000 with 13,769 acre-feet from the Bureau contract and 1,100 acre feet from wells – approximately half of their annual allotment. The BVWD Master Plan is being revised in 2001 and should provide better information on future supply by service area and potential to support development. The majority of future residential development, according to the General Plan, is along this western border of the watershed. There are also planned residential areas around Millville, Oak Run and Round Mountain; those will be limited by the lack of water.

CONCLUSIONS

Land use has and will continue to emphasize agriculture and timber resources as the predominant land use in the watershed. Much of the land in the watershed is currently used for the same purpose as predicted for the future. The majority of land in the watershed is designated for timber and agricultural use in the General Plan, which is consistent with current use. Timber holdings are expected to remain constant, as well as agricultural land enrolled in the Williamson Act program.

Suburban and residential pressure in the western side of the watershed will continue as local and regional urban residents seek a more rural lifestyle. Development of the Shasta County General Plan has provided a good land management base by which future development and uses will blend with the current agricultural interests. The areas designated for residential growth are much more extensive than the current residential areas that have been developed. Residential development is limited to an adequate water supply to support growth. If residential development pushes out into areas of limited water, alternative water sources will have to be explored or growth in these areas will be diminished.

ACTION OPTIONS

The following options are based on review of the land use and demographics in the watershed:

- Encourage retention of large ownerships to enhance stewardship and management efficiency for agricultural resources, fuels management and preservation of open space.
- Encourage development of cottage industries that make use of residual forest products and wood waste from fuel reduction activities.
- Emphasize habitat restoration in areas associated with agricultural lands.
- Encourage the concept of the working watershed aspect of land use – managing and producing natural resources as a land use goal.

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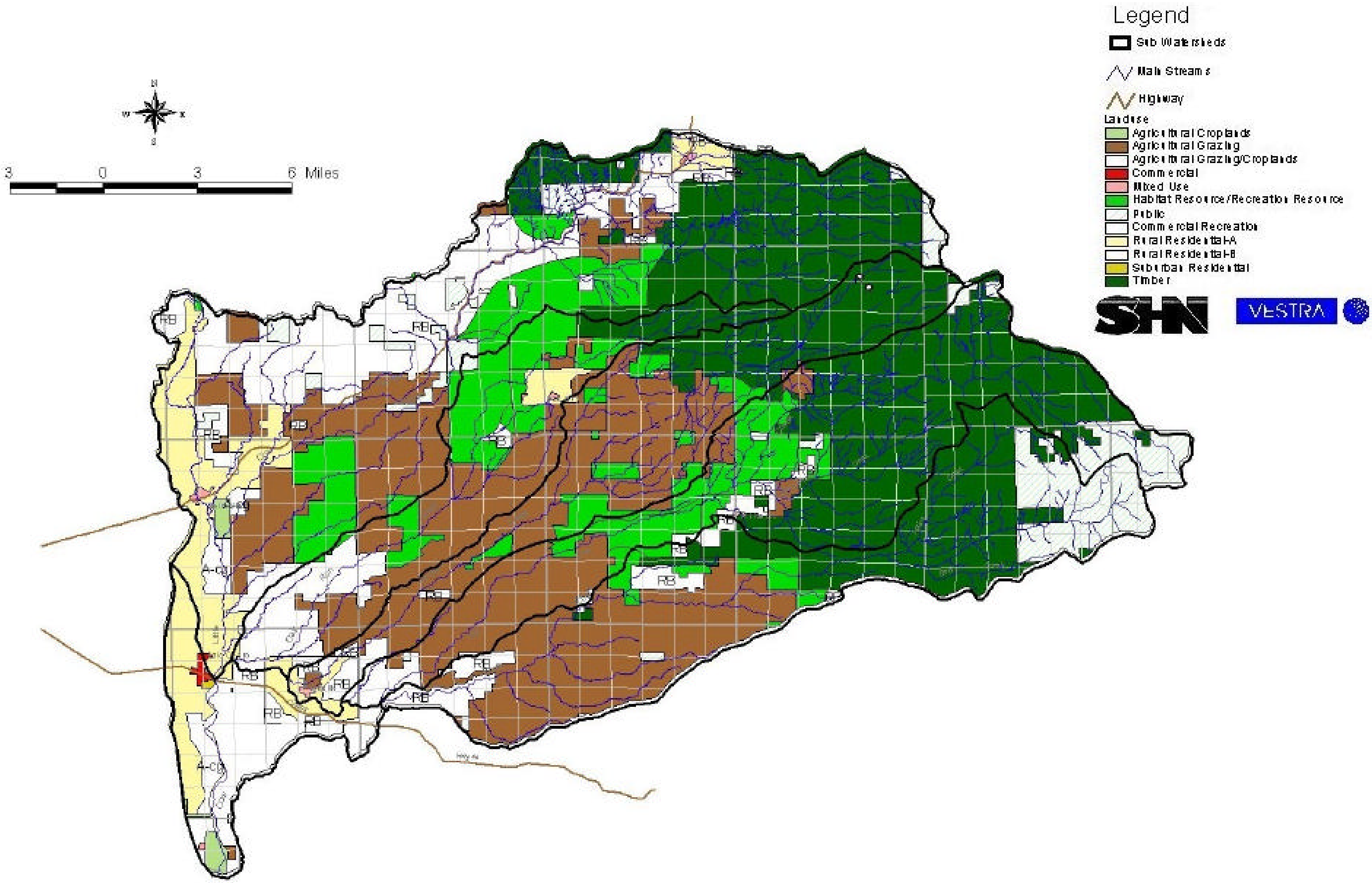
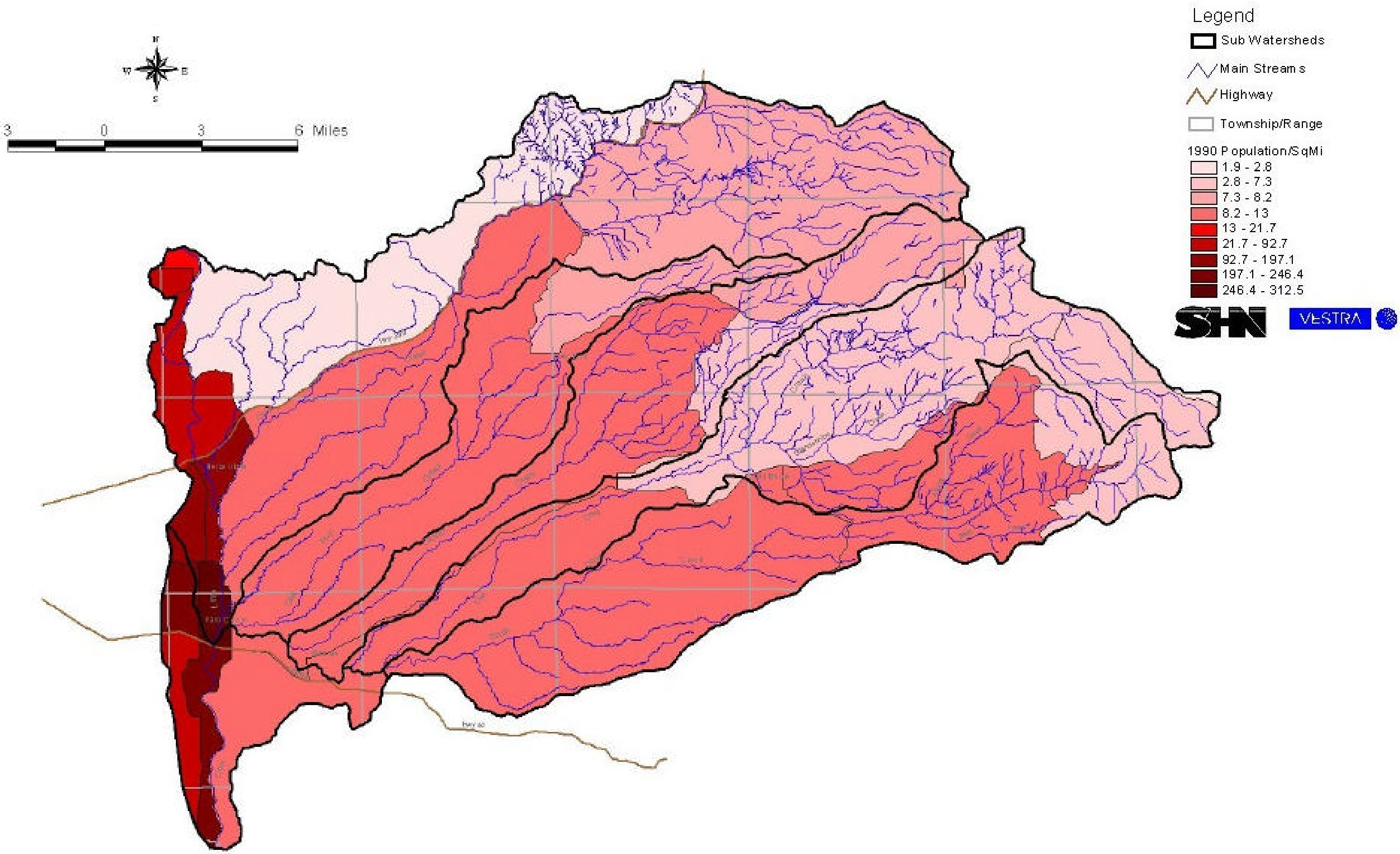


Reference: Shasta County General Plan

FIGURE 3-1
LAND USE
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA



Reference: ESRI Census Data

FIGURE 3-2
DEMOGRAPHICS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

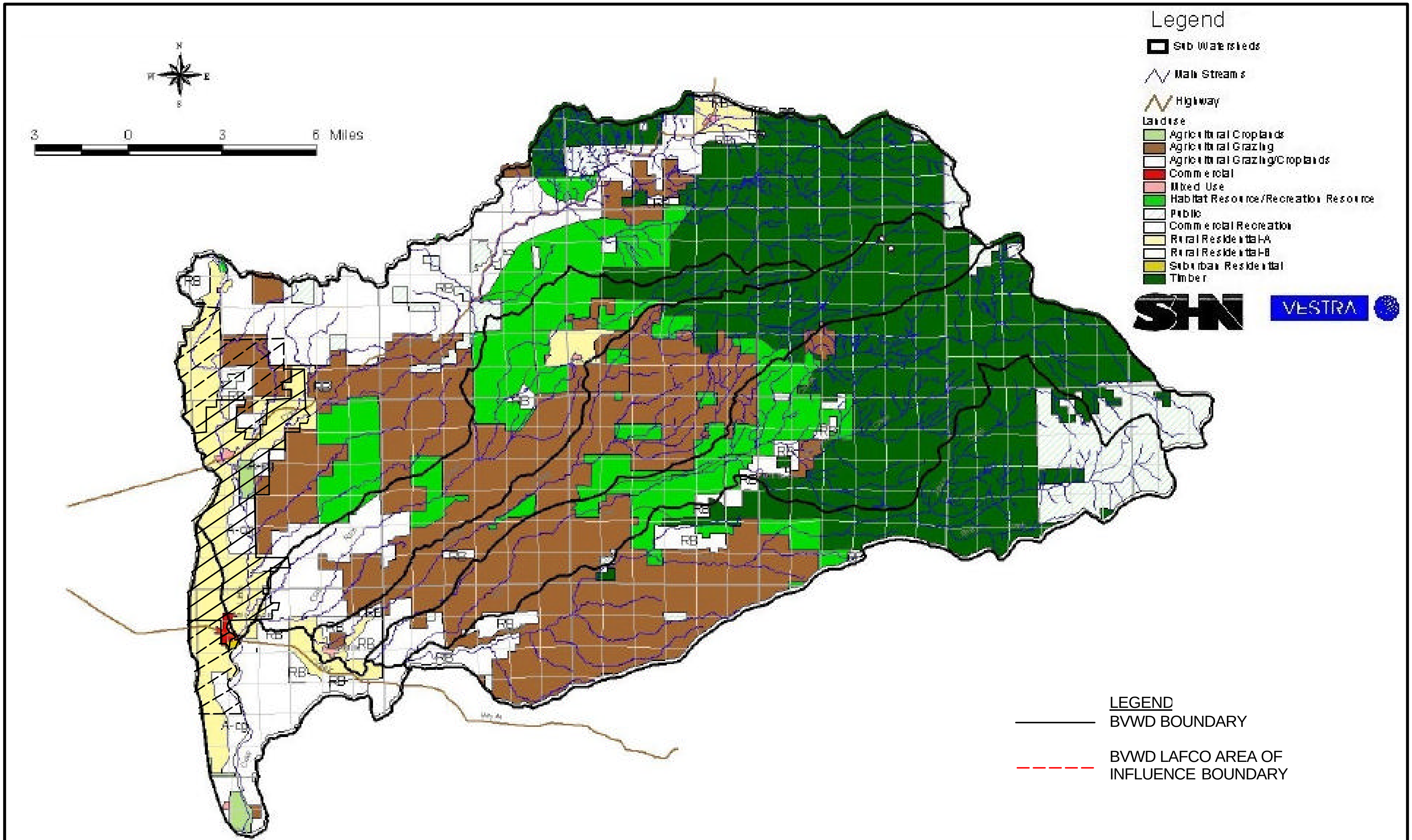


FIGURE 3-3
BELLA VISTA WATER DISTRICT BOUNDARY
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: Shasta County General Plan, BVWD

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REGIMES

The Cow Creek Watershed can be subdivided into three unique geomorphic regimes based on rock type, topography, and erosional/depositional equilibrium state. These regimes include the Mountainous Region located in the eastern 1/3 of the assessment area, the Intraflow Region located in the middle 1/3 of the assessment area and the Basin Region located in the western 1/3 of the assessment area.

MOUNTAINOUS REGION

This region is located east of 121°55' West longitude, at elevations above 2000 feet above mean sea level, and occupies the headwaters of all of the principal tributaries of Cow Creek. The topographic expression of this region consists of dendritic stream patterns superimposed on gentle, southwest dipping deposits of the Tehama Formation. The stream channels in this area generally have moderate to steep gradients, typically have a "V"-shaped cross-section, and have very steep to precipitous slopes forming the channel walls. Separating the channels are interfluvial ridges and mountaintops that have planar to rolling slopes ranging from 0% to 65%. This region is in a process of down cutting (erosion) based on the topographic expression of the interfluvial ridges and the characteristic "V"-shaped stream channels.

The two principal geomorphic processes shaping the landscape of this area include mass wasting and fluvial surface erosion. The primary mass wasting process appears to be debris flows, slides, and falls that occur along the steep channel walls of the stream courses. Abnormally high precipitation events, earthquakes, volcanic activity, and adverse forest management practices generally influence these failures. Glacial processes have shaped some of the landforms at higher elevations (Lydon and O'Brien, 1974). However, the impact that glaciation has had on the landscape is insignificant.

INTRAFLOW REGION

The Intraflow Region is located between 121°55' and 122°10' West latitude, at elevations between 1000 and 2000 feet above mean sea level. This area is located below the mountainous headwaters region and encompasses an area positioned around portions of the higher order stream segments of South Cow Creek, Old Cow Creek, Clover Creek, Oak Run Creek, and Little Cow Creek. In this region the stream channels are sub-parallel in respect to each other, have incised channels, and flow in a southwest direction. Providing interfluvial divides between the streams are broad plateaus composed of mudflow deposits of the Tuscan Formation. These flow deposits dip gently to the southwest and generally have a smooth to rolling surface with slopes ranging from 0 to 15%. Several meadow areas are located on these plateau tops and ponding water is common.

Similar to the mountainous region, the two principal geomorphic processes shaping the landscape of this area include mass wasting and fluvial surface erosion. The most potentially impacting mass wasting phenomenon in this region, however, is the occurrence of large, deep-seated, slide failures that develop on the flanks of the channels. These failures are most common were the streams have down cut to a point were loose consolidated rock of the Montgomery Creek Formation is exposed. This material is easily eroded away, causing the overlying more resistant rock of the Tuscan Formation to fail (Bailey, 1966). Such failures have an immediate and prolonged impact on delivering large quantities of sediment to watercourses. Other mass wasting processes such as debris slides are present within this region.

BASIN REGION

This region is located west of 122°10' West latitude and encompasses the area within the watershed where the principal tributaries coalesce together and intersect with the main branch of Cow Creek. Elevations within this region range from 450 feet to 1000 feet above mean sea level. The fluvially deposited sediments of the Tehama and Red Bluff Formations dominate this area. The geomorphic processes occurring within this region consists largely of fluvial erosion and deposition. This is evident by the occurrence of broad, low gradient channels with meandering stream courses and flood terraces. Mass wasting is reduced to small bank failures occurring along the stream channels.

STREAM SEGMENT DEFINITION

Because a majority of the land within the Cow Creek Watershed is privately held, identifying, verifying and assigning locations to individual features is difficult. The first step in this process, however, is establishing a coordinate system along the major tributaries. For this analysis, the major Cow Creek tributaries were divided into 100-foot segments.

Station 0 is assigned to the confluence of each tributary. For example, the Main Stem of Cow Creek begins at the Sacramento River, Station 0; and ends where Old Cow Creek and South Cow Creek converge, Station 78,000. These stations will be used throughout this section to assign coordinates to specific features within the watershed. By using a standardized system, it is possible to locate, verify and relocate individual features as information is updated. For example, using this system, Diddy Wells Falls is located near Station 79,000 on Little Cow Creek, or 79,000 feet upstream from the confluence of Little Cow Creek and the Main Stem of Cow.

The stream segments were developed using GIS (geographic information system) technology, and are shown on Figure 4-1. In addition, a stream segment script file has been included in the ArcView database that can be used to easily determine stream coordinates for features identified on any GIS layers.

MAJOR FEATURES

Major features along the Main Stem of Cow Creek and five major tributaries include:

- Tributaries,
- Waterfalls and Barriers,
- Breaks in geology
- Diversions.

Quantitative locations for these features are summarized in Tables 4-1 through 4-3 (tributaries and water falls), Table 4-4 (breaks in geology) and Table 4-5 (major diversions). The features are listed by major tributary. In addition, the diversions are sorted by current allotment. A description of the different geologic units is provided in the Geology Section, and additional information on the diversions is presented in the Hydrology Section. Detailed descriptions of the waterfalls follow.

DIDDY WELLS FALLS

Diddy Wells Falls is located on private property along Little Cow Creek in the SW ¼ of SE ¼ of Section 28, Township 33 North, Range 02 West. The falls occurs where the stream channel enters a steep canyon composed of meta-volcanic rock. The vertical drop is at least 20 feet. The canyon has vertical walls, is approximately 20 feet across, 30 feet deep and approximately 300 feet long. The area above the canyon is scoured, indicating that the canyon becomes inundated during high flows. The stream distance between the falls and the confluence of Little Cow Creek with the Main Stem of Cow Creek is approximately 78,000 feet. This information was field verified during April 2001. Photographs of the falls are included at the end of this section.

CLOVER CREEK FALLS

Clover Creek Falls is located on private property along Clover Creek in the NW ¼ of SE ¼ of Section 6, Township 32 North, Range 01 West. The falls occurs near a geologic break between the overlying Tuscan Formation and the underlying Chico Formation. The vertical drop is at least 150 feet. The stream distance between the falls and the confluence of Clover Creek with the Main Stem of Cow Creek is approximately 72,000 feet.

OAK RUN FALLS

Oak Run Falls is located on private property along Oak Run Creek in the SW ¼ of NE ¼ of Section 3, Township 32 North, Range 2 West. The falls occurs near a geologic break between the overlying Metavolcanic rock and the underlying Chico Formation. The vertical drop of the falls is not estimated. The stream distance between the falls and the confluence of Oak Run Creek with South Cow Creek is approximately 65,000 feet.

WHITMORE FALLS

Whitmore Falls is located on private property along Old Cow Creek in the NE ¼ of NW ¼ of Section 21, Township 32 North, Range 01 West. The falls occurs near a geologic break between the overlying Tuscan Formation and the underlying Chico Formation. The vertical drop is at least 15 feet. The stream distance between the falls and the confluence of Old Cow Creek with South Cow Creek is approximately 59,000 feet.

TABLE 4-1
Principal Cow Creek Tributaries

Principal Tributary	Distance Along Cow Creek from Sacramento River to Confluence (feet)	Distance Along Cow Creek from Sacramento River to Confluence (miles)	Tributary Length (miles)
Little Cow Creek	39,000	7.5	37.5
Oak Run Creek	44,000	8.5	26.0

Clover Creek	55,000	10.5	29.5
Old Cow Creek	78,000	15.0	35.5
South Cow Creek	78,000	15.0	30.5

TABLE 4-2
Secondary Cow Creek Tributaries

Secondary Tributary	Distance Along Principal Tributary from Cow Creek to Confluence (feet)	Distance Along Principal Tributary from Cow Creek to Confluence (miles)	Tributary Length (miles)
Little Cow Creek			
Oat Creek	5,000	1.0	5.0
Swede Creek	11,000	2.0	11.5
French Creek	18,000	3.5	9.0
Dry Creek	24,000	4.5	11.0
Salt Creek	41,000	8.0	8.0
Woodman Creek	50,000	9.5	8.5
Diddy Wells Falls	78,000	15.0	<0.5
Seaman Gulch	91,000	17.5	3.0
Norton Gulch	92,000	17.5	4.0
Cedar Creek	118,000	22.5	14.5
Mill Creek	151,000	28.5	6.5
North Fork LCC	165,000	31.0	6.5
Oak Run Creek			
Dry Creek	8,000	1.5	5.5
Dry Creek	56,000	10.5	2.5
Rogers Gulch	56,000	10.5	1.5
Oak Run Falls	65,000	12.5	<0.5
Tracy Creek	68,000	13.0	3.0
Clover Creek			
Dry Clover Creek	62,000	12.0	9.5
Clover Creek Falls	72,000	13.5	<0.5
Coal Creek	80,000	15.0	2.0
Silver Creek	128,000	24.0	3.0
Old Cow Creek			
Whitmore Falls	59,000	11.0	<0.5
Coal Gulch	68,000	13.0	1.0
Glendenning Creek	87,000	16.5	8.0
Hunt Creek	142,000	27.0	4.0
White Fawn Gulch	163,000	31.0	2.0
South Cow Creek			
Clough Gulch	18,000	3.5	5.0
Wilk Creek	26,000	5.0	2.0
Townsend Gulch	29,000	5.5	6.5
Pine Timber Gulch	35,000	6.5	6.5
Hooten Gulch	35,000	6.5	3.5
Mill Creek	56,000	10.5	4.0
Cottonwood Gulch	75,000	14.0	2.0
Hamp Creek	79,000	15.0	3.5
Hagaman Gulch	97,000	18.5	2.0
Atkins Creek	109,000	20.5	7.5
Beal Creek	118,000	22.5	4.5

Bullhock Creek	146,000	27.5	3.0
Beaver Creek	156,000	29.5	0.5
Dry Gulch	156,000	29.5	0.5

TABLE 4-3
Tertiary Cow Creek Tributaries

Tertiary Tributary	Distance Along Secondary Tributary from Principal Tributary to Confluence (feet)	Distance Along Secondary Tributary from Principal Tributary to Confluence (miles)	Tributary Length (miles)
Dry Creek (Little Cow Creek)			
Yank Creek	10,000	2.0	5.5
East Dry Creek	30,000	5.5	4.5
Salt Creek (Little Cow Creek)			
Bacon Creek	12,000	2.0	4.0
Cedar Creek (Little Cow Creek)			
McCandless Gulch	7,000	1.5	3.0
Bear Gulch	11,000	2.0	2.5
Dry Creek (Oak Run Creek)			
Post Gulch	8,000	1.5	4.0
Price Hollow	8,000	1.5	3.5
Dry Clover Creek (Clover Creek)			
Rosebriar Creek	9,000	1.5	3.5
Slaughter Pole Creek	14,000	2.5	2.5
Wildcat Creek	35,000	6.5	<0.5
Hunt Creek (Old Cow Creek)			
West Hunt Creek	5,000	1.0	2.0
White Fawn Creek (Old Cow Creek)			
Peavine Gulch	3,000	0.5	1.5
Atkins Creek (South Cow Creek)			
Sunset Gulch	25,000	5	2.0
Butcher Gulch	40,000	7.5	1.5
Lee March Gulch	40,000	7.5	1.5

TABLE 4-4
Geology Breaks

Geologic Unit	Beginning Tributary Distance (feet)	Ending Tributary Distance (feet)	Percent Coverage
Little Cow Creek			
Alluvium	0	35,000	21
Tuscan Formation	35,000	38,000	2
Chico Formation	38,000	42,000	2
Alluvium	42,000	62,000	12
Chico Formation	62,000	64,000	1
Meta Volcanics	64,000	126,000	38
Chico Formation	126,000	129,000	2
Tuscan Formation	129,000	131,000	1
Montgomery Creek Formation	131,000	148,000	10
Tuscan Formation	148,000	198,000	31
Oak Run Creek			
Alluvium	0	37,000	27
Chico Formation	37,000	40,000	2
Alluvium	40,000	58,000	14
Chico Formation	58,000	63,000	4
Meta Volcanics	63,000	86,000	16
Tuscan Formation	86,000	87,000	1
Chico Formation	87,000	89,000	1
Alluvium	89,000	93,000	3
Chico Formation	93,000	108,000	11
Tuscan Formation	108,000	136,000	21
Clover Creek			
Alluvium	0	16,000	10
Chico Formation	16,000	71,000	35
Tuscan Formation	71,000	74,000	2
Meta Volcanic	74,000	85,000	7
Tuscan Formation	85,000	137,000	33
Dacite	137,000	139,000	1
Tuscan Formation	139,000	157,000	11
Old Cow Creek			
Alluvium	0	5,000	3
Chico Formation	5,000	64,000	31
Tuscan Formation	64,000	102,000	20
Chico Formation	102,000	106,000	2
Montgomery Creek Formation	106,000	115,000	5
Tuscan Formation	115,000	187,000	38
South Cow Creek			
Alluvium	0	1,000	0
Tuscan Formation	1,000	2,000	1
Chico Formation	2,000	13,000	7
Alluvium	13,000	36,000	15
Chico Formation	36,000	43,000	4
Tuscan Formation	43,000	58,000	10
Alluvium	58,000	79,000	13
Tuscan Formation	79,000	161,000	51

TABLE 4-5 Diversions Greater Than One Cubic Foot per Second					
Tributary	**Miles Up Trib.**	**Diversion Name**	**Current Allotment (cfs)**	**Diversion Structure**	**Location Relative To Falls**
Little Cow Creek (64 percent of total)					
Little Cow	11.0	Woodman Ditch	4.75		Below
Little Cow	6.5	Cook and Butcher Ditch	4.57	Flashboard	Below
Cedar Creek	7.5	Halcumb Ditch	4.00		Above
Mill Creek	3.5	Welch and Strayer System	3.00		Above
Little Cow	30.0	Pehrson-Grant-Strawn (Jones) Ditch	2.60		Above
Mill Creek	3.5	Excelsior Ditch	2.00		Above
Cedar Creek	7.5	Johnson (Spaulding)-Haley Ditch	1.30		Above
Oak Run Creek (80 percent of total)					
Oak Run	21.5	Welch and Strayer System	2.84		Above
Oak Run	18.5	Predmore Ditch	2.15		Above
Clover Creek (76 percent of total)					
Clover	24.0	Mill Ditch	4.79		Above
Clover	3.5	Millville Ditch	4.40		Below
Clover	24.0	Bonde Ditch	2.45		Above
Clover	19.5	Welch and Nailor Ditch	2.14		Above
Silver Creek	0.5	Worley Ditch	2.00		Above
Clover	25.5	Guttman Ditch	1.85		Above
Old Cow Creek (95 percent of total)					
Old Cow	24.0	Kilarc Powerhouse Ditch	58.00		Above
Old Cow	10.0	Bassett Ditch	27.61		Below
Old Cow	16.0	Brown Grover	14.01		Above
Old Cow	12.0	Parker Hufford Ditch	11.12		Above
Glendenning	2.5	Neely Glendenning Creek Ditch	7.84		Above
Old Cow	6.5	Crowe Lower Ditch	7.75		Below
Canyon Creek	---	East Canyon Creek Ditch	7.50		Above
Old Cow	21.0	Grindlay Williams Ditch	3.73		Above
Glendenning	4.0	Grindlay Upper Glendenning Ditch	2.86		Above
Canyon	---	West Canyon Creek Ditch	2.50		Above
Old Cow	19.5	Williams Lower Ditch	2.41		Above
Old Cow	13.0	Koehler	2.40		Above
Canyon	---	Murphy Ditch	1.51		Above
Coal Gulch	1.0	Peterson Dam	1.44		Above
Glendenning	3.0	Grindlay South Glendenning Ditch	1.25		Above
Old Cow	---	Owbridge East Ditch	1.18		Above
Old Cow	---	Dargatz Spring	1.03		Above
South Cow Creek (89 percent of total)					
South Cow	10.5	South Cow Creek Powerhouse Ditch	47.91		Na
South Cow	21.0	German Ditch	13.72	Rock and Log	Na
Mill Creek	0.0	Mill Creek Ditch	13.54		Na
South Cow	6.5	Abbott Ditch	13.13		Na
Atkins Creek	1.5	Worden Ditch	5.52		Na

TABLE 4-5 continued Diversions Greater Than One Cubic Foot per Second					
Tributary	**Miles Up Trib.**	**Diversion Name**	**Current Allotment (cfs)**	**Diversion Structure**	**Location Relative To Falls**
South Cow	13.5	E Hufford Ditch	4.99		Na
South Cow	13.5	Roland Staiger Ditch	3.71		Na
South Cow	15.0	Lansing South Ditch	3.61		Na
South Cow	22.5	Beal Creek Ditch	3.55		Na
Atkins Creek	4.5	Hufford Knight Ditch	3.50		Na
South Cow	15.5	Morelli-Carr Ditch	2.10		Na
South Cow	14.5	Lansing North Ditch	1.83		Na
Hagaman Gulch	0.5	Hagaman Gulch Ditch	1.61		Na
Atkins Creek	4.0	Atkins Mill Ditch	1.60		Na
South Cow	4.5	Jennie Hufford Pump	1.45		Na
Hamp Creek	0.5	Lower Hamp Creek Ditch	1.31		Na
South Cow	7.0	Wagoner Ditch	1.10		Na
Hamp Creek	1.5	Upper Hamp Creek Ditch	1.01		Na
Cow Creek (83 percent of total)					
Cow	3.5	Pearson Pump	3.99		Na
Cow	---	Unnamed	3.61		Na
Cow	1.0	M Hawes Pump	2.61		Na
Cow	8.0	Leggett	2.56		Na
Cow	1.5	Bryant Pump	2.54		Na
Cow	12.0	Lynes Pump	2.34		Na
Cow	4.5	AF Hufford Pump	2.26		Na
Cow	9.5	Tuttle Pump	1.94		Na
Cow	1.0	R Hawes West Pump	1.93		Na
Cow	9.5	Shuffelberger Pump	1.65		Na
Cow	12.5	J Hufford Pump	1.57		Na
Cow	13.0	Hall South Pump	1.41		Na
Cow	2.0	Beatie Pump	1.16		Na
Cow	4.0	Swoboda Brosher Pump	1.07		Na

Moller Pump – 1,000 gpm pump on Main Stem of Cow Creek.

LONGITUDINAL PROFILES

Longitudinal profiles along the Main Stem of Cow Creek and the five major tributaries are shown on Figures 4-2 through 4-7. Major changes, or knick points, along the profiles commonly represent breaks in the geology. Many of these breaks are identified on the figures.

CHANNEL SLOPE

Although longitudinal profiles are useful for comparing stream segments and identifying major breaks in the profiles, they do not provide sufficient detail to identify key features. Gradient or slope, on the other hand, is a surrogate for stream energy and can be used to identify features that impact the distribution of energy such as changes in geology and channel confinement, major diversions and major tributaries. Confinement controls potential response and generally reflects the long-term history of a valley where past events have left their imprint.

As an aid to planning future field activities, it is useful to synthesize segment information into general response potential zones. Classification of segments into source, transport and response reaches using gradient criteria of >20 percent for source, 3 to 20 percent for transport and <3 percent for response reaches may reveal general patterns of sediment transport characteristics associated with reach level morphology. (PALCO, 2000).

Source reaches may provide storage sites for colluvium and may be subject to mass wasting events. Transport reaches rapidly deliver sediment to downstream response reaches, where sediment is more gradually transported downstream. Response reaches immediately downstream of transport reaches thus are relatively susceptible to changes in sediment supply. Response reaches are most likely to exhibit pronounced morphologic adjustments to changes in sediment supply.

The distribution of source, transport and response reaches governs the distribution of potential impacts and influences recovery times in the channel network as well as the composition and structure of the biological communities inhabiting the stream channel.

The gradient along Cow Creek and major tributaries are displayed graphically on Figures 4-8 though 4-13. Key features that correspond to the slope changes are also identified on these figures. Note that the peaks shown on the figures are increases in the slope of the stream, or areas that are steeper. Hence, the higher the peak, the steeper the slope, and the greater the velocity of the creek. Based on the results, most of the stream segments fall into the response (<3 percent) and transport (3 to 20 percent) reaches. The gradient along the upper reaches of Little Cow Creek exceeds 20 percent. Exposures of Montgomery Creek Formation in this area are particularly susceptible to mass wasting. The gradient maps are intended as a coarse screen for identifying potential transport and response reaches.

STREAM CHANNEL CHARACTERISTICS

The source reaches generally occupy the headwaters region of all of the principle tributaries of Cow Creek. The principal rock types in this region consist of relatively young Holocene volcanic deposits and interlayered flow deposits of the Tuscan Formation. Stream channels in this region generally exhibit a confined, “V”-shaped cross-section, have moderate to steep channel walls, and form dendritic stream patterns. Due to the high-energy environment, as a result of having confined channels with steep gradients, the stream courses typically exhibit evidence of scour, have low pool to rapid ratios, and low sinuosity. Outcrops of bedrock are common in the channel bottoms.

The transport reaches are located down gradient of the source reaches and are characterized as having sub-linear, generally confined channels that range in cross-section from being “V” to “U” in shape. Bedrock in this area consists predominantly of interlayered flow deposits of the Tuscan Formation and Chico Formation with minor exposures of the Montgomery Creek Formation. Additionally, Meta volcanics are exposed in the reach along Little Cow Creek. Outcrops of bedrock are exposed in the channel bottoms and the pool to rapid ratio is generally equivalent (i.e., there is an equal length of linear feet of pooled water to cascading water along the stream course).

Lastly, the response reaches are located adjacent to and upstream of the confluence between the main branch of Cow Creek and its principle tributaries. In this area the channel morphology generally exhibits a low energy environment with broad, low gradient channels, meandering stream courses, and flood terraces. Bedrock in this area is composed of fluvial deposited material of the Tehama and Red Bluff Formations. Despite the relatively low energy environment, vertical exposures of bedrock persist along the outside bank of meanders, where peak flows have undermined the channel walls. The pool to rapid ratio in this region is generally large with long segments of low-energy, slack water punctuated by rapids. The rapids generally form where a step in the channel has occurred as a result of differential weathering between layers of bedrock with varying competencies. In these areas, it is common to have bedrock exposed in the channel bottom. Otherwise, the channel floor is generally covered in a layer of loosely consolidated, fluvially deposited material.

A review of historic air photographs over ten year intervals since 1940, compared with the historic topographic mapping for the western portion of the watershed shows that the alignment of the main stem of Cow Creek has not changed appreciably in the last 100 years. This means that the banks, of at least the main stem, are fairly stable. Numerous anadromous fishery restoration documents reference bank instability and erosion as major sources of sediment and turbidity in the South Cow Creek and Old Cow Creek portions of the watershed. Data supporting these statements was not available for this assessment.

Representative photographs of bedrock exposures and channel confinement along several of the major Cow Creek tributaries are included at the end of this section.

SEDIMENT TRANSPORT

Stream sediment can usually be attributed to surface erosion and mass wasting. Overall sediment contributions from each of these processes may be equivalent (Redwood National Park, 1997, Watershed Analysis).

SURFACE EROSION

Surface erosion occurs when detachable soils on sufficiently steep slopes are exposed to overland flow or the impact of rainfall. In watersheds that are intensively managed, surface erosion is commonly subdivided into hillslope erosion and road erosion. Sediment contributions from hillslope erosion are generally greater than the contributions from road erosion (Redwood National Park, 1997).

Potential hillslope erosion is commonly rated based on slope, soil characteristics, vegetation and precipitation (California State Board of Forestry, 1984). Areas most susceptible to high or extreme surface erosion are characterized by steep slopes, shallow coarse-grained soils containing very little clay, sparse vegetative cover and intense rainfall. Some of these conditions occur throughout the eastern portion of the Cow Creek watershed.

Slope

Other than inherent soil properties, the slope is one of the most important erosion factors. The kinetic energy attributed to overland water flow is directly related to velocity and volume. A slope map of the Cow Creek watershed is shown on Figure 4-14. As shown, steep slopes in excess of 50 percent characterize the eastern 1/3 of the watershed.

Soils

The sandy loam soils within the Cohasset-Windy-McCarthy association are very erosive. These soils occur predominately in the eastern one-third of the watershed, from Oak Run and Whitmore to the eastern boundary of the watershed.

Vegetation

Patterns of vegetation vary throughout the watershed. In areas of intensive management (agriculture, forestry) there is a potential of increased surface erosion due to reduced vegetative cover and impacts of ground-based equipment, such as tractors and logging equipment. Much of the land in the eastern 1/3 of the watershed is managed for timber production.

Precipitation

The amount and duration of precipitation, when combined with the above factors, can significantly influence surface erosion. Rainfall on steep slopes that are conducive to erosion and have little to no vegetation are the most prone to erosion, mass wasting and delivery of sediment to watercourses. Changing one of the elements can significantly change the amount of erosion anticipated. As noted in Section 1, the highest rainfall levels occur in the eastern and northeastern portion of the watershed at higher elevations, where slopes are steepest.

Based on these factors the greatest potential for hill slope erosion is along the eastern one third of the watershed.

ROAD EROSION

Numerous studies have concluded that roads on managed and ranch lands are a major source of erosion and sedimentation. The amount of sediment produced from forest and ranch roads is determined by the physical conditions such as slope and geology, amount and type of traffic, construction method and material, and the design of the drainage system. Management of these roads plays an important part in reducing surface erosion, i.e., eliminating ditches, changing culvert sizes, armoring slopes, revegetation, seasonal closures, and changing road locations.

Slope

Where roads are located on steep slopes they are typically prone to cut and fill-slope failures, where excavated material attempts to move to the angle of repose and become stable. Failures are typically small in size, 3-10 cubic yards, and this debris is transported off site to vegetated slopes or in some cases stream channels. Roads on steep slopes are typically located in the eastern portion of the watershed on forested lands. Changing management practices over the last decade has provided significant reductions in road related failures through protection of slopes and road placement.

Geology

The placement of roads on geologic types that are prone to movement or failure (unstable lands, mass wasting) can have significant effects on surface erosion. Past road construction practices focused on the development of roads using the shortest distance between points, thereby reducing initial construction costs. This practice invariably built roads over unstable areas leading to road failures and sediment transport to stream channels. Current practices recognize these geologic features and construct roads around unstable areas or design roads to minimize impacts to these sensitive sites.

Traffic

The amount of traffic can have a significant impact on the amount and type of surface erosion. Roads that are used infrequently typically have a uniform road surface, free of wheel rutting, that in many cases is covered with vegetation (grass, forbs) and debris such as leaves, sticks and rocks. Since the roads are not frequently used, little surface dust is available for transport off-site, and the partial covering of the road surface reduces rainfall impact that could mobilize any sediment and transport it to nearby streams.

Roads that are frequently used often have a road surface free of vegetation and debris, and have large amounts of loose soil and dust that are easily transported off-site by rainfall and wind. During wet season use, ruts appear in the roadway acting as conduits for water to cut through the road surface and move large amounts of sediment off-site, in some cases causing fill slope failures. Impacts can be reduced by surface treatments (rock, soil binders, paving), active maintenance to eliminate rutting and seasonal closures of roads.

The type of vehicle use also plays an important role in surface erosion. Light truck and vehicle use will have limited impacts on unsurfaced roads. Typical problems occur on sharp turns where soil is actively moved to the outside edge of the roadway, on steep sections where traction is difficult (forming a wash-board effect), and in wet areas where ruts are formed. Effects from these areas are generally limited and easily maintained. Heavy trucks and equipment can have similar effects, but can also have additional effects on surface erosion. Since these vehicles are generally larger, they require wider surface widths exposing more cut bank and requiring larger fill slopes. Sections of roadways can become compacted, causing the roadway to settle and allowing water to pond on the surface where water saturates the soil and can lead to road prism failure or continual surface erosion and minor bank failure.

Construction

Historic construction practices of building roads very near stream channels, have impacted portions of the watershed by accelerating mass wasting and channel cutting. These practices have been long abandoned and new roads are now located in stable areas, well away from water courses. Past road building standards included cut and fill construction, sloping roads into the hillside where a ditch was constructed to transport water off the roadway, steep grades to minimize road distance, using native materials for road surfaces and placing temporary logs structures in streams as crossings. Current management practices and construction standards have significantly changed in the last 20 years. Road cut and fill is managed to minimize large fills and slope armoring and protection is incorporated into road design. Inside ditches are being eliminated in favor of out-sloping roads to allow better drainage and stream crossings are constructed to handle significant storm events. Steep road segments have been eliminated in favor of flatter grades that are easier to manage.

Drainage Design

Historic road building practices throughout the watershed included filling of intermittent channels with soil, using logs (Humboldt crossings) covered by soil to cross perennial streams, and constructing inside ditches to drain roadways. As management practices changed, so did drainage design and structures. Intermittent channels are now crossed with culverts or low water crossings. These types keep water from ponding behind the roadway and eliminating the loss of the road prism during storm events.

It was recognized that log crossings could cause road failures as they allowed large volumes of water to pond in the channel, often leading to roadway failures and large amounts of sediment to enter the stream system. These structures were also ineffective at moving large volumes of water during storm events. These crossings were replaced with metal culverts that offered a permanent opening under the roadway allowing water to easily pass. Recent increases in the size of many of these culverts, along with rock armoring of the side slopes, allow flood events to pass without adverse effects to the roadways.

Inside ditches are still in use in many roads in the watershed. These ditches collect surface water from roads and the hillslope and channel them to culverts for disposal. These culverts (cross-drains) are installed at intervals to move ditchwater out of the road prism and downslope where it is generally absorbed by soil and vegetation. In some cases, the outfall from these culverts can cause surface erosion and down cutting of the slope if volumes of water are great. Improvements in management of this drainage include:

- Installation of rock aprons at culvert outfalls to reduce the velocity of the water and eliminate surface erosion;

- Removal of culverts and installation of “rolling dips” in the roadway to channel surface water off the road to a larger surface area, reducing concentrations of water;

- Elimination of ditch and culverts and out-sloping of roadways to allow surface water to drain off the roadway for the entire road length, effectively eliminating large volumes of water at concentrated points;

- Combinations of the above practices with road surface rocking, or spot rocking, to reduce velocities of surface runoff.

Approximately 30 percent of the watershed is managed as commercial timberlands under the Timber Production Zone (TPZ) designation. Management practices for these lands are prescribed by the Forest Practice Rules, and administered by CDF. Roads with older construction features from the 1950s and 1960s (inside ditches, undersized culverts, poor alignments) are being updated and improved with new construction practices and management standards. These updates have the effect of reducing surface erosion from these roads.

MASS WASTING

Mass wasting includes shallow rapid landslides, debris torrents, large-persistent deep-seated failures and smaller sporadic deep-seated failures. Shallow rapid landslides, also known as debris flows, commonly occur on steep slopes where soil overlies bedrock. The primary mass wasting processes in the steep eastern portion of the watershed appears to be debris flows, slides and falls that occur along the steep channel walls of the stream courses. Abnormally high precipitation events, earthquakes, volcanic activity, and adverse forest management practices generally influence these failures.

The most potentially impacting mass wasting phenomenon in this region is the occurrence of large, deep-seated, slide failures that develop on the flanks of the channels. These failures are most common where the streams have down cut to a point where loose consolidated rock of the Montgomery Creek Formation is exposed. This material is easily eroded away, causing the overlying, more resistant rock of the Tuscan Formation to fail (Bailey, 1966).

Mass wasting is a common geologic process in the upper reaches (source and transitional areas) of Cow Creek. Representative photographs of typical landslide features within the Cow Creek Watershed are included at the end of this section.

CONCLUSIONS

The area of the watershed most prone to sediment generation is the upland eastern portion of the watershed. Currently, sediment does not appear to be depositing in the lower reaches of the watershed. Large portions of the tributary channels from the uplands to the main stem show exposed bedrock, with Tuscan in the upper reaches, Chico Formation in the mid-sections, and Tehama and Red Bluff Formations in the lowest portions.

A review of historic air photos and available maps show that the configuration of the channel on the main stem has not changed significantly over 100 years. As a result, bank erosion, from the main stem does not likely contribute a significant amount of sediment. No data is available to document the bank erosion discussed in Old Cow and South Cow Creeks.

Most upland forest roads were constructed in the 1950s and 1960s with inside ditches. Private timber companies are working to rebuild and improve the forest roads to reduce sediment deposition. Upland forest roads are not believed to be a significant contributor to sediment deposition in the Cow Creek system.

Channel condition problems, sediment input and bank issues may occur in isolated areas of the watershed tributaries, generally associated with portions of Old Cow Creek, South Cow Creek and Atkins Creek. Data is limited to work conducted in this area by the Latour State Forest.

Significant physical obstructions (falls) occur in Little Cow, Oak Run Creek, Clover Creek and Old Cow Creek.

The following data is missing in this area:

- Channel surveys have not been conducted on the majority of the watershed.

- Hard data on sources of increased sediment and percentage of contribution of sources is not available.
- Upland roads in the watershed have not been inventoried nor assessed.

ACTION OPTIONS

1. Verify that upland forest roads are not major sources of increased sediment transport in the watershed, via an evaluation of the road network, to identify individual road segments requiring improvement or decommissioning.

2. Continue efforts to rebuild vintage forest roads to modern BMP standards.

3. Conduct hydrologic studies and/or channel evaluations of primary tributaries to identify specific areas requiring restoration activities.

4. Evaluate the need to improve spawning substrate in upper reaches.

REFERENCES

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Photo 4-1: Typical private property sign found throughout the Cow Creek Watershed.

Photo 4-2: Diddy Wells Falls on Little Cow Creek.

Photo 4-3: Diddy Wells Falls, looking downstream at incised canyon walls.

Photo 4-4: Clover Creek Falls.

Photo not currently available.

Photo 4-5: Oak Run Falls

Photo 4-6: Whitmore Falls on Old Cow Creek.

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Photo 4-14: Rotational failure.

Photo 4-15: Head scarp of active landslide.

Photo 4-16: Toe of active landslide.

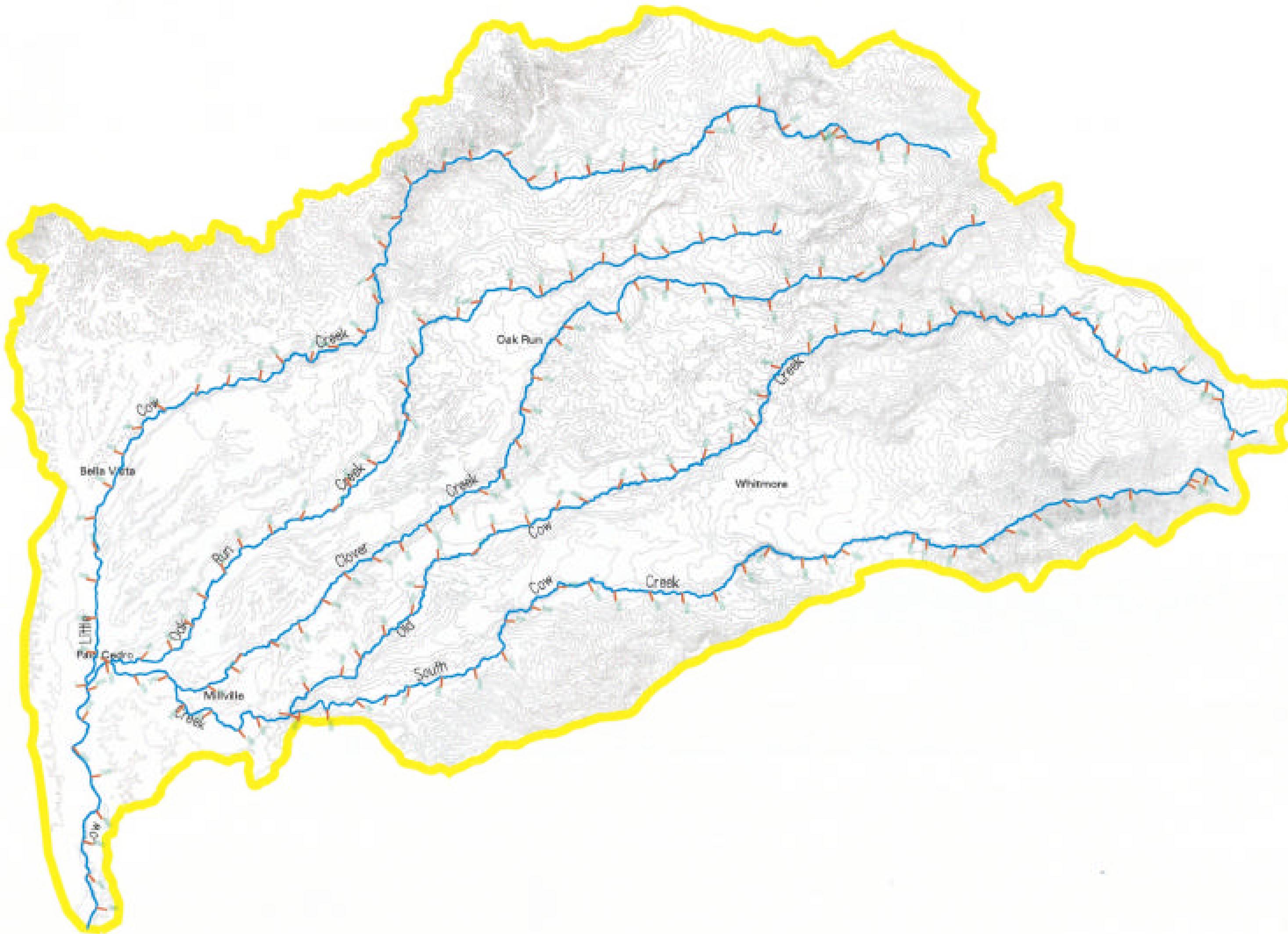

FIGURE 4-1
STREAM SEGMENTS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: USGS

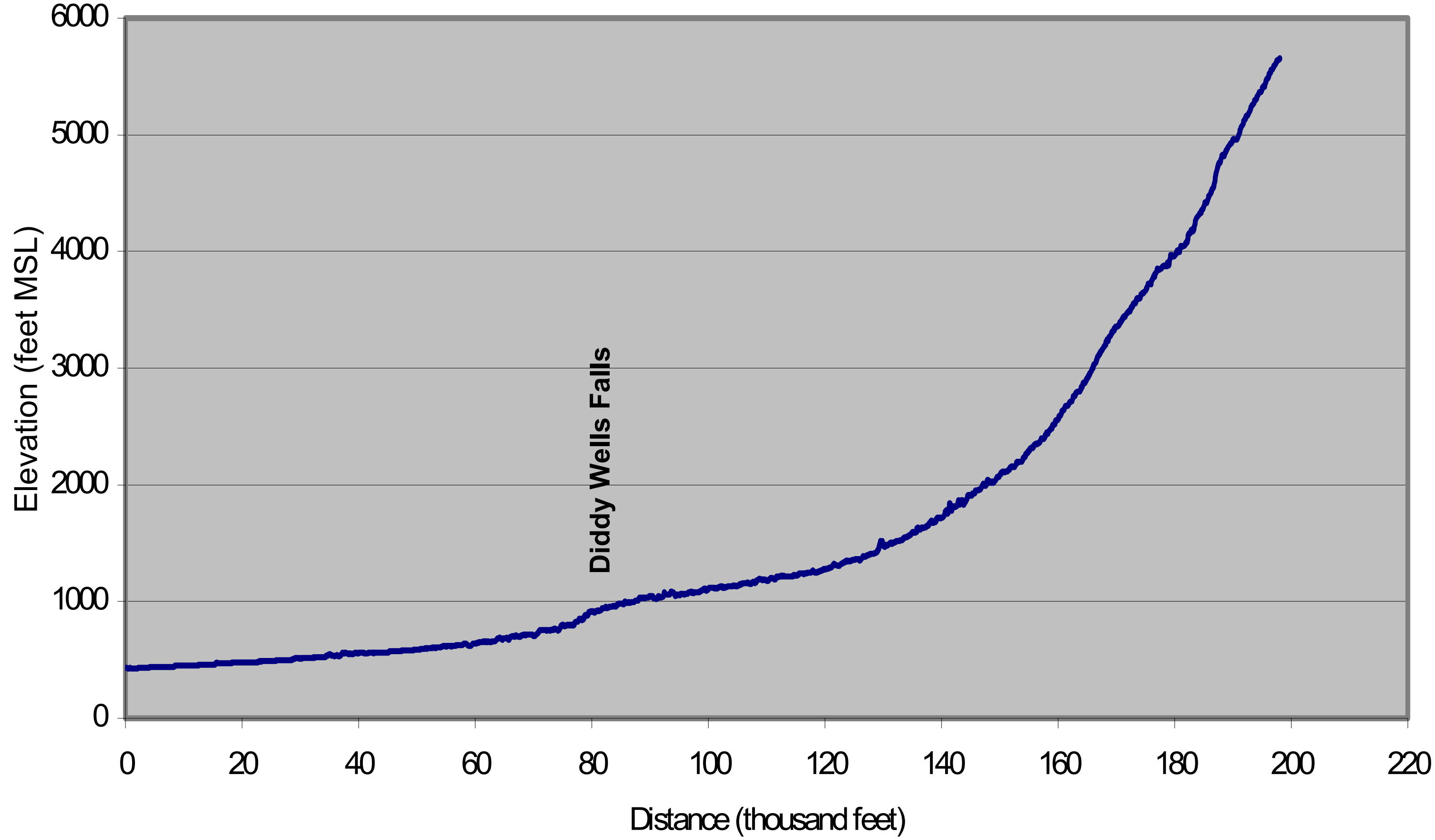

FIGURE 4-2
PROFILE – LITTLE COW CREEK
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

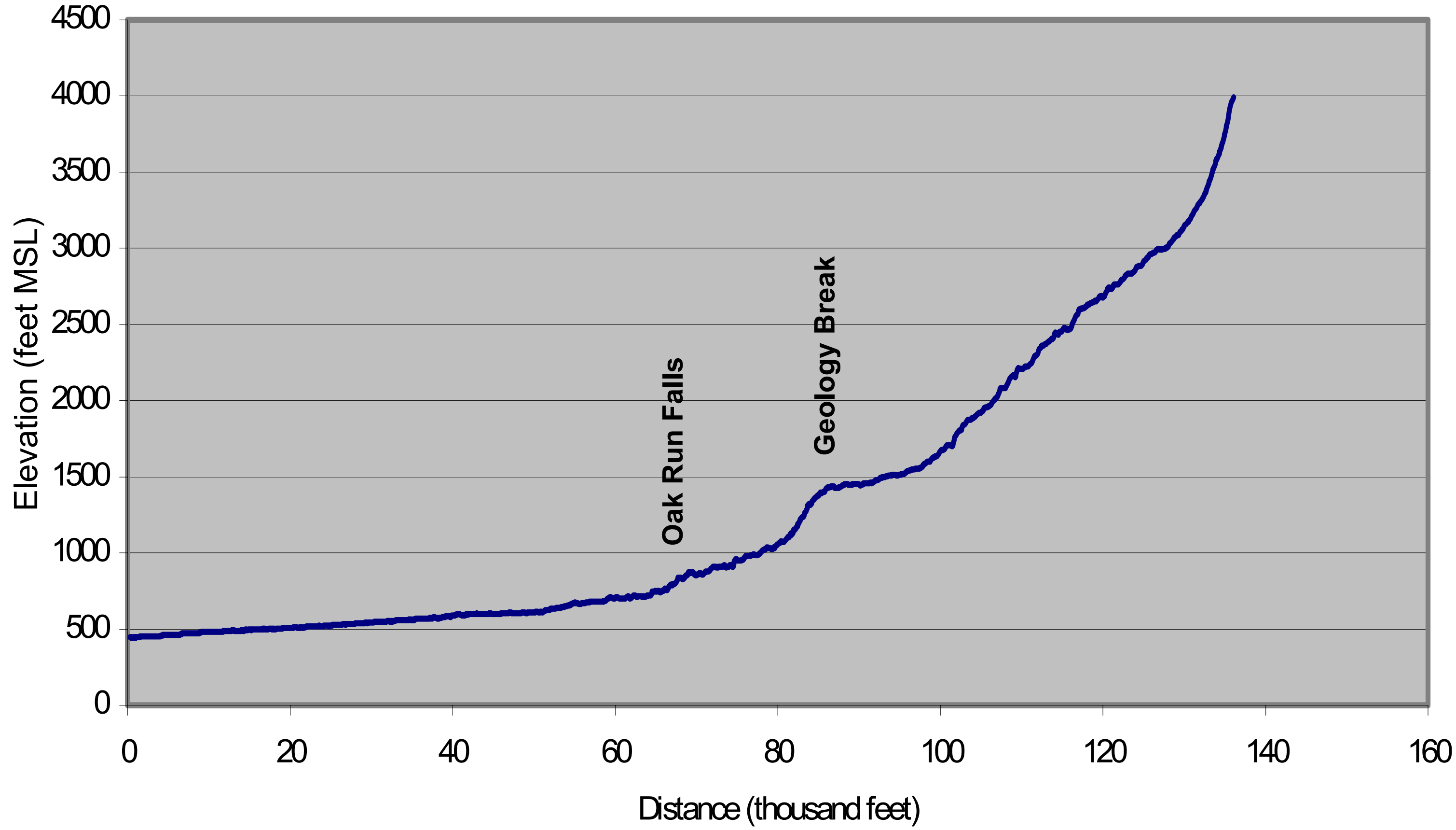

FIGURE 4-3
PROFILE – OAK RUN CREEK
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

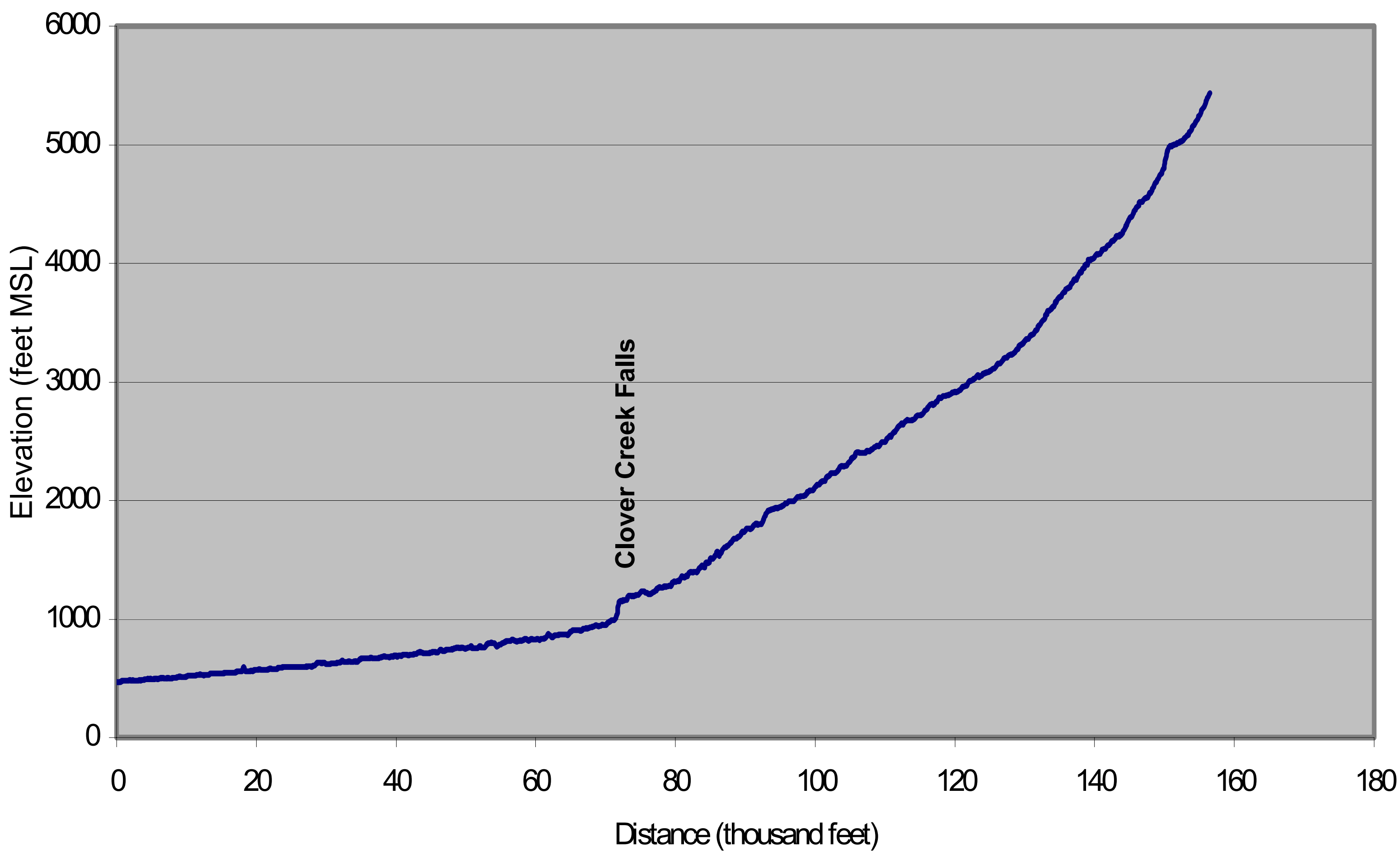

FIGURE 4-4
PROFILE – CLOVER CREEK
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

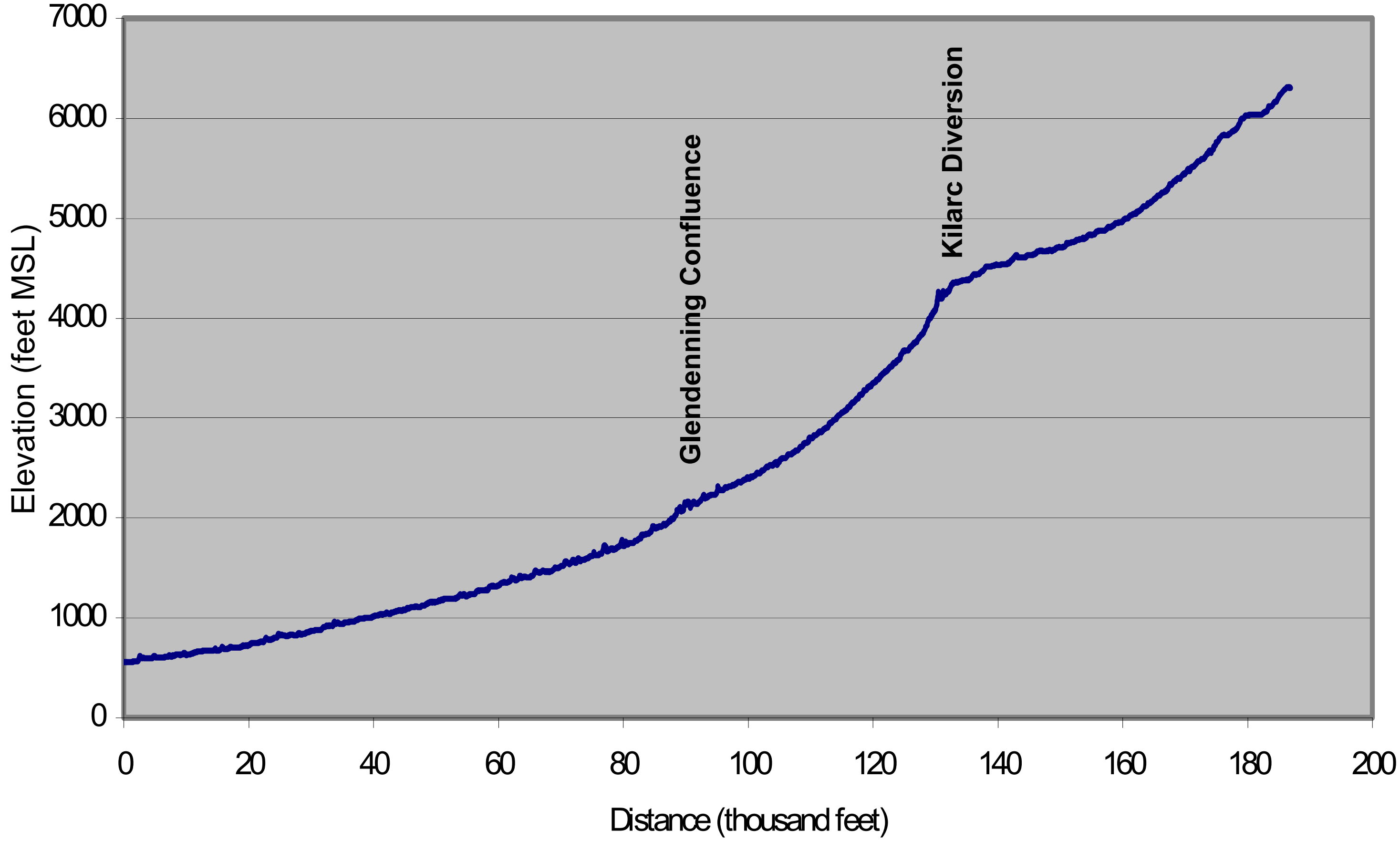

FIGURE 4-5
PROFILE – OLD COW CREEK
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

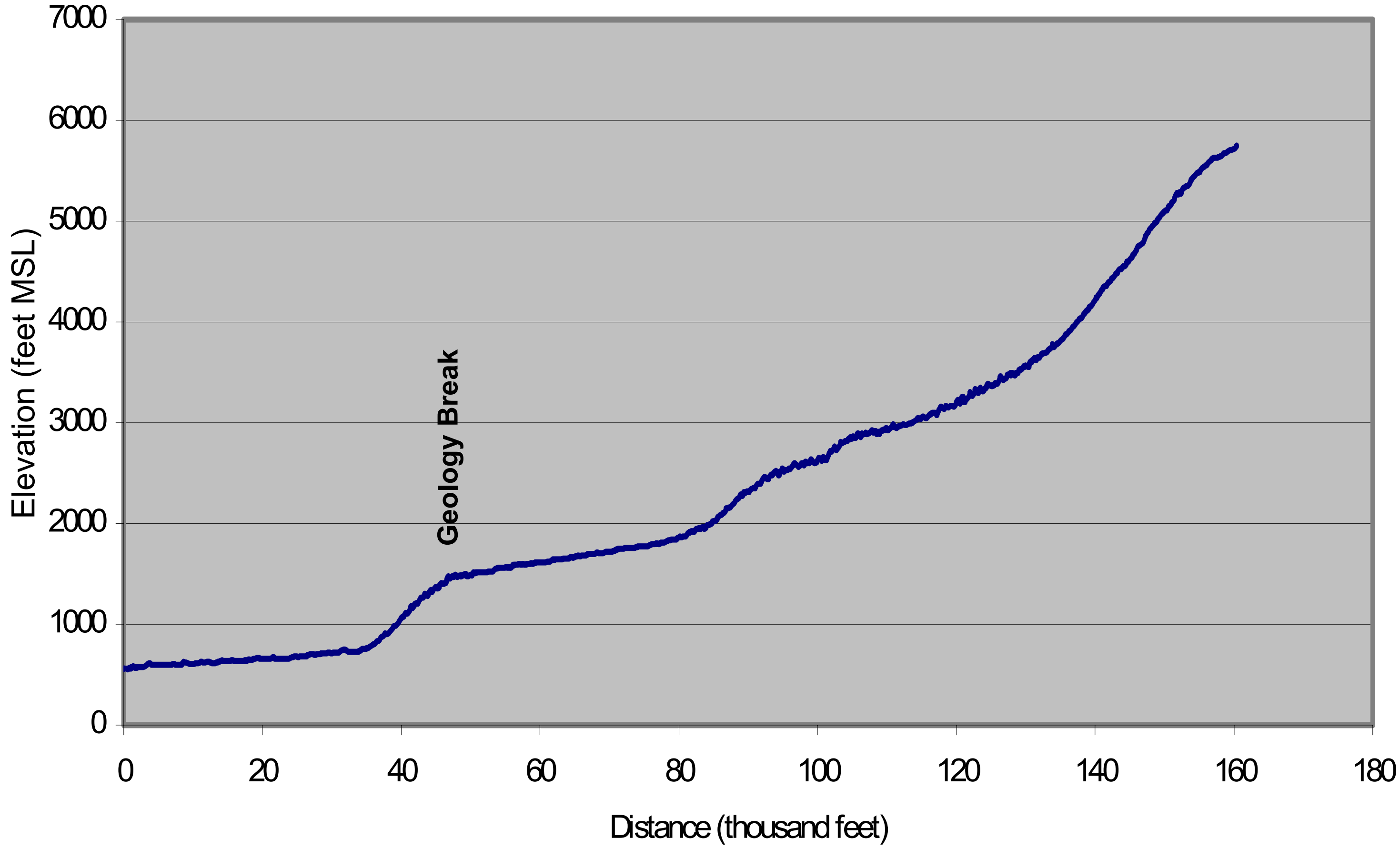

FIGURE 4-6
PROFILE – SOUTH COW CREEK
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

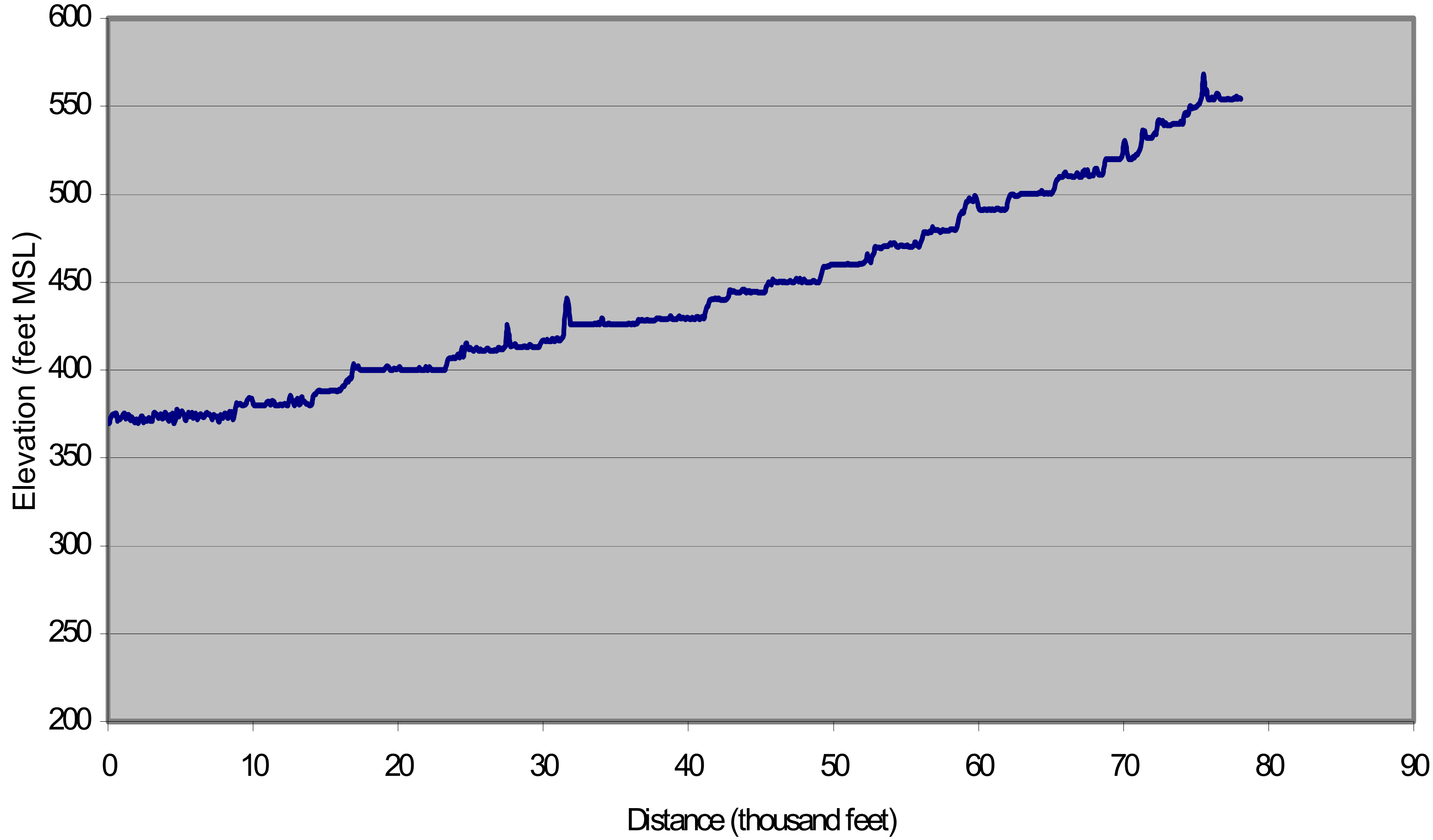

FIGURE 4-7
PROFILE – MAIN STEM COW CREEK
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

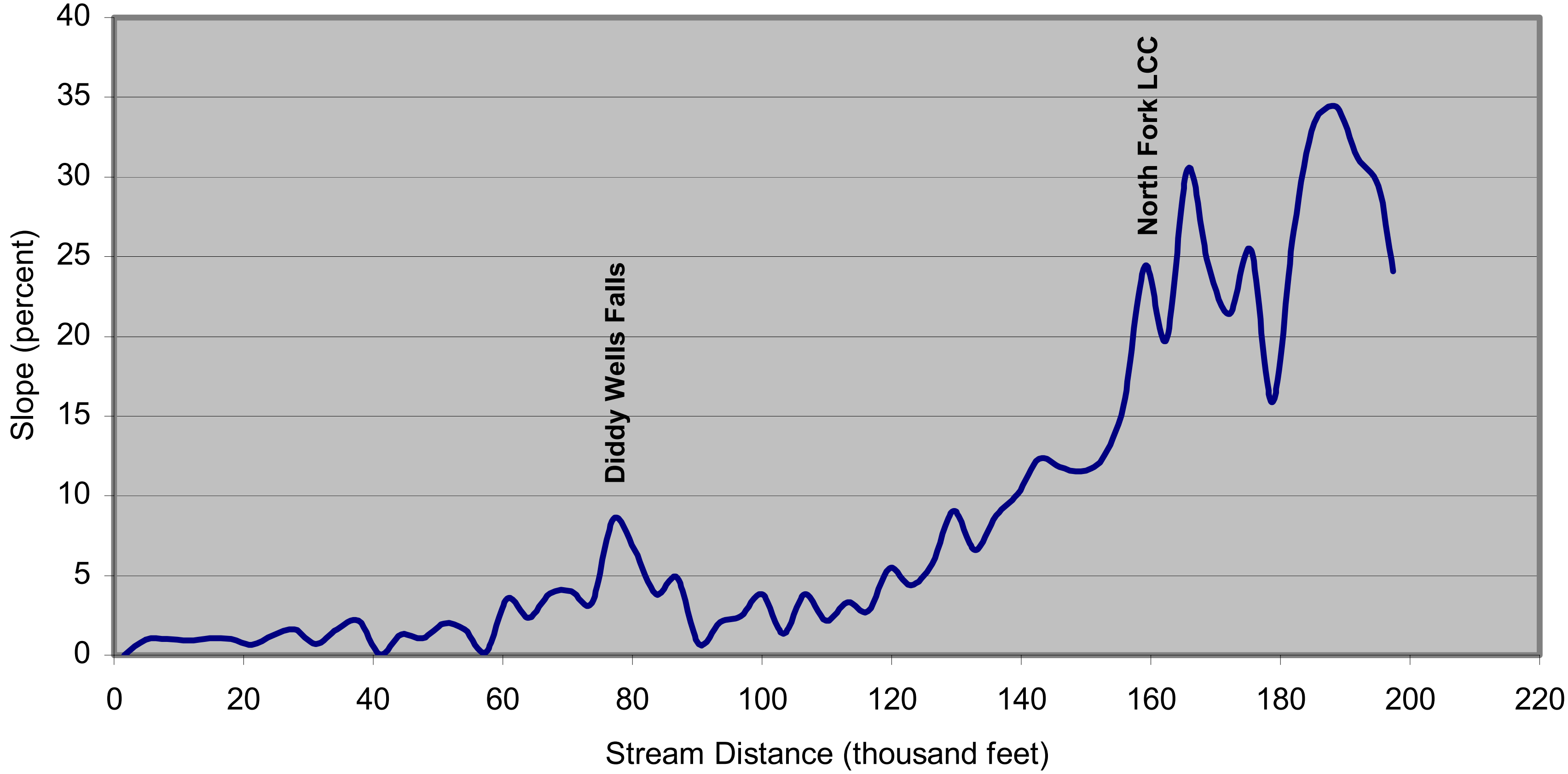

FIGURE 4-8
CHANNEL SLOPE – LITTLE COW CREEK
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

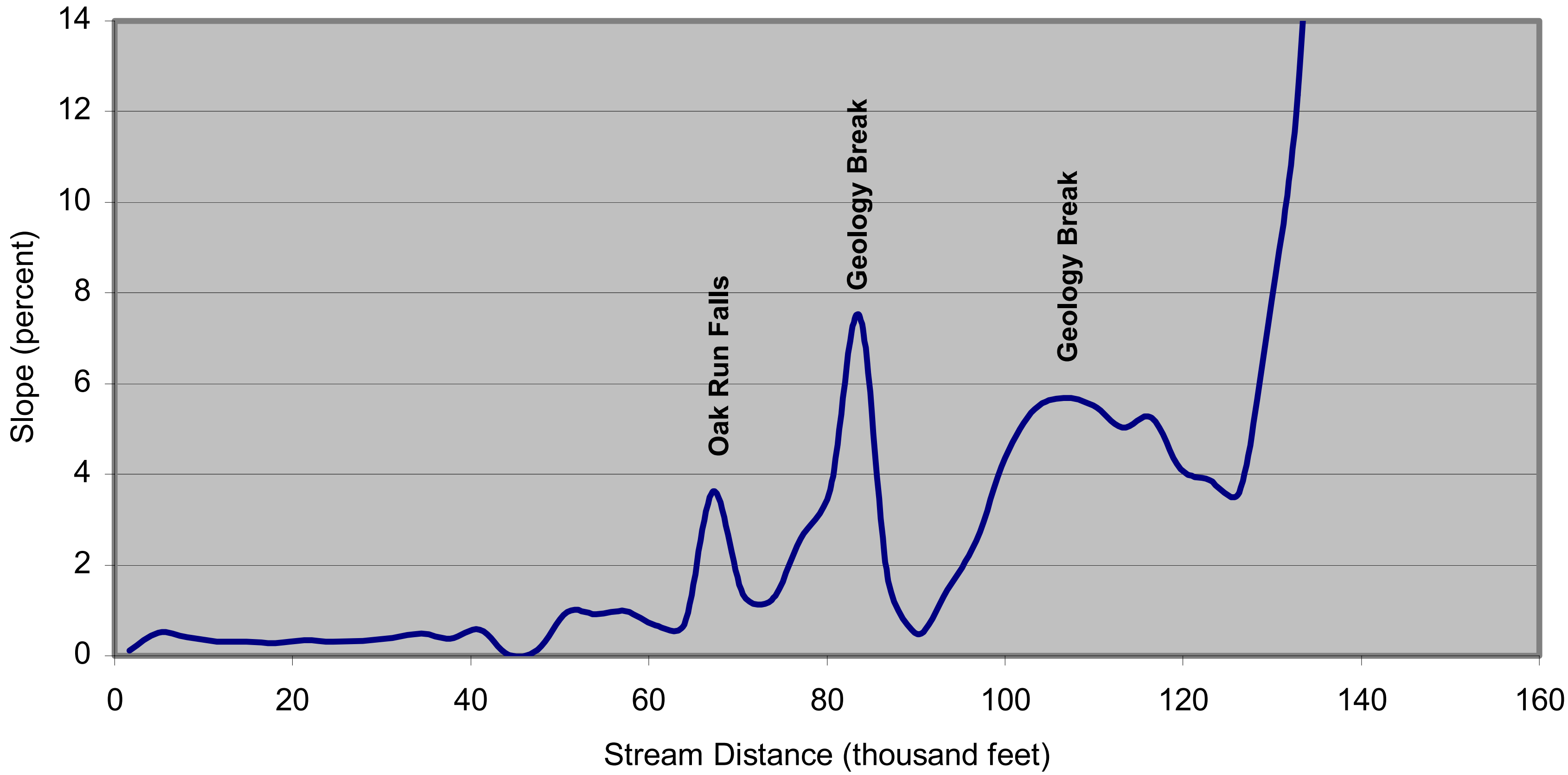

FIGURE 4-9
CHANNEL SLOPE – OAK RUN CREEK
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

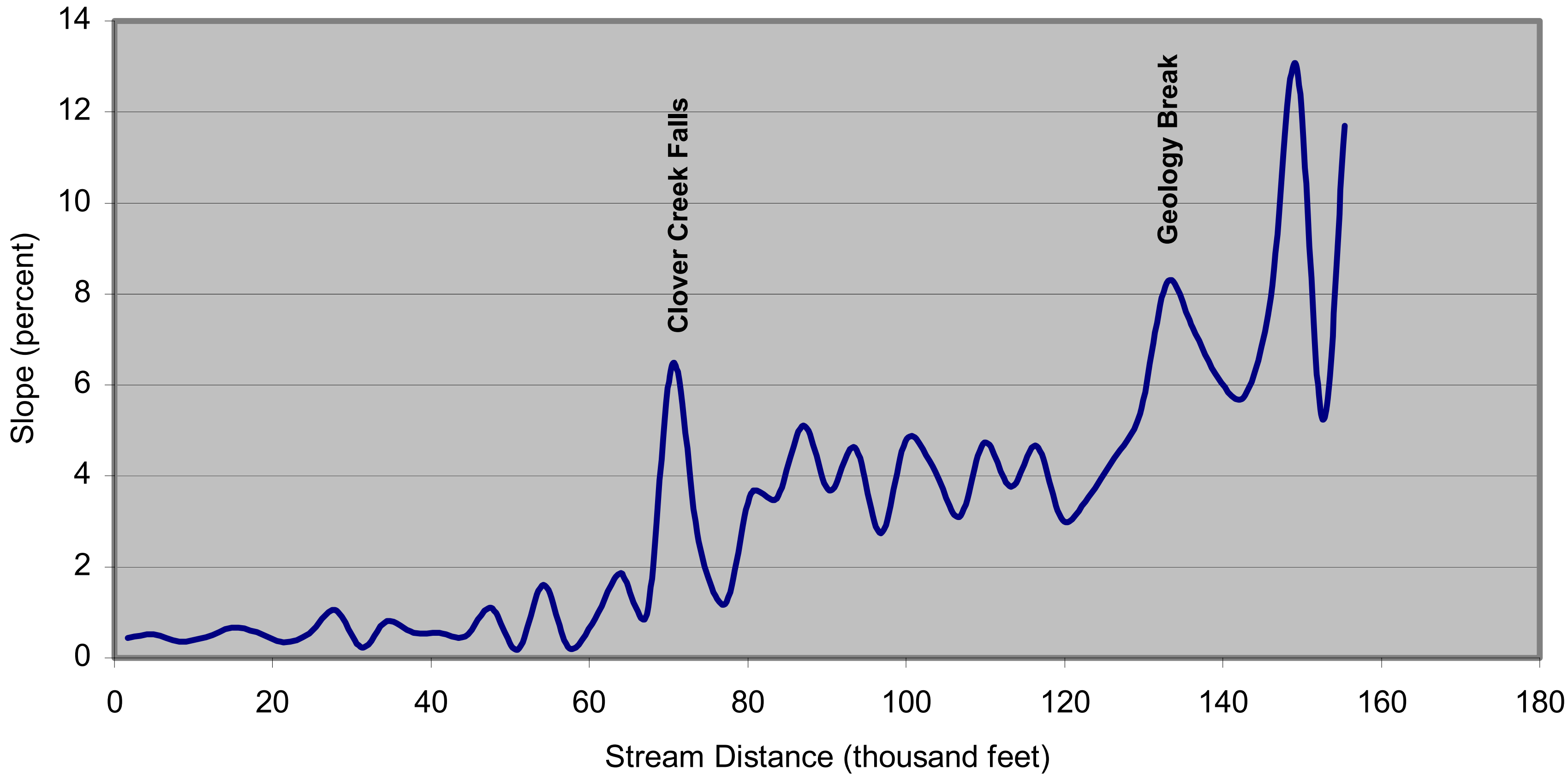

FIGURE 4-10
CHANNEL SLOPE – CLOVER CREEK
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

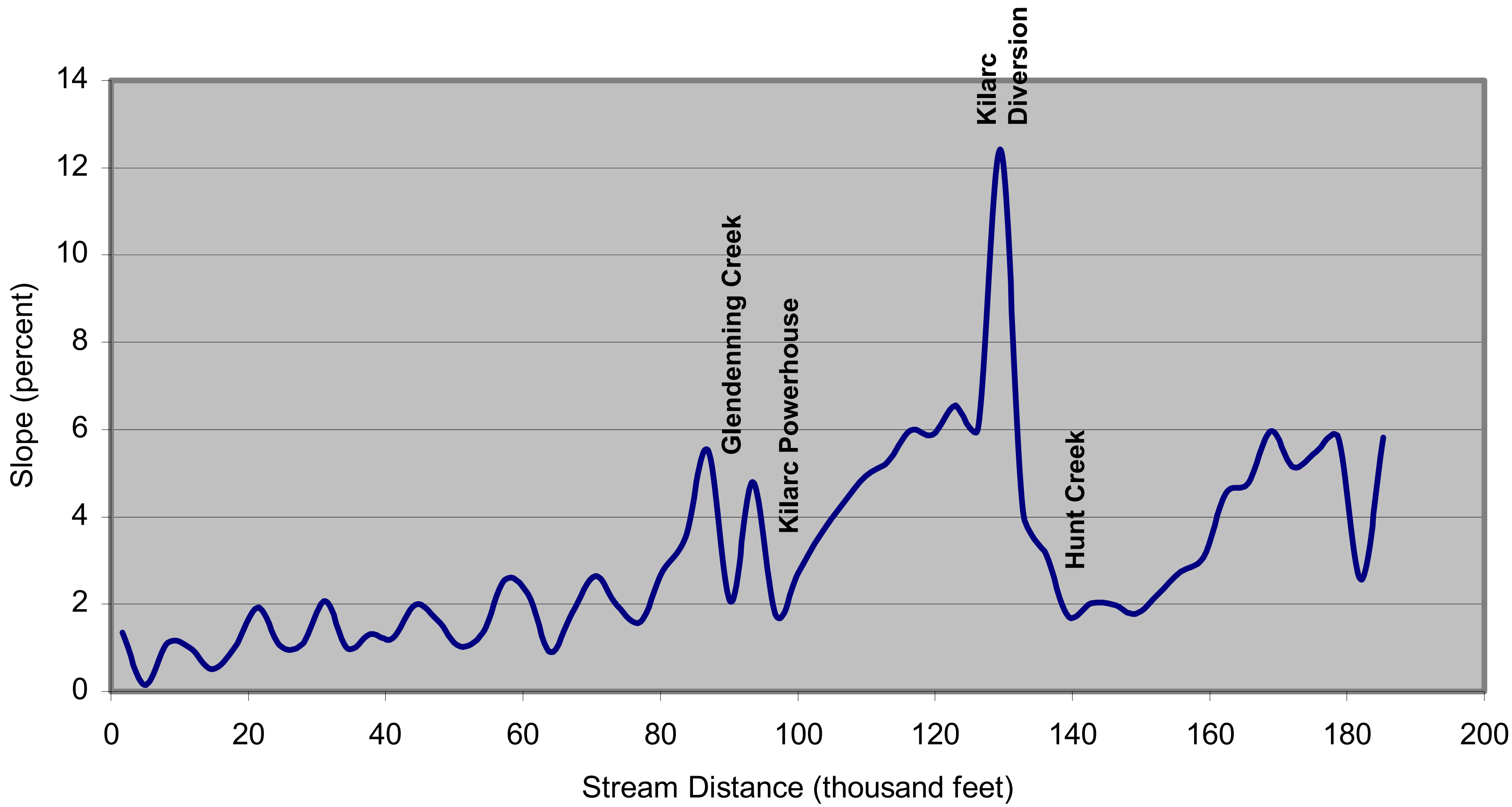

FIGURE 4-11
CHANNEL SLOPE – OLD COW CREEK
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

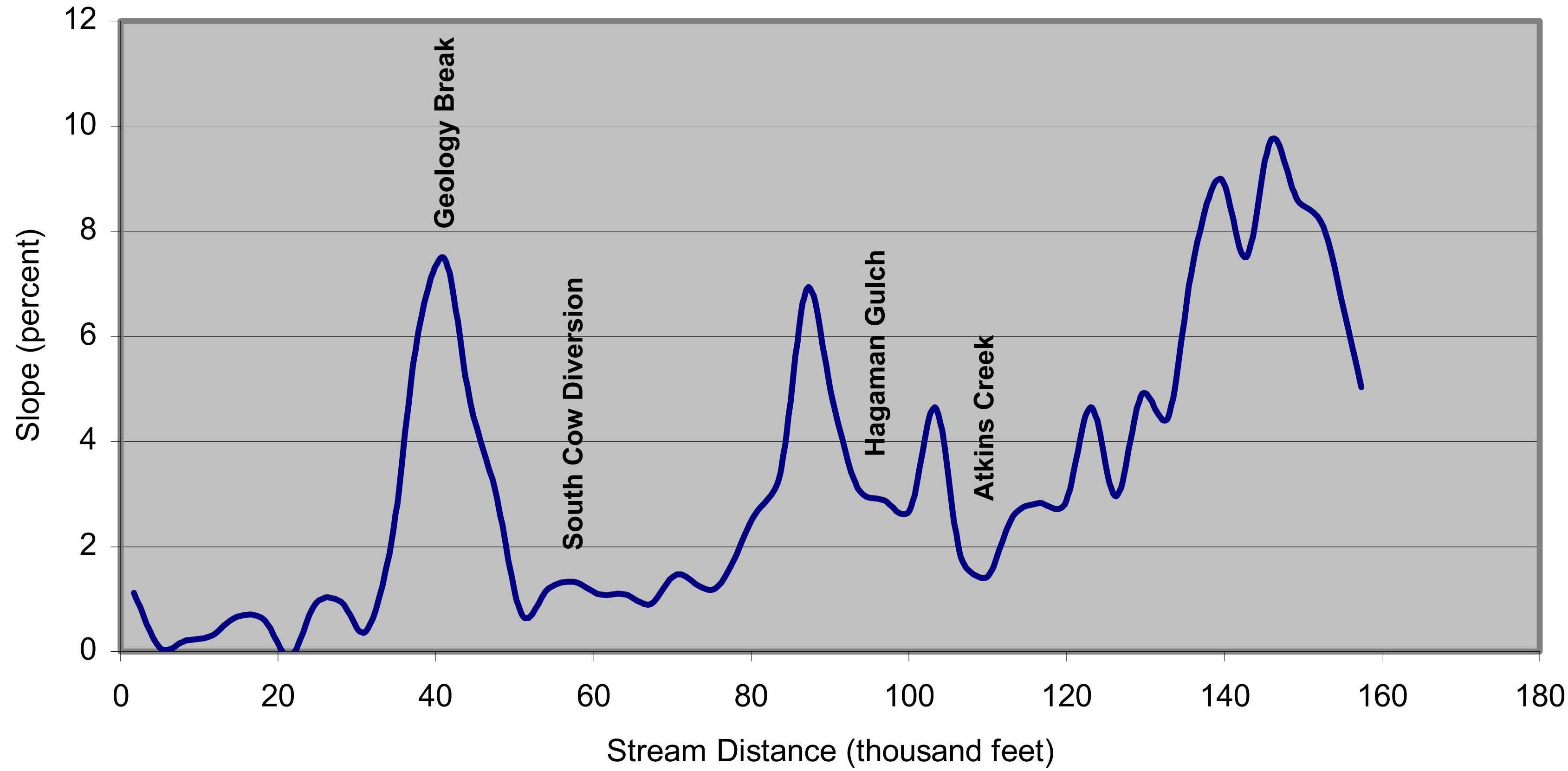

FIGURE 4-12
CHANNEL SLOPE – SOUTH COW CREEK
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

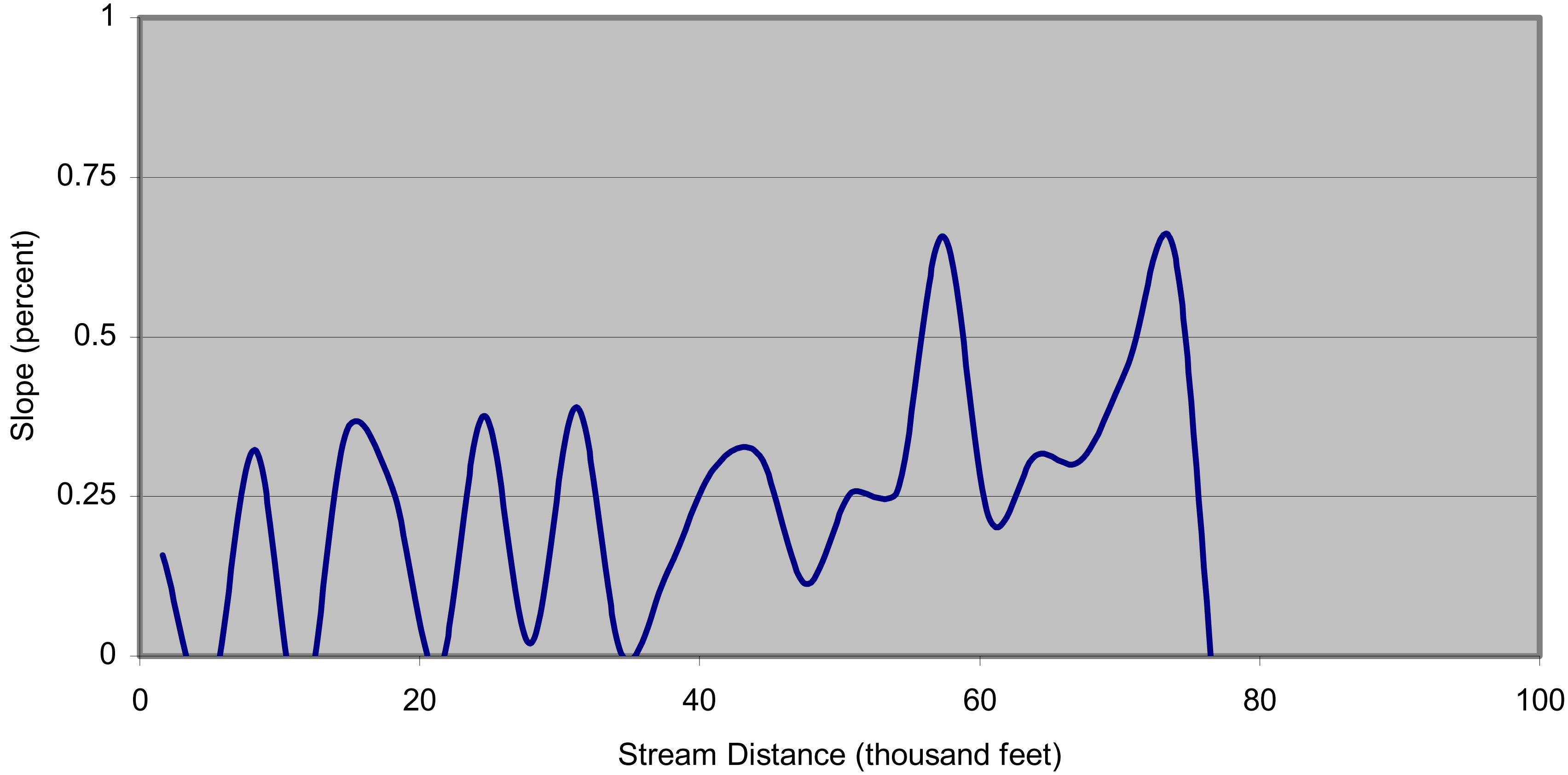

FIGURE 4-13
CHANNEL SLOPE – MAIN STEM COW CREEK
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

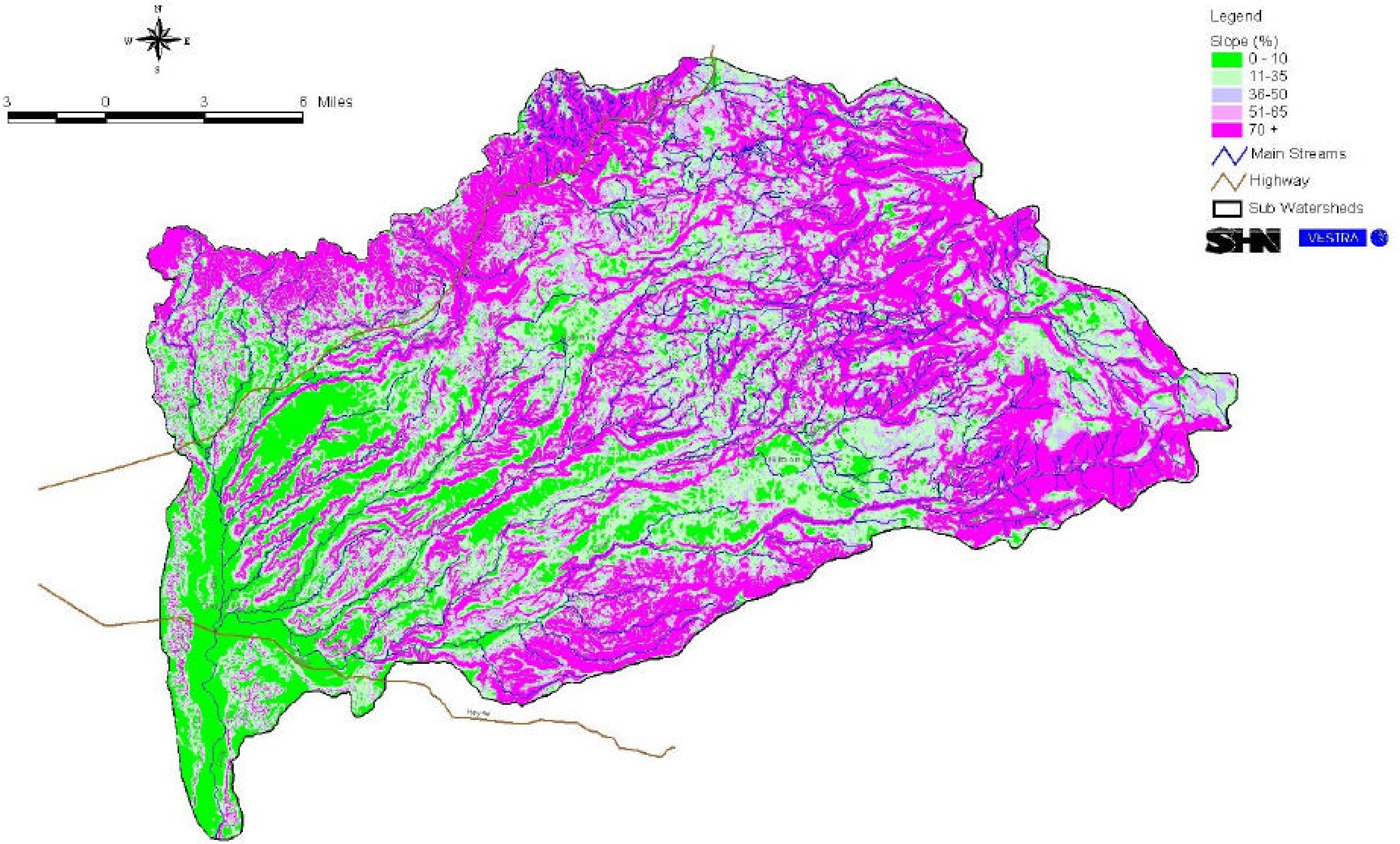

FIGURE 4-14
SLOPE MAP
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: USGS DEMs

Section 5
HYDROLOGY

Section 5
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Section 5
HYDROLOGY

Basic hydrologic information on the Cow Creek Watershed is discussed in this section. This information includes general watershed characteristics, surface water runoff and water rights and diversions.

A portion of the hydrologic data presented in this section is based on the water year calendar. A water year begins on October 1 and ends 12 months later on September 30. Each water year is designated by the calendar year in which the 12-month period ends. For example, the maximum instantaneous peak flow recorded along the main stem of Cow Creek occurred on November 16, 1981. Based on the water year calendar, this event occurred in 1982.

WATERSHED CHARACTERISTICS

The Cow Creek Watershed is the most northerly uncontrolled tributary to the Sacramento River. It is located in Shasta County on the eastern side of the Sacramento River, downstream from Shasta Lake. Major tributaries, including Little Cow Creek, Oak Run Creek, Clover Creek, Old Cow Creek and South Cow Creek flow in a southwesterly direction and form the main stem of Cow Creek near Millville. Sub-watersheds discussed in this section are presented in Figure 5-1. The entire watershed encompasses approximately 274,000 acres.

TABLE 5-1
Sub-watersheds Cow Creek

Sub-Watershed	Tributary Length (miles)	Acres	Percent
Little Cow Creek	37.5	91,900	33
Oak Run Creek	26.0	30,138	11
Clover Creek	29.5	34,917	13
Old Cow Creek	35.5	54,420	20
South Cow Creek	30.5	50,479	18
Main Stem Cow Creek	15	12,830	05
Total	174	274,684	100

The topography of the Cow Creek Watershed varies significantly from flat valley areas the main stem to steep mountainous areas along the upper reaches. Elevations vary from approximately 350 feet above sea level on the valley floor to nearly 7400 feet in mountainous areas.

Annual precipitation within the watershed ranges from about 25 inches in the valley areas to about 65 inches in the northeastern mountainous portion of the watershed. Average annual precipitation near Whitmore, at an elevation of about 2840 feet, is 51.13 inches. From 75 to 90 percent of the annual total precipitation is received between November 1 and April 30. Summer thundershowers commonly occur in the mountainous areas, but they account for only a small percentage of the total annual supply of moisture.

REFERENCE CONDITIONS

No data is available on reference conditions in the Cow Creek Watershed relating to hydrology. Historic references identify "bountiful" water and lush mountain meadows. It is probably safe to assume that the abundant springs and creeks in the mountainous areas and reasonable ease of diverting water based on topography were among the reasons that drew early settlers to the Cow Creek watershed. Reference flows can be estimated using current measured flows plus diverted flow by tributary.

SOURCES

USGS maintained 12 stations in the Cow creek system and DWR maintained an additional 15 stations. Most stations are no longer maintained. With the exception of the USGS (Millville) station 11374000, the period of record was brief and is generally insufficient to provide statistical flow records by tributary.

TRENDS

The Mann-Kendall statistical procedure was used to determine whether the annual mean and peak flow data recorded at the Millville station between 1950 and 1998 have been increasing or decreasing over the time period. The results show that there has been no statistically increasing or decreasing trend in runoff through the station at the 99 percent confidence level. In other words, peak annual flows have not increased or decreased since 1950. Since original diversion construction and adjudications, flows have not changed. This data coincides with the trend analysis conducted on climate data that shows no significant increase or decrease in precipitation over the period of record. Of note this would also imply that the amount of water diverted for agricultural or other uses has also not changed appreciably, (within the ability of instruments to measure) over the time period.

SURFACE WATER RUNOFF

Historically, the United States Geological Survey (USGS) has operated a number of stream gages throughout the watershed. Station locations are shown in Figure 5-2, and available data are summarized on Tables 5-2 and 5-3. The tables also include a summary of gage elevation, channel distance from the confluence to the stream gage and drainage area contributing to each gage (USGS, 2001).

The most complete hydrologic record is available for Station Number 11374000. This station is located on the main stem of Cow Creek, approximately three miles upstream from the confluence of the main stem and the Sacramento River. The drainage area contributing to this gage is approximately 425 square miles or 98 percent of the entire Cow Creek Watershed. This gage is commonly called the Millville Gage. Daily records are available for this gage from 1949 until present (USGS, 2001).

Annual flows for the Millville gage, between 1950 and 1998, are summarized on Figure 5-3. As shown, the minimum annual flow of 175 cubic feet per second (cfs) occurred in 1977, and the maximum annual flow of 1,728 cfs occurred in 1998. The average annual flow during the period of record is 695 cubic cfs. Annual flows were below the average annual flow between 1987 and 1992, and above the average annual flow in 1993, 1995, 1996 and 1998.

Monthly flows for the Millville gage, between 1950 and 1998, are summarized on Figure 5-4. As shown, average monthly flows vary between 38 cfs in August and 1,780 cfs in January. In contrast, the minimum daily flow of 0.02 cfs was recorded on July 29, 1997, and the maximum daily flow of 32,500 cfs was recorded on December 27, 1951.

FLOOD HISTORY

Cow Creek Watershed ranks third behind the Cottonwood Creek and Stony Creek watersheds for producing the largest peak flood flows within the northern Sacramento Valley (DWR, 1969). Of these watersheds, Cow Creek is the most northerly and the only one located on the east side of the Sacramento River. It has been estimated that flood flows from the Cow Creek Watershed account for approximately 21 percent of the peak discharge for the Sacramento River between Shasta Dam and Red Bluff (DWR, 1969).

The Cow Creek Watershed probably experienced major flooding in conjunction with widespread flooding throughout the northern Sacramento Valley in 1861-62, 1907 and 1909. Brief newspaper articles and high water marks also show that major flooding occurred in 1937 and 1940 (DOA, 1971). More recent stream flow data show that major flooding occurs approximately every five years. Annual instantaneous peak flows between 1950 and 1998 are shown on Figure 5-5. Individual peak events are listed in descending order on Table 5-4.

The largest recorded flow along Cow Creek occurred on November 16, 1981. The estimated peak flow on this date was 48,700 cubic feet per second near the Millville Gage. The estimated gage height was 21.22 feet. Based on the high water marks in the vicinity of the Millville gage, it is known that higher flood stages have occurred. The most recent flood flow occurred on January 2, 1997. The recorded flow on this date was 37,700 cfs. The average annual instantaneous peak flow is 23,000 cfs (USGS, 2001).

The recurrence interval or return period for peak flows greater than or equal to a given value are shown on Figure 5-6. Figure 5-6 was generated using annual instantaneous peak flows between 1950 and 1998, and the equation:

$$\text{Return Period}_{\text{(recorded flow)}} = (\text{years of record} + 1)/\text{rank}_{\text{(recorded flow)}}$$

Using Figure 5-6, it is possible to estimate how often the peak instantaneous flow in Cow Creek will be equal to or greater than a given value. For example, the instantaneous peak flow in Cow Creek can be expected to exceed 30,000 cfs once every three years.

Despite the large flood flows that have occurred within Cow Creek, the watershed has suffered minimal damage. According to the Department of Water Resources (1969), the maximum flow in the main stem of Cow Creek is 16,000 cfs. This is also referred to as "bank full flow", which is the maximum flow before potential damage may occur. Bank full discharge is assumed to be the discharge at which channel-forming processes begin to occur. Historically, this damage has been mainly confined to agricultural lands. Due to considerable urban development, however, future flood flows may have a larger impact and the flood stage may actually increase with the same rainfall.

TABLE 5-2 Daily Mean Flows Cow Creek Watershed										
Station ID	**Location**	**Elevation**	**Distance[2]**	**Area**	**Coverage**			**Data (cfs)**		
		(feet)	**(feet)**	**(sq. miles)**	**Dates**	**Records**	**Type[3]**	**Mean**	**Minimum**	**Maximum**
11372080		1560	56,500	---	84-99	5069	I	4.6	0	11
11372200	S Cow	640[1]	13,500	77.3	56-72	5847	C	112.4	0.5	4,120
11372325	Kilarc	3840[1]	128,000	---	83-99	5769	I	3	0	4.9
11372330	Olsen	1720	81,500	---	90-99	1709	I	18.4	0	129
11372350	O Cow	2340	99,500	32.6	90-99	1709	I	34.4	6.9	1,510
11372500	Cow	490	61,500	166	No Record					
11372700	Clover	1940[1]	94,500	19	57-59	867	C	35.1	4.3	322
11373000	Clover	490	1,500	52.5	No Record					
11373200	Oak Run	1420[1]	86,500	11	57-66	3428	C	15.7	0.1	560
11373300	L Cow	1140[1]	108,500	60.8	57-65	2922	C	139.6	4.1	4,840
11373500	L Cow	450	3,500	145	No Record					
11374000	Main Cow	410[1]	16,000	425	49-99	1862	C	695.5	0.02	32,500

[1] Elevation estimated from USGS quadrangle map.
[2] Distance are from the gage to the confluence of the main tributary and the main stem of Cow Creek, estimated using GIS.
[3] I = Record between start and end dates is incomplete, C = Record between start and end dates is complete.

TABLE 5-3
Annual Peak Flows
Cow Creek Watershed

Station ID	Location	Elevation	Distance[2]	Area	Coverage			Data (cfs)		
		(feet)	(feet)	(sq. miles)	Dates	Records	Type[3]	Mean	Minimum	Maximum
11372080		1560	56,500	---	No Record					
11372200	S Cow	640[1]	13,500	77.3	55-72	16	C	4,476	2,400	6,970
11372325	Kilarc	3840[1]	128,000	---	No Record					
11372330	Olsen	1720	81,500	---	No Record					
11372350	O Cow	2340	99,500	32.6	97	1	C	2,280	2,280	2,280
11372500	Cow	490	61,500	166	12-14	3	C	6,400	2,500	10,500
11372700	Clover	1940[1]	94,500	19	58-59	2	C	845	821	868
11373000	Clover	490	1,500	52.5	12-14	3	C	3,303	1,040	6,300
11373200	Oak Run	1420[1]	86,500	11	57-76	17	C	1,247	346	3,860
11373300	L Cow	1140[1]	108,500	60.8	57-64	6	C	6,058	3,500	9,090
11373500	L Cow	450	3,500	145	12-13	2	C	5,220	2,440	8,000
11374000	Main Cow	410[1]	16,000	425	50-98	49	C	23,561	1,270	48,700

[1] Elevation estimated from USGS quadrangle map.
[2] Distance from the gage to the confluence of the main tributary and the main stem of Cow Creek, estimated using GIS.
[3] I = Record between start and end dates is incomplete, C = Record between start and end dates is complete.

ESTIMATING RUNOFF

Daily mean flows for the USGS gaging station, located on Clover Creek approximately 18 miles upstream from the confluence of Clover Creek and the main stem of Cow Creek, are available for 1957, 1958 and 1959 (Table 5-2). This gage is located approximately six miles downstream from the Mill ditch. To estimate the long-term flows at this station, it can be assumed that available records reflect long-term flows. An alternate method is to correlate the available Clover Creek data with data from the Millville station located on the main stem of Cow Creek. Data from the Millville station are available from 1948 to present. A third method is to assume that runoff at the Clover Creek station is proportional to the drainage area and can be estimated directly from the Millville data. Estimated long-term flows on Clover Creek, at the USGS gaging station, are presented in Figure 5-7.

TABLE 5-4
Annual Peak Flow Summary
Cow Creek Watershed

Year	Date	Peak Flow (cfs)	Gage Height (feet)
1981	Nov 16	48,700	21.22
1951	Dec 27	45,200	21.55
1986	Mar 08	39,000	18.89
1982	Nov 16	38,200	18.71
1997	Jan 02	37,700	21.58
1969	Dec 19	36,400	18.17
1978	Jan 09	36,000	18.31
1960	Dec 01	35,800	19.67
1974	Jan 15	35,300	17.81
1969	Jan 12	33,800	17.57
1956	Jan 15	33,000	19.06
1965	Jan 05	32,700	19.00
1959	Feb 16	31,500	18.74
1966	Jan 04	31,400	18.71
1998	Feb 03	30,300	19.59
1970	Dec 04	30,000	16.64
1980	Jan 13	26,200	15.75
1993	Jan 21	25,400	18.17
1962	Oct 12	24,800	16.98
1995	Mar 14	24,300	17.83
1961	Dec 01	23,900	16.68
1957	Nov 13	23,600	16.55
1987	Mar 12	23,500	14.57
1975	Feb 13	23,200	14.51
1967	Jan 21	23,100	15.71

WATER RIGHTS AND DIVERSIONS

Little Cow Creek is commonly called North Cow Creek. Although, by common usage, both names are correct, an attempt has been made to use Little Cow Creek for consistency. In this section, North Cow Creek is used interchangeable with Little Cow Creek because many of the water rights along Little Cow Creek were originally assigned to North Cow Creek.

WATER RIGHTS GENERAL

Water rights in the Cow Creek Watershed are either appropriated or riparian. An appropriated right is an exclusive right to take a specific amount of water from a particular source for a specific use on a specific site for a specific amount of time. Riparian rights, on the other hand, belong to the land bordering a water source. The following discussion is provided as a general introduction to the concept of water rights and should not be considered legal opinion.

Appropriated Rights

An appropriative right is an entitlement to water based on a specific use. This type of right may be sold or transferred with the property or separately. In general, the party that first diverts the water has rights priority over subsequent appropriators or users. Actual levels of priority are generally specified in the appropriation. In situations where priorities conflict, or in situations where rights were established prior to the appropriation system, the rights may be adjudicated. Adjudications are judgments decreed by the court and carry the full force of law. The court or an assigned water master generally administers adjudicated rights. Most of the water rights in the Cow Creek system have been adjudicated. These are discussed later in this section.

A senior may not change an established use of the water to the detriment of a junior. This restriction includes junior's reliance on a senior's return flow. A senior may not enforce a water right against a junior if such a right would not be put to beneficial use.

The elements of appropriation include:

- intent to use the water;
- diversion or control of the water;
- reasonable and beneficial use of the water; and,
- priority of appropriation.

Appropriative right is an acquisition of a water right subject to the issuance of a permit by the State Water Resources Control Board. The priority is based on the date a permit is issued. A priority-based permit system was implemented under the Water Commission Act of 1913. Presently the system is codified in CWC § 1200, et seq.

Riparian Rights

A riparian right is the right to use water based on the ownership of property that abuts a natural watercourse. Water claimed by virtue of a riparian right must be used on the riparian parcel. Such a right is generally attached to the riparian parcel of land except where a riparian right has been preserved on non-contiguous parcels after the land has been subdivided, *Hudson v. Dailey*, (1909) 156 Cal. 617. Riparian rights were adopted in California as a part of the English Common Law when California entered statehood in 1850. At that time, however, gold miners were already operating under their own system of prior appropriation to claim water rights. Conflicts between appropriations and riparian rights have continued since.

In general, riparian users are entitled to enough water to make beneficial use of the water on the land as long as no other riparians are harmed by such use. Riparian rights in California are now limited to "reasonable and beneficial use."

In contract to appropriative rights, there is no priority of riparian right; senior and junior riparians do not exist. Water conflicts between riparian users are resolved on the basis of reasonable use. The court has held that in times of water shortage, all riparians must adjust water use to allow for an equal sharing of the available water supply.

California Doctrine

The California Doctrine is a system of water rights that recognizes both appropriative and riparian rights. Early California law recognized both appropriation and riparian rights by applying priority to disputes between appropriators and by applying riparian principles to disputes between riparians. In 1872 California officially recognized the rights of appropriators by allowing the filing of water claims with county recorders. Within 14 years, the California Supreme Court had to determine who had superior water rights when a downstream riparian rancher and an upstream appropriator each claimed a superior right to use water. The Court held that a riparian's rights are superior to the rights of an appropriator except in cases where the water had been appropriated before the riparian acquired the patent to his land, *and* after the passage of the 1866 Mining Act which recognized appropriation. Generally, a reasonable use by a riparian will trump an appropriative right so long as the patent to the riparian parcel was acquired from the United States prior to the date of appropriation.

In 1926 the Court held that a riparian could assert priority over an appropriator to make beneficial use of the water – even if the riparian use was unreasonable. In response, in 1928 the California Constitution was amended to require all water use in California to be "beneficial and reasonable." Generally today, a riparian user cannot defeat an appropriative right unless the riparian user proves the appropriation is causing undue interference with the riparian's reasonable use of the water.

COW CREEK ADJUDICATIONS

Water rights on North Cow Creek and its tributaries, Oak Run Creek, Clover Creek and Cow Creek, including Old Cow Creek, South Cow Creek, Lower Cow Creek and the Upper Tributary Areas of the Cow Creek System were determined by the Shasta County Superior Court and are set forth in separate decrees. These decrees establish the diversions, allotments and type of use. Spring flows are also appropriated in these decrees.

The Cow Creek Watermaster service area covers North Cow Creek, Oak Run Creek and Clover Creek. Watermaster service begins on May 1st and continues until September 30th of each year. Old Cow Creek and tributaries, South Cow Creek and tributaries, and Lower Cow Creek are not regulated by Watermaster service.

Historically, the watershed has sufficient water to supply all demands until late July, when the supply gradually decreases to about 60-70 percent of the allotments by mid-September. For the past few years, the water supply has been sufficient throughout the entire irrigation period.

Types of diversions within the system range from placement of rocks or logs within the creek, to culverts, to concrete flashboard dams. Few of the diversions are metered or screened.

North Cow Creek

Water rights on the North Cow Creek system were established under Judgment and Decree 5804, dated April 29, 1932. A report prepared by the Division of Water Rights of the Department of Public Works of the State of California dated 1925, and the accompanying map "North Cow and Oak Run Creek Watersheds Showing Diversion Systems and Irrigated Areas" dated 1923, identify 116 diversions and the associated irrigated acreages. There are two pumps currently operating that are included in the decree, but not in the 1925 report. These pumps are described as the Lemm Pump (diversion 109A) and the Melton Pump (diversion 110A).

Currently, the North Cow Creek system includes 43 diversion points along North Cow Creek, Cedar Creek and Mill Creek. A maximum of 33.67 cfs can be diverted from North Cow Creek and its tributaries at all times. The original and current diversion records for the Watermaster are summarized in Table 5-5. The diversions are shown on Figure 5-8.

The rights are divided into three classes: Cedar Creek Users, North Cow Creek Class A Users, and North Cow Creek Class B Users. Cedar Creek Users are entitled to continuous flow during the period between May 1st and October 30th of each year. During times of inadequate water supply, the users divide the available water supply in a ratio of their respective allotments. North Cow Creek Class A and Class B Users are entitled to continuous flow from North Cow Creek and its tributaries when the net available water supply is in excess of 28.60 cfs. A rotation schedule was set up for the North Cow Creek Class A and Class B Users during times when the net available water supply of North Cow Creek and its tributaries was less than 28.60 cfs. During odd weeks, the Class A Users could divert their maximum flow allotments, while the Class B Users could divert their minimum flow allotments. During even weeks, the Class B Users diverted their maximum allotments, while the Class A Users diverted their minimum allotments.

According to the Watermaster, this rotation schedule was abandoned in 1934, in favor of continuous flow. The continuous flow allotments for North Cow Creek are half the flow allotments provided by the original rotation allotment. Cedar Creek continuous flow amounts were not affected by the changes made to North Cow Creek allotments.

Oak Run Creek

Water rights on the Oak Run Creek system were established under Judgment and Decree 5701, dated July 22, 1932. A report prepared by the Division of Water Rights of the Department of Public Works of the State of California dated 1925, and the accompanying map "North Cow and Oak Run Creek Watersheds Showing Diversion Systems and Irrigated Areas" dated 1923, describe 23 diversions and the associated irrigated acreages.

At the present time, the Oak Run Creek System includes 12 diversion points along Oak Run Creek and individual springs and irrigates 404.9 acres, 130 acres of which is also irrigated by the Welch-Nailor Ditch from the Clover Creek System. Currently, a maximum of 6.31 cfs can be diverted from Oak Run Creek and its tributaries at all times. The original and current diversion records for the Watermaster are summarized in Table 5-6. The diversions are shown on Figure 5-8.

When the flow in Oak Run Creek is less than 5.40 cfs immediately above the Welch-Strayer intake, 43 percent shall be diverted into the ditch and 57 percent shall remain in Oak Run Creek. If the flow of Oak Run Creek below the Welch-Strayer intake is insufficient to provide the total supply of allotments, then the users below shall divide the water supply in ratios representative of their allotments.

The Welch-Strayer Ditch system consists of two diversions and ditches from two separate watershed areas. Initially, 3.0 cfs is diverted from Mill Creek, a tributary to North Cow Creek. This water is then transferred to Oak Run Creek. Originally, the Welch-Strayer Ditch carried the flow, but after a washout of the ditch, the Excelsior Ditch was enlarged to carry both its own 2.0 cfs and the 3.0 cfs from the Welch-Strayer Ditch. The North Cow Creek Decree allows for a loss of 0.7 cfs throughout the ditch, so 2.3 cfs is the flow that is actually transferred to Oak Run Creek. This 2.3 cfs is the allotment for the Welch-Strayer Diversion, described in the Oak Run Decree that serves 130 acres within the Oak Run Watershed. Additionally, a portion of 2.15 cfs (54.2 acres out of 71.8 total acres) diverted from Clover Creek through the Welch-Nailor Ditch also serves four of the same properties that receive water from the Welch-Strayer System.

Currently there is only one diversion on Oak Run Creek that is metered. The Watermaster has requested that all of the diversions on Oak Run Creek be metered.

Clover Creek

Water rights on the Clover Creek system were established under Judgment and Decree 6904, dated October 4, 1937. The diversion points and acreage irrigated described in the decree are depicted on two maps, one map referred to as the "Division of Water Rights Map," which was prepared by the Division of Water Rights of the Department of Public Works of the State of California from surveys it made in 1927, entitled, "Clover Creek Showing Diversion Systems and Irrigated Lands," dated 1927, and the other map prepared by the Division of Water Resources from a re-survey of the lands of Klinger, Hall and Fugitt in 1932.

The Clover Creek System includes 23 diversion points along Clover Creek, South Clover Creek, Silver Creek, Wyndam Creek, Slaughter Pole Creek and Rose Briar Creek and irrigates 917.8 acres. A maximum of 23.27 cfs can be diverted from Clover Creek and its tributaries during the period of May 1st to October 31st of each year for domestic, stock watering and irrigation purposes. At times when the net available water supply is inadequate to supply the combined allotments, the owners prorate the net available water supply in accordance with their net maximum allotments. The original and current diversion records for the Watermaster are summarized in Table 5-7. The diversions are shown on Figure 5-9.

Included in the decree is a schedule that establishes the maximum allotments to each of the ditches and users. In addition to the allotments described in the schedule, there are a few others that are summarized below.

The decree states that James Anderson is entitled to divert 10.0 cfs from Clover Creek through the Mill Ditch for power purposes at the Anderson Sawmill, except during irrigation season if the net available water supply is inadequate to supply the combined allotments, then he shall not divert any water for power purposes.

The decree also provides that five parties are allowed to divert the entire flow in the Anderson Swale, which receives waste and return flow from the Anderson Sawmill, J.B. Anderson irrigated lands, and the Fred Wheelock lands, for domestic, stock watering and irrigation purposes.

At any time that the amount of water received by William Stacher from the Anderson Swale is less than 0.6 cfs, he is entitled to divert supplemental flow from Wild Cat Creek.

Cow Creek System

Water rights on the Cow Creek system, including Old Cow Creek, South Cow Creek, Lower Cow Creek and the upper tributary areas of the Cow Creek system, were established under Decree No. 38577, dated August 25, 1969. The State Water Rights Board examined the creek system from December 1963 to February 1965 and mapped all the diversions and irrigated lands. The findings are presented in a report "Water Supply and Use of Water on Cow Creek Stream System" dated May 1965.

The report describes 116 diversions mapped within the system, 39 in the Old Cow Creek Watershed, 36 in the South Cow Creek Watershed, and 41 in the Lower Cow Creek Watershed. In 1965 the diversions irrigated approximately 5,800 acres, 2,750 acres in Old Cow Creek, 1,470 acres in South Cow Creek, and 1,580 acres in Lower Cow Creek. The diversions, allotments, use, irrigated acreage and owner(s) at the time of the decree are summarized on Table 5-8. The diversions are shown on Figure 5-8.

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The rights are divided into four separate groups designated as the Independent Tributary Group, the Old Cow Creek Group, the South Cow Creek Group and the Lower Cow Creek Group. The allotments in each group are broken into four priority classes, as well as a surplus class and a special class. The priority classes were established so that in the event of insufficient water supply, the available supply would be prorated in accordance with allotments in that priority class. No priority class is entitled to use water until all the rights with lower numbers have been supplied. Surplus class rights rank below third-class rights, but above fourth-class rights. These priority classes are summarized in Table 5-9.

TABLE 5-9
Group Priority Class Listing

Group	Priority Class					
	Special	First	Second	Third	Surplus	Fourth
Independent Tributary	10	42	12	5		147
Old Cow Creek		48	23	2	2	24
South Cow Creek		31	23	3	1	7
Lower Cow Creek		100	56	6	5	46

Allotments for irrigation are from March 1st to October 31st of each year. All allotments in the first priority class are for domestic and stock watering purposes. These first priority class claimants are entitled to the first priority class allotments during the non-irrigation season, from November 1st to March 1st.

The decree addresses special provisions regarding multi-user diversions, which include the South Cow Creek Ditch Association, the Brown-Grover Ditch, the Bassett Ditch, the Parker-Hufford Ditch and the Abbott Ditch.

Bypass or minimum flows are required under most adjudications. In addition, DFG section 5937 requires sufficient flows to maintain fish populations.

HYDROELECTRIC FACILITIES

Department of Fish and Game records indicate that eight hydroelectric facilities are located within the Cow Creek Watershed. These facilities are summarized in Table 5-10. The facilities owned by Pacific Gas and Electric (PG&E) on Old Cow Creek (Kilarc Powerhouse) and South Cow Creek are operated under one license.

The Kilarc Powerhouse, located north of Millville, is the oldest operating powerhouse maintained by PG&E. The Keswick Electric Company built the powerhouse in 1903 and 1904. At full capacity, it can generate 3.2 megawatts of electricity. The facility is named for oil manufactured by Westinghouse Company. PG&E has plans to transfer the Kilarc and South Cow generating facilities and approximately 2,218 acres of land associated with the Kilarc-Cow Creek project to a new owner. Eight hundred ninety acres of the land proposed for transfer is designated for timber production (TPZ).

CONCLUSION

The most complete hydrologic record is available for Station Number 11374000. This station is located on the main stem of Cow Creek, approximately three miles upstream from the confluence of the main stem and the Sacramento River. The drainage area contributing to this gage is approximately 425 square miles or 98 percent of the entire Cow Creek Watershed. This gage is commonly called the Millville Gage. Daily records are available for this gage from 1949 until present (USGS, 2001). Flow data for tributaries is limited.

The hydrologic conditions in the watershed have not changed significantly since 1950. The Mann-Kendall statistical procedure was used to determine if the annual mean and peak flow data have undergone an increasing or decreasing trend since 1950. The results show that there has not been a statistical upward or downward trend at the 99 percent confidence level.

The Cow Creek Watershed ranks third behind the Cottonwood Creek and Stony Creek watersheds for producing the largest peak flood flows within the northern Sacramento Valley (DWR, 1969). Of these watersheds, Cow Creek is the most northerly and the only one located on the east side of the Sacramento River. It has been estimated that flood flows from the Cow Creek Watershed account for approximately 21 percent of the peak discharge for the Sacramento River between Shasta Dam and Red Bluff (DWR, 1969).

The largest recorded flow along Cow Creek occurred on November 16, 1981. The estimated peak flow on this date was 48,700 cubic feet per second near the Millville Gage.

No pre-adjudication data are available to determine historic flows. Hydrologic data by tributary is not available. Where data is available, it is of short duration and not in necessary locations. No water budget is available for Cow Creek.

ACTION OPTIONS

1. Evaluate water conservation measures for existing diversions to increase stream flows.

2. Evaluate the possibility of augmenting stream flows by offsite storage and retention of winter flood flows to improve habitat for fish and wildlife.

3. Evaluate possibility of vegetation management to augment stream flows to improve habitat for fish and wildlife.

4. Obtain flow on tributaries to determine potential impacts.

5. Determine the impact of non-metering and lack of screens on diversions.

6. Determine how to improve water conditions for fish and other riparian obligate species.

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TABLE 5-5
North Cow Creek

Diversion No. (See Map Dated 1923)	Report on Water Supply and Use of Water from North Cow Creek and Tributaries (April 30, 1925)			Judgement & Decree 5804 (April 29, 1932)						Watermaster Records	
	Stream	Diversion Name	Total Irrigated Acres*	Total Irrigated Acres	Continuous Allotment (cfs)	Class A Allotment (cfs)	Class B Allotment (cfs)	Continuous Flow Distribution of A & B Classes	Owner	Current Allotment	Current Owner
1	Toldy Springs Channel	A.S. Patton South Ditch	54.6	86.2	0.85				Frisbie	1.46	McMillian, Finley
2	Toldy Springs Channel	A.S. Patton North Ditch	35								
3	Unnamed Spring	Patton Spring Ditch		4.9	0.15				Frisbie		
4	Cedar Creek	Bishop Ditch	8.4	9.1	0.50				Bishop	0.50	Ford, Elwood
5-6	Spring	Bishop Spring Ditch	2.7		Entire Flow				Bishop		
7-8-9	Cedar Creek	Erickson Ditch	24		Entire Flow				Erickson Div 8, 9		
10	Spring	Erickson Spring Pipeline	1.1		Entire Flow				Erickson		
11	North Fork North Cow Creek	Sam Roe Ditch	20.8	10.8		0.45		0.23	Red River Lumber	0.00	Transferred to McMillian, Finley
				10.0			0.45	0.23	Calkins		
12	North Cow Creek	Renbow Ditch	Acreage included under McCandless Ditch Diversion 34 and Johnson-Haley Diversion 31	26.6		1.25		0.63	Hansen	0.63	Rickert, J.D.
				34.4			1.25	0.63	Spaulding	0.504	Emerald, Robert
										0.063	Wright, John
										0.028	Williams, Leon
										0.014	Chappelaine, Dwight
										0.021	Williams, Leon
13 15	North Fork North Cow Creek & Spring Channel	Earl Patton Ditch	25.1	25.1			1.00	0.57	Plaetke	0.57	McMillian, Finley
14	Spring Channel	Earl Patton Spring Ditch	3.5		Entire Flow				Plaetke		
15	Spring	Earl Patton Feeder Ditch			Entire Flow				Plaetke		
16	Spring	Earl Patton House Spring Ditch	0.5		Entire Flow				Plaetke		
17-18-19	Unnamed Tributary to Middle Fork North Cow Creek	F.H. Kenyon Ditch	22.2								
20	Unnamed Spring Channel	F.H. Kenyon Upper Spring Ditch	2.9								
21	Unnamed Spring Channel	F.H. Kenyon Middle Spring Ditch	2.4								
22	Unnamed Spring Channel	F.H. Kenyon Lower Spring Ditch	2.4								
23	Spring Channel	Unnamed Spring Channel	Acreage included under F.H. Kenyon Ditch								
24	Middle Fork North Cow Creek	John Kenyon Ditch (Frisbie & Dozier)	9	10.1		0.60	0.60	0.60	Fassett	0.60	Roseburg Resources
25	Spring	Dozier-Frisbee-Turner Reservoir Spring	Acreage included under John Kenyon Ditch		Entire Flow				Fassett		
26	Spring	Dozier-Frisbee-Turner Garden Spring	1.1		Entire Flow				Fassett		
27	Spring	Frisbee House Spring			Entire Flow				Fassett		
28	North Cow Creek	Ellerkamp Ditch	1.5	1.5			0.25	0.13	Ellerkamp	0.13	Roseburg Resources
29	North Cow Creek	Pehrson-Grant-Strawn(Jones) Ditch	131	64.3		2.60		1.30	Pehrson	1.30	Greenslade, Gordon
				34.1			1.30	0.65	Grant	0.65	Hale, Elwein
				32.9			1.30	0.65	Jones	0.11	Stewart, Hugh
										0.54	Johnson, Edward
30											
31	Cedar Creek	Johnson(Spaulding)-Haley Ditch	63.3	32.6	1.30				Haley	1.30	Truthen, John
32	Cedar Creek	Halcumb Ditch	69.9	100	4.00				Bidwell	4.00	
33	Cedar Creek	Roe Ditch	7.1	7.1	0.30				Rowe	0.30	Smith, Marina
34	Cedar Creek	McCandless Ditch	10.8								
35	Haley Waste Water	Johnson Waste Water Ditch	3.7		Flow of 0.65 cfs allotted from return water (waste channel)				Spaulding		
36	Haley Waste Water Channel	McCandless Waste Water Ditch	17.6		Flow of 0.65 cfs allotted from return water (waste channel)				Hansen		
37	Spring	McCandless Upper Spring Ditch	12.2		Entire Flow				Hansen		
38	Spring	McCandless Lower Spring Ditch	3.5		Entire Flow				Hansen		
38	Haley-Johnson Waste Water Channel	Sub-irrigated (no ditch)	7.3								

TABLE 5-5
North Cow Creek

Diversion No. (See Map Dated 1923)	Report on Water Supply and Use of Water from North Cow Creek and Tributaries (April 30, 1925)			Judgement & Decree 5804 (April 29, 1932)						Watermaster Records	
	Stream	Diversion Name	Total Irrigated Acres*	Total Irrigated Acres	Continuous Allotment (cfs)	Class A Allotment (cfs)	Class B Allotment (cfs)	Continuous Flow Distribution of A & B Classes	Owner	Current Allotment	Current Owner
39	Cedar Creek	Pehrson Cedar Creek Ditch	3.6		Flow of 0.25 cfs from Cedar Creek from Tues-Weds				Pehrson		
40	Cedar Creek	Hadley Upper Ditch	17	20.8	0.80				Hadley	0.738	Miller, Jeffrey
41	Cedar Creek	Hadley Lower Ditch	3.8							0.062	Miller, Jeffrey R.
42	Cedar Creek	Smith Mountain Ditch	7.7								
43	Long Gulch & Cedar Creek	Smith Long Gulch Pipe	10.8								
44	Spring	Smith Spring Pipeline	0.4								
45	Mill Creek	Welch and Strayer Ditch System (see Oak Run Creek also)	130		1.00				Ross & Cox	1.00	Current Owners & Allotments are described in Oak Run Creek Schedule for Welch-Strayer System
					0.50				Ballard	0.50	
					0.50				Passons	0.50	
					0.50				Rice	0.50	
					0.50				English	0.50	
46-48	Springs				Entire Flow				Ross, Cox, Ballard, Passons, Rice, English		
49-50	Mill Creek & South Fork of Mill Creek	Excelsior Ditch	64.5		0.50				Rose	0.00	Transferred decreed 0.5 cfs to Cornelius
					0.50				Angle	0.458	Case, Donald
										0.10	Field, Herbert
										0.10	Sparks, R. & L.
										0.046	Stehar, Jeff
										0.046	Schmyer, William
					0.50				Thomas	0.75	Cornelius, John
					0.50				Maxwell & Phillips	0.50	Edwards, Philip
51-55	Springs	Excelsior Ditch			Entire Flow				Rose, Angle, Thomas, Maxwell, Phillips		
56	Spring Channel & Mill Creek	Webb Ditch	10								
57-58	Mill Creek (seepage)	Hawes Orchard Ditch	1.6								
59	Spring Channel	Hawes Upper Spreading Dam	0.6								
60	Rose Return Water Channel	Hawes Garden Ditch	1.2								
61	Rose Return Water Channel	Hawes Lower Spreading Dam	1.1								
62	Rose Return Water Channel	Hawes Short Garden Ditch	0.2								
63	Rose Return Water Channel	Hawes North Garden Ditch	0.3								
64	Rose Return Water Channel	Hawes South Garden Ditch	0.5								
65											
66											
67	Spring	Angle Spring Ditch	0.2		Entire Flow				Angle		
68	Included Under Excelsior Ditch	Maxwell Waste Water	0		Flow of 0.50 cfs allotted under 49-50				Maxwell, Phillips		
69	North Cow Creek	Phillips Mill Ditch	0.8		Flow of 7.50 allotted, but not currently monitored				Phillips		
70	North Cow Creek	Phillips Garden Ditch	0.3		Flow 0.25 allotted in decree, but only 0.13 cfs is currently monitored			0.13	Phillips	0.13	Lee, Monty
71	Unnamed Wash	Phillips Waste Ditch	0								
72	Spring	Strawn Maple Spring Ditch	Acreage included in Pehrson-Grant-Strawn Ditch		Entire Flow				Jones		
73	Spring	Strawn Alder Spring Ditch	0		Entire Flow				Jones		
74	Spring	Grant Spring Ditch	0.3		Entire Flow				Grant		
75	Pehrson-Grant-Strawn Ditch	Borquist Ditch	0		Flow of 1.30 cfs allotted under 29				Pehrson		

TABLE 5-5
North Cow Creek

Diversion No. (See Map Dated 1923)	Report on Water Supply and Use of Water from North Cow Creek and Tributaries (April 30 1925)			Judgement & Decree 5804 (April 29, 1932)						Watermaster Records	
	Stream	Diversion Name	Total Irrigated Acres*	Total Irrigated Acres	Continuous Allotment (cfs)	Class A Allotment (cfs)	Class B Allotment (cfs)	Continuous Flow Distribution of A & B Classes	Owner	Current Allotment	Current Owner
76	Springs	Pehrson Big Spring Ditch	Acreage included in Pehrson-Grant-Strawn Ditch		Entire Flow				Pehrson		
77	Springs	Pehrson Indian Spring Ditch									
78	Springs	Pehrson Lake Spring Ditch									
79	Springs	Pehrson Reservoir Spring Ditch									
80	Springs	Pehrson House Spring Ditch									
81	Dungan Gulch	Dungan Gulch Upper Ditch	5.2								
82	Dungan Gulch	Dungan House Pipeline	0.3								
83	Dungan Gulch	Dungan Gulch Main Ditch	24.2								
84	Unnamed Wash	Dungan Upper Unnamed Wash	2.9								
85	Unnamed Wash	Dungan Middle Unnamed Wash	0.9								
86	Unnamed Wash	Dungan Lower Unnamed Wash	0.9								
87	Spring	Dungan Little Valley Spring Ditch	1.9								
89	North Cow Creek	Bibbens Ditch		2.34			0.95	0.47	Baker	0.29	Henrich, Walter & Irene
										0.03	Kerns, Julius
										0.15	Humphrey, Richard
88	North Cow Creek	Eldridge Upper Ditch	54.5	83.1		3.20		1.60	Eldridge	1.60	Rutherford, Gary
90	North Cow Creek	Eldridge Lower Ditch	22.9								
91	North Cow Creek	Eldridge Island Ditch	1.7								
92	North Cow Creek	Eldridge House Ditch	1								
93-94	North Cow Creek	Hobson Upper Ditch	10.7	53.9		2.15		1.07	Hobson	0.03	Merlo, Ray
										0.91	Vail, R.
		Hobson Lower Ditch	43.2							0.06	Hafer, Leroy
										0.07	Cheek, Stephen
95-96	Springs	Hobson Orchard Springs	0.7		Entire Flow				Hobson		
97	Spring	Hobson House Pipeline	0.5		Entire Flow				Hobson		
98	Spring	Ward House Pipeline	0		Entire Flow				Ward		
99-100	North Cow Creek	Scoggins(Ward Upper) Ditch	13.4	62.5			2.50	1.25	Ward	0.18	Benavidez, Benjamin
										0.09	Hayes, David
		Ward Lower Ditch	46.1							0.41	Emerald, Robert
										0.49	Atkinson, Israel
										0.08	Payne, Lloyd
101	Included in Cook & Butcher Ditch Diversion 110	Red River Lumber Co. Flume	0								
102	North Cow Creek	Huffman Ditch	14.6	14.6			0.60	0.30	Asher	0.30	Peterson, Stanley
103	Spring	Asher House Pipeline	0		Entire Flow				Asher		
104	North Cow Creek	Afterthought Mine Pump	0		0.04			0.04	California Zinc Co.	0.57	Cow Creek Land Co.
105	North Cow Creek	Afterthought Mine Pump	0		0.55			0.55	California Zinc Co.		
106	North Cow Creek	Wisey Ditch	52.1	45.2		1.80		0.90	Wisey	0.90	Rickert, J.D.
107	North Cow Creek	Woodman Ditch	107.2	53.6		2.40	2.40	2.40	Lemm	2.40	Rickert, Warren, etal
108	Slough	G. Rutherford Slough Pump	2.8	3.5		0.15		0.15	G. Rutherford	0.15	Lorenz, K.
				3.4			0.15				
109	North Cow Creek	John Rutherford Pump	18.8	9.4		0.40	0.40	0.37	J. Rutherford	0.27	Lorenz, K.
										0.10	Matthews, Earl
109A	North Cow Creek	Lemm Pump				0.20		0.10	Lemm	0.05	Duralia, George
										0.05	Richelieu, R.W.
110	North Cow Creek	Cook and Butcher Ditch	208.1	209.9		1.875	1.875	1.87	Red River Lumber	1.87	Meyer, Thelma
						0.375	0.375	0.37	Lofton	0.08	Brown, Scott
						0.375	0.375	0.37	Chatham	0.75	Chatham, G.
						0.75	0.75	0.75	Kozum	0.56	Wooten, Shannon
										0.09	Jones, Armour
										0.09	Rogers, John & Phyllis
										0.19	Jochim, Carl
										0.56	Pike Company
						0.75	0.75	0.75	Olson	0.57	Stone, Frank
						0.375	0.375	0.37	Sharp	0.00	Transferred to others
110A	North Cow Creek	Melton Pump				0.02	0.02	0.02	Melton, Cal Zinc	0.02	Williams, Estelle
										0.02	Bland, Delores
111	North Cow Creek	Gray Ditch	11.7	9.9		0.40	0.40	0.40	Redding Savings Bank	0.40	Rickert, J.D.
112	North Cow Creek	Gray Upper Pump	5	9.8							
113	North Cow Creek	Gray Lower(Anderson) Pump	2.4	2.4			0.10	0.05	Anderson	0.013	Lane, Carole
										0.013	Copeland, James
										0.012	Poulsen, Don
										0.012	Smurzynski, Chester

TABLE 5-5
North Cow Creek

Diversion No. (See Map Dated 1923)	Report on Water Supply and Use of Water from North Cow Creek and Tributaries (April 30, 1925)			Judgement & Decree 5804 (April 29, 1932)						Watermaster Records	
	Stream	Diversion Name	Total Irrigated Acres*	Total Irrigated Acres	Continuous Alotment (cfs)	Class A Alotment (cfs)	Class B Alotment (cfs)	Continuous Flow Distribution of A & B Classes	Owner	Current Allotment	Current Owner
114	North Cow Creek	Boyle Pump Ditch	12.2	12.2			0.50	0.25	Boyle	0.25	Phillips, Robert
115	North Cow Creek	Bogue Pump Ditch	11.1	11.1			0.45	0.23	Bogue & Hunt	0.115	Roley, Robert
										0.115	Rawlings, Emily
116	North Cow Creek	Butzbach Pump Ditch	15.5	15.5			0.60	0.30	Butzbach	0.3	Rutherford, Gary
				Totals:	13.49			20.88		33.67	

* Includes irrigated and sub-irrigated acres

TABLE 5-6
Oak Run Creek

Diversion No. (See Map Dated 1923)	Report on Water Supply and Use of Water from Oak Run Creek and Tributaries (April 30, 1925)			Judgement & Decree 5701 (July 22, 1932)		Watermaster Records	
	Stream	Diversion Name	Total Irrigated Acres*	Allotment (cfs)	Owner	Current Allotment	Current Owner
1	Oak Run Creek	Rose Domestic Pipeline	Used for domestic purposes				
2	Unnamed Wash	Jackson Ditch	2.6				
3	Oak Run Creek	Jackson Ditch					
4	Spring	Smith Upper Spring Ditch	31.2				
5	Oak Run Creek	Maxwell Mill Ditch	Used for power and other purposes at Maxwell Mill				
6	Spring	Smith Lower Spring Ditch	18.3				
7	Spring	Maxwell Sawdust Flume	Used for power and other purposes at Maxwell Mill				
8	Spring	Maxwell Spring Ditch	0.6				
9	Oak Run & Clover Creeks	Welch & Strayer Ditch System	130	0.3335	Ross & Rice	0.40	Mitchell, Lloyd
						0.10	Gilkey, John
				0.383	Ballard	0.50	Wendt, Bruce
				0.383	Ensley	0.24	Volbrecht Family Trust
				0.7165	Rice	0.50	Anderson, Eugene
				0.383	English	1.00	Snider, R.E.
				0.10	McCarty	0.10	Anderson, Eugene
10	Oak Run Creek	Melton Upper Ditch	5.4	0.25	Melton	0.25	Strawn, Gerald
11	Oak Run Creek	Melton Lower Ditch	0.8				
12	Oak Run Creek	Melton South Ditch	1.5				
13	Oak Run Creek	Alpaugh Ditch	22.8	0.40	Melton	0.05	Strawn, H.R.
14	Oak Run Creek	Predmore Ditch	90.8	1.80	Murphy & Cook	1.25	Strawn, Merrick
						0.90	Hageman, Robert
15	Oak Run Creek	Kirkendahl Ditch	31.5	0.65	Colby	0.65	Treise, Rose
16	Unnamed Swale	Kirkendahl Ditch					
17	Spring	Murphy Spring Ditch	8.7	0.25	Murphy		
18	Murphy-Estep Branch of Oak Run Creek	Murphy Slough Ditch					
19	Murphy-Estep Branch of Oak Run Creek	Estep Ditch	39.2				
20	Spring	Estep Domestic Pipeline	Used for domestic purposes				
20	Spring	Estep Calf Pasture Spring	1.6				
21	Oak Run Creek	Winters Ditch	18.4	0.37	Darrah	0.37	Snider, R.E.
22	Spring	Winters Spring Ditch	1.5	0.025			
23	Unnamed Gulch	English House Ditch	Acreage included under Welch Strayer Ditch System				
* includes irrigated and sub-irrigated acres		Totals:	404.9	6.044		6.31	

TABLE 5-7
Clover Creek

Diversion No. (See Map Dated 1923)	Judgement & Decree 6904 (October 4, 1937)					Watermaster Records	
	Stream	Diversion Name	Total Irrigated Acres	Allotment (cfs)	Owner	Current Allotment	Current Owner
	Clover Creek	Anderson Sawmill - discharging to Anderson Swale		10.00	Anderson		
	Return flow from Anderson Sawmill, J.B. Anderson irrigated lands, Fred Wheelock irrigated lands	Mill Ditch System - West		1/4	Klinger		
		Mill Ditch System - West		1/4	Hall & Fugitt		
		Mill Ditch System - South		1/6	Sheridan		
		Mill Ditch System - South		1/6	Sheridan, E., A., J., M.		
		Mill Ditch System - South		1/6	Stacher		
	Wild Cat Creek	Wild Cat Ditch		Entire Flow	Stacher		
1	Silver Creek	Worley Ditch	79.00	2.00	Worley	2.00	Collins, Jack
2	Clover Creek	Guttman Ditch	23.50	1.85	Ray	1.00	Cole, Stephen
			24.90		Thomas	0.85	Whitney Ranch
			5.20		Hall & Fugitt		
3	Clover Creek	Bonde Ditch	48.00	2.45	Hall & Fugitt	0.66	Carrington, Francis
			2.00		Weigart	0.49	Collins, Jack
			34.70		Lysinger	0.65	Lindsay, C.W.
			21.30		Love	0.65	Easley, Gale
4	Clover Creek	Mill Ditch	9.00	4.80	Wright	0.14	Burham, Paul
						0.26	Koher, Ted
			30.90		Anderson	1.20	Carrington, Francis
			6.60		Burdick	0.276	Swain, A.
						0.012	Frisbie, Ray
						0.012	Murphy, Martin
			36.60		Wheelock	1.50	Carrington, Francis
			69.30		Klinder	0.60	Carrington, Francis
			10.10		Sheridan	0.27	Mazzotta, J.A.
			21.30		Sheridan, E., A., J., M.	0.135	Pollard, R.
						0.067	Wahl, Kenneth
						0.068	Struckman, Glenn
			25.50		Stacher	0.24	Mazzotta, J.A.
						0.013	Harr, Randall
5	Clover Creek	Rodgers Ditch	6.20	0.25	Weigart	0.25	Collins, Jack
6	Wyndam Creek	Maxwell Ditch	16.80	0.35	Maxwell	0.066	Ross, D.R.
						0.175	Bailey, R.M.
						0.022	Ross, D.R.
						0.087	Danielson, J.
9	Clover Creek	Welch and Nailor Ditch	16.10	2.15	Axner	0.36	Axner, P.C.
						0.36	Murphy, Preston
			1.50		Ide	0.24	Wendt, B.
			30.00		English	0.24	Medica, Thomas
			13.80		Ensley	0.24	Volbrecht Family Trust
			10.40		Rice	0.36	Anderson Family Trust
					Passons	0.34	Snider, R.E.
10	Clover Creek	Yordy Upper Ditch	12.10	0.40	Yordy	0.40	This right has not been under watermaster service since 1954
11	Clover Creek	Yordy Lower Ditch					

TABLE 5-7
Clover Creek

Diversion No. (See Map Dated 1923)	Judgement & Decree 6904 (October 4, 1937)					Watermaster Records	
	Stream	Diversion Name	Total Irrigated Acres	Allotment (cfs)	Owner	Current Allotment	Current Owner
12	Clover Creek	Hufford Upper Ditch	23.70	0.70	Reineke	0.70	Cilar, Chad
13	Clover Creek	Hufford Lower Ditch					
22	South Clover Creek	Reineke South Clover Ditch	57.10	1.40		1.40	
23	Clover Creek	Reineke Clover Ditch					
15	South Clover Creek	Covey Ditch	6.70	0.25	Covey	0.25	Mazzolta, J.A.
16	South Clover Creek	Harper Ditch	11.60	0.25	Harper	0.25	
17&18	South Clover Creek	Hunt Ditch	4.90	0.40	Hunt	0.40	
19	Slaughter Pole Creek	Slaughter Pole Ditch	14.50	0.40	Stacher	0.40	
20	South Clover Creek	Rice South Clover Ditch	1.30	0.15	Rice	0.15	
21	Rose Briar Creek	Rose Briar Ditch	27.40	0.70	Rice	0.70	
24	Clover Creek	Webb Ditch	9.10	0.35	Hunt	0.35	Ladd, Roy
25	Clover Creek	Hereford Pump	0.10	0.02	Hufford	0.02	Moseman (McArthur)
26	Clover Creek	Millville Ditch	206.60	4.40	Millville Ditch Company	4.40	Millville Ditch Company
		Totals:	917.80	23.27		23.25	

TABLE 5-8
Cow Creek Adjudication Decree 38577 August 25, 1969

Old Cow Creek, South Cow Creek, Lower Cow Creek, Upper Tributary Area of Cow Creek System

Diversion No.	Stream	Diversion Name	Irrigated Acres	Allotment						Use	Owner
				Special	1	2	3	Surplus	4		
Unnamed	Old Cow Creek	Unnamed	19.3		See Paragraph 14				0.48	irrigation	Schmitt, James
1	Upper Tributary	Latour Spring No. 1	Parcel 47		0.01	0.04				industrial	Shasta Forests Co.
1b	Upper Tributary	CDF	Parcel 2		0.01				0.16	industrial	CDF
1d	Upper Tributary	CDF	Parcel 6		0.01					domestic	CDF
2	Canyon Creek	Kimberly-Clark	Parcel 4		0.01	0.35				industrial	Kimberly-Clark Corporation
3	Old Cow Creek	Kilarc Powerhouse Ditch					58.00			power	PG&E
4	Canyon Creek	West Canyon Creek Ditch					2.50			power	PG&E
4c	Canyon Creek	East Canyon Creek Ditch					7.50			power	PG&E
5	Canyon Creek	Murphy Ditch	269.8		0.01	1.50				irrigation	Murphy, Richard & Eva
5a	Upper Tributary	Murphy Ditch from Farsland Springs	see div 5	Entire Flow						irrigation	Murphy, Richard & Eva
5b	Upper Tributary	Murphy Ditch from Unnamed Springs	see div 5	Entire Flow						irrigation	Murphy, Richard & Eva
6	Old Cow Creek	Grindlay Williams Ditch	3.2		0.01	0.10				irrigation	Albert, Vertzel & Mable
6	Old Cow Creek	Grindlay Williams Ditch	56		0.01	2.44				irrigation	Herring, Virgil & Evelyn; Collins, Richard & Mary
6	Old Cow Creek	Grindlay Williams Ditch	4.6		0.01	0.12				irrigation	Hutchins, William & Mary Jane
6	Old Cow Creek	Grindlay Williams Ditch	1.2		0.01	0.03				irrigation	Skipworth, Henry & Edna
6	Old Cow Creek	Grindlay Williams Ditch	25.8		0.01	0.99				irrigation	Williams, Wallace
			25						0.63	irrigation	
7	Old Cow Creek	MacMillian Spring	1.5		0.01	0.04				irrigation	MacMillian, Emma
8	Upper Tributary	Murphy Upper Springs	see div 5	Entire Flow						irrigation	Murphy, Richard & Eva
9 & 9a	Upper Tributary	Murphy Lower Springs	see div 5	Entire Flow							
9b	Upper Tributary	Murphy Lower Springs	see div 5	Entire Flow							
10	Old Cow Creek	Kilarc Domestic Spring			0.01					domestic	PG&E
11	Old Cow Creek	Williams Lower Ditch	82.1		0.01	2.26				irrigation	Williams, Wallace
			5.6			0.14				irrigation	
12s	Spring Creek	Shasta Forests Co.	Parcel 32		0.05				0.06	domestic & industrial	Shasta Forests Co.
12	Old Cow Creek	Grindlay Upper Glendenning Ditch	34		0.01	0.85				irrigation	Herring, Virgil & Evelyn; Collins, Richard & Mary
			80						2.00	irrigation	
13	Old Cow Creek	Grindlay Lower Glendenning Ditch	9.8		0.01	0.24				irrigation	
14	Old Cow Creek	Grindlay South Glendenning Ditch	50						1.25	irrigation	
15	Upper Tributary	Scott Spring	7.4	Entire Flow						irrigation	Scott, C. Emlen
16	Old Cow Creek	Neely Glendenning Creek Ditch	10		0.01	0.33				irrigation	Brink, M.W. & Grace Baptist Church
			295						7.50	irrigation	
17	Upper Tributary	Neely Spring	9.2	Entire Flow						irrigation	Brink, M.W.
18	Old Cow Creek	Owbridge East Ditch	86					1.18		irrigation	Couser, Ralph & Helen
19	Old Cow Creek	Dargatz Spring			0.01					domestic & stock watering	Herring, Virgil & Evelyn; Collins, Richard & Mary

TABLE 5-8
Cow Creek Adjudication Decree 38577 August 25, 1969

Old Cow Creek, South Cow Creek, Lower Cow Creek, Upper Tributary Area of Cow Creek System

Diversion No.	Stream	Diversion Name	Irrigated Acres	Allotment						Use	Owner
				Special	1	2	3	Surplus	4		
19	Old Cow Creek	Dargatz Spring	15.8		0.01	0.40					Dargatz, Oliver; Sanford, Fern & Lee, Opal
			24.2						0.61		
20 21 22 23	Old Cow Creek	Owbridge Ditches	26.4		0.01	0.67				irrigation	Couser, Ralph & Helen
24	Old Cow Creek	Atkins Ash Creek Ditch	7					0.19		irrigation	Boksa, Demeter & Aurelia
24	Old Cow Creek	Atkins Ash Creek Ditch	4		0.01	0.15				irrigation	Atkins, Leary
			10						0.25		
25	Old Cow Creek	Atkins Upper Spring	50.8		0.01	1.28				irrigation	
			7.9						0.20		
26	Old Cow Creek	Atkins Lower Spring	16.4		0.01	0.41				irrigation	
			15						0.38		
27	Upper Tributary	Atkins Domestic Spring		Entire Flow						domestic	Atkins, Leary
28	Old Cow Creek	Brown Grover	23.4		0.01	1.16				irrigation	Atkins, Leary
28	Old Cow Creek	Brown Grover	199		0.01	4.66				irrigation	Brower, Lowell & Vietta
28	Old Cow Creek	Brown Grover	169		0.01	4.66				irrigation	Gilbert, Roxie
28	Old Cow Creek	Brown Grover	60.7		0.01	1.16				irrigation	Peterson, Charlie & Corrine
28	Old Cow Creek	Brown Grover	128		0.01	2.32				irrigation	Stevenson, George & Jeanette
Unnamed	Old Cow Creek	Unnamed	21	drainage water from Brewer Ranch			1.10			irrigation	Dymesich, George
Unnamed	Old Cow Creek	Unnamed	8.3	drainage water from Brewer Ranch						irrigation	Schmitt, James
Unnamed	Old Cow Creek	Unnamed	1.7	drainage water from Atkins Lands						irrigation	Shaw, Charles & Joy
29	Old Cow Creek	Koehler	37.5		0.01	2.06				irrigation	Koehler, Roderick
			13						0.33	irrigation	
30	Coal Gulch, Tribs & Springs	Peterson Dam	24		0.01		0.60			irrigation	Peterson, Charlie & Corrine
			33						0.83	irrigation	
31	Old Cow Creek	Parker Hufford Ditch	87.5		0.01	2.77				irrigation	Parker, James & Margaret
31	Old Cow Creek	Parker Hufford Ditch	135 58.2		0.01	2.77				irrigation	Carter, Martin & Helen
31	Old Cow Creek	Parker Hufford Ditch	5.6		0.01	2.76				irrigation	Koehler, Roderick
31	Old Cow Creek	Parker Hufford Ditch	0.1			0.01				irrigation	Weaver, Paul
31	Old Cow Creek	Parker Hufford Ditch	12.3			0.44				irrigation	Riggio, Steve
31	Old Cow Creek	Parker Hufford Ditch	40.9		0.01	2.33				irrigation	Dymesich, George
Unnamed	Old Cow Creek	Unnamed	18						0.45	irrigation	
Unnamed	Old Cow Creek	Unnamed	29.6						0.75	irrigation	
Unnamed	Old Cow Creek	Unnamed	64						1.60	irrigation	
32	Fern Spring	Plath Pipeline	10		0.01				0.25	irrigation	Nolan, Thomas & Wanda
33 34	Fern Spring Fern Spring	Bogue Pipeline Bogue Reservoirs	31.3		0.01	0.78				irrigation	Bogue, H.E. & Phyllis
35	Old Cow Creek	Parker Ditch	12.7		0.01	0.75				irrigation	Parker, James & Margaret
36	Old Cow Creek	Bassett Ditch	22.4		0.01	2.31				irrigation	Dymesich, George
36	Old Cow Creek	Bassett Ditch	6.8		0.01	0.43				irrigation	Riggio, Steve
Unnamed	Old Cow Creek	Unnamed	18.7						0.47	irrigation	

TABLE 5-8
Cow Creek Adjudication Decree 38577 August 25, 1969

Old Cow Creek, South Cow Creek, Lower Cow Creek, Upper Tributary Area of Cow Creek System

Diversion No.	Stream	Diversion Name	Irrigated Acres	Allotment						Use	Owner
				Special	1	2	3	Surplus	4		
36	Old Cow Creek	Bassett Ditch	50 30.8 229.6		0.01	8.27				irrigation	Carter, Martin & Helen
36	Old Cow Creek	Bassett Ditch	266.3 370.7		0.01	16.56				irrigation	Crowe Hereford Ranch
37	Old Cow Creek	Crowe Lower Ditch	133		0.01	7.74				irrigation	
38	Basin Hollow Creek	Crowe Pump			0.01					domestic	Crowe Hereford Ranch
39	Old Cow Creek	Crowe Reservoir Ditch			0.01					domestic & stock watering	Crowe Hereford Ranch
40	Upper Tributary - South Cow Creek	Location 2	Parcel 1		0.01				0.04	industrial	CDF
40a	Upper Tributary - South Cow Creek	Location 9	Parcel 1		0.01				0.10	industrial	CDF
40b	Upper Tributary - South Cow Creek	Location 8	Parcel 1		0.01				0.14	industrial	CDF
40c	Upper Tributary - South Cow Creek	Location 13	Parcel 1		0.01				0.14	industrial	CDF
40d	Upper Tributary - South Cow Creek	Location 3	Parcel 1		0.01				0.15	industrial	CDF
40e	Upper Tributary - South Cow Creek	Location 10	Parcel 1		0.01				0.14	industrial	CDF
40g	Upper Tributary - South Cow Creek	Location 11	Parcel 1		0.01				0.10	industrial	CDF
40j	Upper Tributary - South Cow Creek	Location 14	Parcel 1		0.01				0.14	industrial	CDF
40k	Upper Tributary - South Cow Creek	Location 12	Parcel 1		0.01				0.10	industrial	CDF
41a	Upper Tributary - South Cow Creek	Location 7	Parcel 1		0.01				0.15	industrial	CDF
41	South Cow Creek	Beal Spring	8.4			0.13				irrigation	Scott Lumber Co.
41	Upper Tributary - South Cow Creek	Beal Spring	Parcel 1						0.16	industrial	Scott Lumber Co.
42	South Cow Creek	Beal Creek Ditch	10		0.01	0.52				irrigation	Faber, Darrell & Hazel
42	South Cow Creek	Beal Creek Ditch	41.4		0.01	3.01				irrigation	Morelli, Virginia
43	South Cow Creek	German Ditch	29.4			0.74	See Paragraph 23			irrigation	Brady, Jack & Ruth
43	South Cow Creek & Upper Tributary	German Ditch					See Paragraph 23			domestic & industrial	CDF
43	South Cow Creek	German Ditch			0.06		See Paragraph 23			domestic	Chellis, Mary
43	South Cow Creek	German Ditch			0.03		See Paragraph 23			domestic	Combs, Leslie & Ellen
43	South Cow Creek	German Ditch	4.2				See Paragraph 23			irrigation	Cook, Roger & Turk, Ellen
43	South Cow Creek	German Ditch	2			0.03	See Paragraph 23			irrigation	Gibson, Laine & Patricia
43	South Cow Creek	German Ditch			0.03		See Paragraph 23			domestic	Knight, Remi

TABLE 5-8
Cow Creek Adjudication Decree 38577 August 25, 1969

Old Cow Creek, South Cow Creek, Lower Cow Creek, Upper Tributary Area of Cow Creek System

Diversion No.	Stream	Diversion Name	Irrigated Acres	Allotment						Use	Owner
				Special	1	2	3	Surplus	4		
43	South Cow Creek	German Ditch	37			0.74	See Paragraph 23			irrigation	McTimmonds, Guy & Patricia
43	South Cow Creek	German Ditch	24.8			1.18	See Paragraph 23			irrigation	Miller, C.E.; Weller, Edward & Lucille
43	South Cow Creek	German Ditch	2.6			0.06	See Paragraph 23			irrigation	Mix, Robert
43	South Cow Creek	German Ditch	64.2			1.21	See Paragraph 23			irrigation	Reimer, George & Dorothy
43	South Cow Creek	German Ditch	4			0.06	See Paragraph 23			irrigation	Rynd, Donald & Shelly
43	South Cow Creek	German Ditch			0.03		See Paragraph 23			domestic	Linhart, Russel & Mary
43	South Cow Creek	German Ditch	142.2			7.37	See Paragraph 23			irrigation	Shasta Forests Co.
43	South Cow Creek	German Ditch	7			0.15	See Paragraph 23			irrigation	Weir, Frank
43	South Cow Creek	German Ditch	17.9			0.59	See Paragraph 23			irrigation	Wiley, Marvin
43	South Cow Creek	German Ditch				1.44	See Paragraph 23			power	PG&E
43a	Upper Tributary	McTimmonds Ditch	37	Entire Flow						irrigation	McTimmonds, Guy & Patricia
44	Atkins Creek	Hufford Knight Ditch				0.62				power	Knight, Remi
44	Atkins Creek	Hufford Knight Ditch	17		0.01	1.01				irrigation	Hufford, Elmer & Christine
44	Atkins Creek	Hufford Knight Ditch	58.2		0.01	1.85				irrigation	Knight, Remi
44a	Upper Tributary - Atkins Creek	Location 5	Parcel 5		0.01					domestic	CDF
44f	Upper Tributary - Atkins Creek	Location 6	Parcel 4		0.01				0.14	industrial	CDF
45	Atkins Creek	Atkins Mill Ditch	8		0.01	0.40				irrigation	Hufford, Elmer & Christine
45	Atkins Creek	Atkins Mill Ditch	31.7			1.19				irrigation	Knight, Remi
46	Atkins Creek	Knight South Ditch	5		0.01	0.13				irrigation	Knight, Remi
47	South Cow Creek	Worden Ditch	74.8		0.01	2.30				power & irrigation	Shaver Investment Corp.
			128.2						3.21		
						2.10				power	
48	Hagaman Gulch	Hagaman Gulch Ditch	see div 42		0.01	1.60				irrigation	Morelli, Virginia
49	South Cow Creek	Morelli-Carr Ditch	46.8		0.01	1.33				irrigation	Morelli, Virginia
49	South Cow Creek	Morelli-Carr Ditch	22.2		0.02	0.74				irrigation	Smith, Donald & Thelma
50	Hamp Creek	Upper Harp Creek Ditch	see div 42		0.01	1.00				irrigation	Morelli, Virginia
51	Hamp Creek	Lower Harp Creek Ditch	43.9		0.01	1.30				irrigation	Morelli, Virginia
52	South Cow Creek	Morelli Domestic Spring	2		0.01	0.03				irrigation	Morelli, Virginia
53	South Cow Creek	Lansing South Ditch	75.9		0.01	2.46				irrigation	Smith, Donald & Thelma
			24.9				0.62			irrigation	
			20.9					0.52		irrigation	
54	South Cow Creek	Rose Ditch	2.4		0.01	0.09				irrigation	Smith, Donald & Thelma
55	South Cow Creek	Lansing North Ditch	50.2		0.01	1.82				irrigation	Smith, Donald & Thelma
56	South Cow Creek	Rose Domestic Spring			0.01					domestic & stock watering	Smith, Donald & Thelma
57	South Cow Creek	Carr Stockwater		included under diversion 49							Smith, Donald & Thelma
58	South Cow Creek	Carr Domestic Pump									Smith, Donald & Thelma

TABLE 5-8
Cow Creek Adjudication Decree 38577 August 25, 1969

Old Cow Creek, South Cow Creek, Lower Cow Creek, Upper Tributary Area of Cow Creek System

Diversion No.	Stream	Diversion Name	Irrigated Acres	Allotment						Use	Owner
				Special	1	2	3	Surplus	4		
59	South Cow Creek	Lansing Domestic Spring			0.01					domestic & stock watering	Smith, Donald & Thelma
60	South Cow Creek	E. Hufford Ditch	133		0.01	3.98				irrigation	Hufford, Elmer & Christine
			40						1.00	irrigation	
61	South Cow Creek	Roland Staiger Ditch	59.2		0.01	1.67				irrigation	Sorensen, George & June
61	South Cow Creek	Roland Staiger Ditch	33.6		0.01	1.86				irrigation	Staiger, J. Dana & Bon
			6.4						0.16	irrigation	
62	South Cow Creek	E. Hufford Domestic Spring			0.02					domestic	Hufford, Elmer & Christine
63	South Cow Creek	Staiger Pump									Staiger, J. Dana & Bon
64	South Cow Creek	South Cow Creek Powerhouse Ditch			0.01		47.90	See Paragraph 23		power	PG&E
65	Old Cow Creek	Neely Bear Gulch Ditch	24.5		0.01	0.61				irrigation	Brink, M.W.
			79.9						2.00	irrigation	
66	Old Cow Creek	Cook and Turk	4.2	See Paragraph 23						irrigation	Cook, Roger & Turk, Ellen
67	Covey North Springs	Covey North Springs	3.6		0.01	0.09				irrigation	Covey, Harry & Colleen
68	Covey Main Spring	Covey Main Spring									
67	Covey North Springs	Covey North Springs	14.8		0.01	0.37				irrigation	Covey, Myrtle
68	Covey Main Spring	Covey Main Spring									
67	Covey North Springs	Covey North Springs	20		0.01	0.50				irrigation	Donohue, Paul & Doris
68	Covey Main Spring	Covey Main Spring									
68	Covey Main Spring	Covey Main Spring	7.2		0.01	0.18				irrigation	Atkins, Roy
			10						0.25	irrigation	
69	Covey Creek	Covey Creek Ditch	6.6		0.01	0.17				irrigation	Jungster, Henry & Elizabeth
69a	Covey Creek	Jungsten Ditch	6		0.01				0.15		
70	South Cow Creek	Bullard Pump	2		0.01	0.05				irrigation	Bullard, Harry & Frona
			35						0.88	irrigation	
71	Mill Creek	Mill Creek Ditch					12.10			power	PG&E
72	South Cow Creek	Wagoner Ditch	3.7		0.01	0.26				irrigation	Wagoner, W.G.
			33						0.83	irrigation	
73	Lower Cow Creek	Abbott Ditch	82.9		0.01	1.51				irrigation	Hunt, W.H. Estate
			27.2						1.05	irrigation	
73	Lower Cow Creek	Abbott Ditch	96		0.01	6.03				irrigation	Abbott, Alan & Blanche
73	Lower Cow Creek	Abbott Ditch	79.8		0.01	3.02				irrigation	Farrell, Virgil & Henrietta
73	Lower Cow Creek	Abbott Ditch	13.4		0.01	0.75				irrigation	Jones, Jesse
73	Lower Cow Creek	Abbott Ditch	14.6		0.01	0.75				irrigation	Jones, Velma
Unnamed	Lower Cow Creek	Unnamed	102	See Paragraph 14					2.55	irrigation	Abbott, Alan & Blanche
Unnamed	Lower Cow Creek	Unnamed	24	See Paragraph 14					0.60	irrigation	Farrell, Virgil & Henrietta
Unnamed	Lower Cow Creek	Unnamed	12.5	See Paragraph 14					0.31	irrigation	Jones, Jesse
Unnamed	Lower Cow Creek	Unnamed	6	See Paragraph 14					0.15	irrigation	Jones, Velma
74	Lower Cow Creek	Jennie Hufford Pump	0.5		0.01	0.01				irrigation	Hufford, Jennie
			57						1.43	irrigation	
75	Lower Cow Creek	Hunt Pump	33		0.01	0.55				irrigation	Hunt, W.H. Estate

TABLE 5-8
Cow Creek Adjudication Decree 38577 August 25, 1969

Old Cow Creek, South Cow Creek, Lower Cow Creek, Upper Tributary Area of Cow Creek System

Diversion No.	Stream	Diversion Name	Irrigated Acres	Allotment						Use	Owner
				Special	1	2	3	Surplus	4		
76	Lower Cow Creek	Espinosa Pumps	48.7		0.01	0.61				irrigation	Espinosa, Harold & Virginia
			22.2				0.37			irrigation	
77	Lower Cow Creek	Roberts Pump	5		0.01				0.08	irrigation	Roberts, David & Bonnie
78	Lower Cow Creek	Hall South Pump	29.6		0.01	0.40				irrigation	Hall, Jura Lawrence
			40						1.00	irrigation	
79	Lower Cow Creek	Hall North Pump	25		0.01	0.33				irrigation	Hall, Jura Lawrence
			25						0.42	irrigation	
80	Lower Cow Creek	J. Hufford Pump	41.4		0.01	0.69				irrigation	Hufford, Jesse
			52					0.87		irrigation	
81	Lower Cow Creek	Lynes Pump	39.1		0.01	0.66				irrigation	Lynes, Ronald & Vivian
			99.4						1.67	irrigation	
82	Lower Cow Creek	Wetzel Pump	15		0.01	0.19				irrigation	Parker, Stanley
83	Lower Cow Creek	Meinsken Pump	2		0.01	0.03				irrigation	Roesner, Elmer
84	Lower Cow Creek	Blomquist Pump	36.3		0.01	0.45				irrigation	Blomquist, Theodore
85	Lower Cow Creek	Bishop Pump	0.3		0.01	0.01				irrigation	Bishop, Jack & Thelma
			7.7						0.13	irrigation	
86	Lower Cow Creek	Junkans South Pump	29		0.01	0.49				irrigation	Junkans, Elmer
87	Lower Cow Creek	Junkans North Pump	40.6		0.01	0.51				irrigation	
88											
89											
90	Lower Cow Creek	Tuttle Pump	117.6		0.01	1.93				irrigation	Tuttle, Carl & Vivian
91	Lower Cow Creek	Shefelberger Pump	98.6		0.01	1.64				irrigation	Shufelberger, etal
92	Lower Cow Creek	Schulz Pump	31.4		0.01	0.52				irrigation	Schulz, Walter & Mary
93	Lower Cow Creek	Frisbie Pump	19		0.01	0.32				irrigation	Nichols, Jodie & Anna
94	Lower Cow Creek	Otten Pump	23		0.01	0.29				irrigation	Otten, Alex & Esther
			17						0.28	irrigation	
95	Lower Cow Creek	Leggett Pump	56.8		0.01	0.95				irrigation	Leggett, Howard & Gladys
			18						0.30	irrigation	
95 & 95d	Lower Cow Creek	Leggett	78					1.3		irrigation	Leggett, Howard & Gladys
96	Lower Cow Creek	Fraley North Pump	54.6		0.01	0.91				irrigation	Fraley, Harold & Esther
			48.4						0.81	irrigation	
97	Unnamed Stream Tributary to Lower Cow Creek	Dicker Reservoir	1					25 afa		irrigation stockwater recreation	Emerald, Robert & Nadine
98	Lower Cow Creek	Harris Pump	1		0.01	0.02				irrigation	Harris, John & Fannie
			2						0.03	irrigation	
98d	Lower Cow Creek	J. Maslonka	4.5		0.01	0.07				irrigation	Maslonka, John & Luetta
98e	Lower Cow Creek	T. Foruria	5		0.01	0.08				irrigation	Foruria, Theodore & Patricia Ann
99	Lower Cow Creek	Fraser Pump	6		0.01	0.10				irrigation	Fraser, Thomas & Morag
			31.7						0.53	irrigation	
100	Lower Cow Creek	Fraley South Pump	13		0.01	0.22				irrigation	Fraley, Harold & Esther
101	Lower Cow Creek	Maynard Pump	48.8		0.01		0.81			irrigation	Maynard, R. & E.D.
102											

TABLE 5-8
Cow Creek Adjudication Decree 38577 August 25, 1969

Old Cow Creek, South Cow Creek, Lower Cow Creek, Upper Tributary Area of Cow Creek System

Diversion No.	Stream	Diversion Name	Irrigated Acres	Allotment						Use	Owner
				Special	1	2	3	Surplus	4		
103	Lower Cow Creek	Bragg Pump	2.2		0.01	0.04				irrigation	Nixon, Bill & Opal
104	Lower Cow Creek	Carter-McKee Pump	2.5		0.01	0.04				irrigation	Carter, Paul & Juanita
104	Lower Cow Creek	Carter-McKee Pump	5		0.01	0.08				irrigation	McKee, Charles & Jane
105	Lower Cow Creek	Stone-Fitzpatrick Pump	43.8		0.01	0.74				irrigation	Fitzpatrick, David & Mildred Cobb, Alfred & Marian
105	Lower Cow Creek	Stone-Fitzpatrick Pump	11.4		0.01	0.19				irrigation	Stone, F.C. & Geneva & Charles & Clara
			5						0.08		
106	Lower Cow Creek	Morse Pump	10		0.01	0.17				irrigation	Morse, Alvin & Donna
107	Lower Cow Creek	A.F. Hufford Pump	33.4		0.01	0.56				irrigation	Carter, Martin & Helen
			101.6						1.69	irrigation	
108	Lower Cow Creek	Herman Pump	39		0.01	0.50				irrigation	Herman, William & Helen
108	Lower Cow Creek	Herman Pump	2.5		0.01	0.03				irrigation	Hoffman, Margot
108	Lower Cow Creek	Herman Pump	2.5		0.01	0.03				irrigation	Tippin, Jerry & Gloria
109	Lower Cow Creek	Swoboda Brothers Pump	24.2		0.01	0.41				irrigation	Swoboda, John & Lucille
			8.4						0.14	irrigation	
109	Lower Cow Creek	Swoboda Brothers Pump	14		0.01	0.25				irrigation	Swoboda, Lawrence & Helen
			14						0.25	irrigation	
110	Lower Cow Creek	Pearson Pump	116		0.01	1.93				irrigation	Carter, Martin & Helen
			40					0.73		irrigation	
			55.6					0.7		irrigation	
110	Lower Cow Creek	Pearson Pump	2.2		0.01	0.04				irrigation	Murphy, Tal & Marian
			34						0.57	irrigation	
111	Lower Cow Creek	Beatie Pump	50.8		0.01	0.86				irrigation	Beatie, Arthur & Joy Ann
112	Lower Cow Creek	Beatie Pump Stockwatering									
111	Lower Cow Creek	Beatie Pump	16		0.01	0.28				irrigation	Meyer, Alice
112	Lower Cow Creek	Beatie Pump Stockwatering									
113	Lower Cow Creek	Bryant Pump	40.2		0.01	0.49				irrigation	Bryant, Robert & William
			41.6				0.51			irrigation	
			32.4						0.54	irrigation	
114	Lower Cow Creek	R. Hawes West Pump	10.4		0.01	0.17				irrigation	Hawes, Roy & Daryl
			104.8				1.75			irrigation	
115	Lower Cow Creek	R. Hawes East Pump	13		0.01	0.22				irrigation	
116	Lower Cow Creek	M. Hawes Pump	59		0.01	0.97				irrigation	Hawes, Melvin & Ruth
			61.6				1.03			irrigation	
			36						0.60	irrigation	

TABLE 5-10
Hydroelectric Facilities

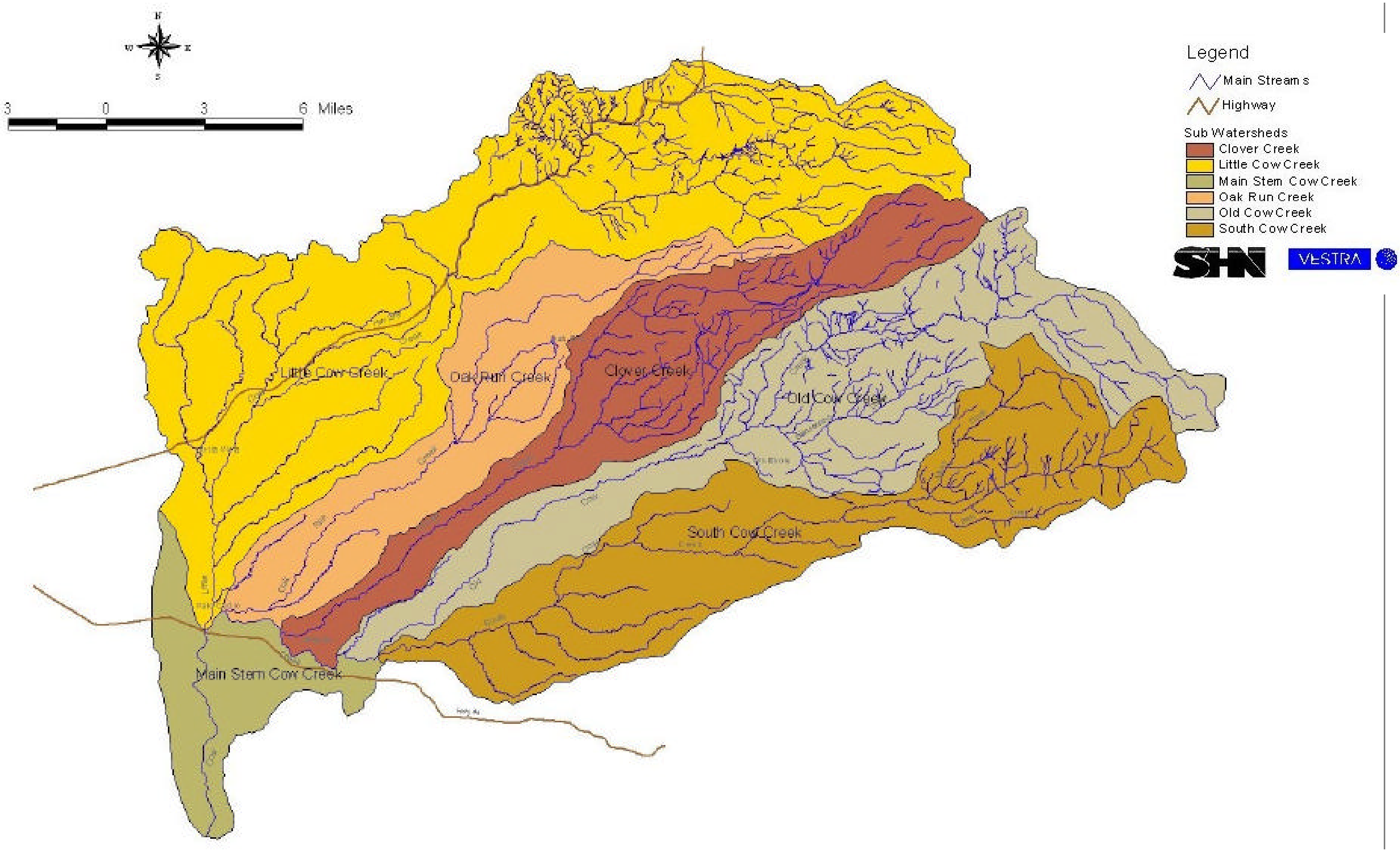
Facility Name	FERC License	Bypass Flow & Amount Diverted	Fish Screen/Ladder	Comments
Kilarc-South Cow Creek	606	Kilarc (Old Cow Creek) 2 cfs bypass flow South Cow Creek 4 cfs bypass flow during normal years, 2 cfs bypass flow during dry years.	Kilarc & South Cow Creek have fish screens. South Cow Creek has fish ladder.	South Cow Creek diversion dam was a fish barrier prior to the installation of fish ladder. FERC license expires 3/27/2007.
Mega Hydro	5306 Exempt 1000kW	Clover Creek 6 cfs bypass flow 36 cfs diverted	Fish screen	DFG records indicate this plant is active.
Morrow-Stone Hydro	Exempt	South Cow Creek 2 cfs bypass flow	Unknown	DFG last looked at facility in 1994 to accept bypass facilities. No records since.
McMillan Hydro	Exempt Plant #1 – 500kW & 199kW Plant 2 – 300kW	North Fork Little Cow Creek 3 cfs bypass flow	No fish screen	Facility consisted of two separate developments, one destroyed in 1992 Fountain Fire. FERC issued amendment in 1994 to reconstruct the second development, but DFG has no records since that time.
T&G Hydro	6905 Exempt 100&350kW	Canyon Creek Bypass flows sufficient to maintain hydraulic continuity in Canyon Creek 10 cfs diverted	No fish screen as of 1998 inspection.	DFG records indicate this plant is active.
Clover Leaf Hydro	7057 Exempt 200kW	Clover Creek 6 cfs bypass flow 15 cfs diverted	Fish ladder and fish screen	DFG records indicate this facility is active.
Olson Power	8361 5MW	Old Cow Creek 30 cfs bypass flow 120 cfs diverted	Fish screen	DFG records indicate this facility is active.
All of the hydroelectric facilities with the exception of the PG&E and Olson facilities are exempt from the FERC Licensing. The Olson Power plant was licensed in 1987 for a period of 50 years.				

Photo 5-1: Cook & Butcher Diversion on Little Cow Creek.

Photo 5-2: Mill Diversion on Clover Creek

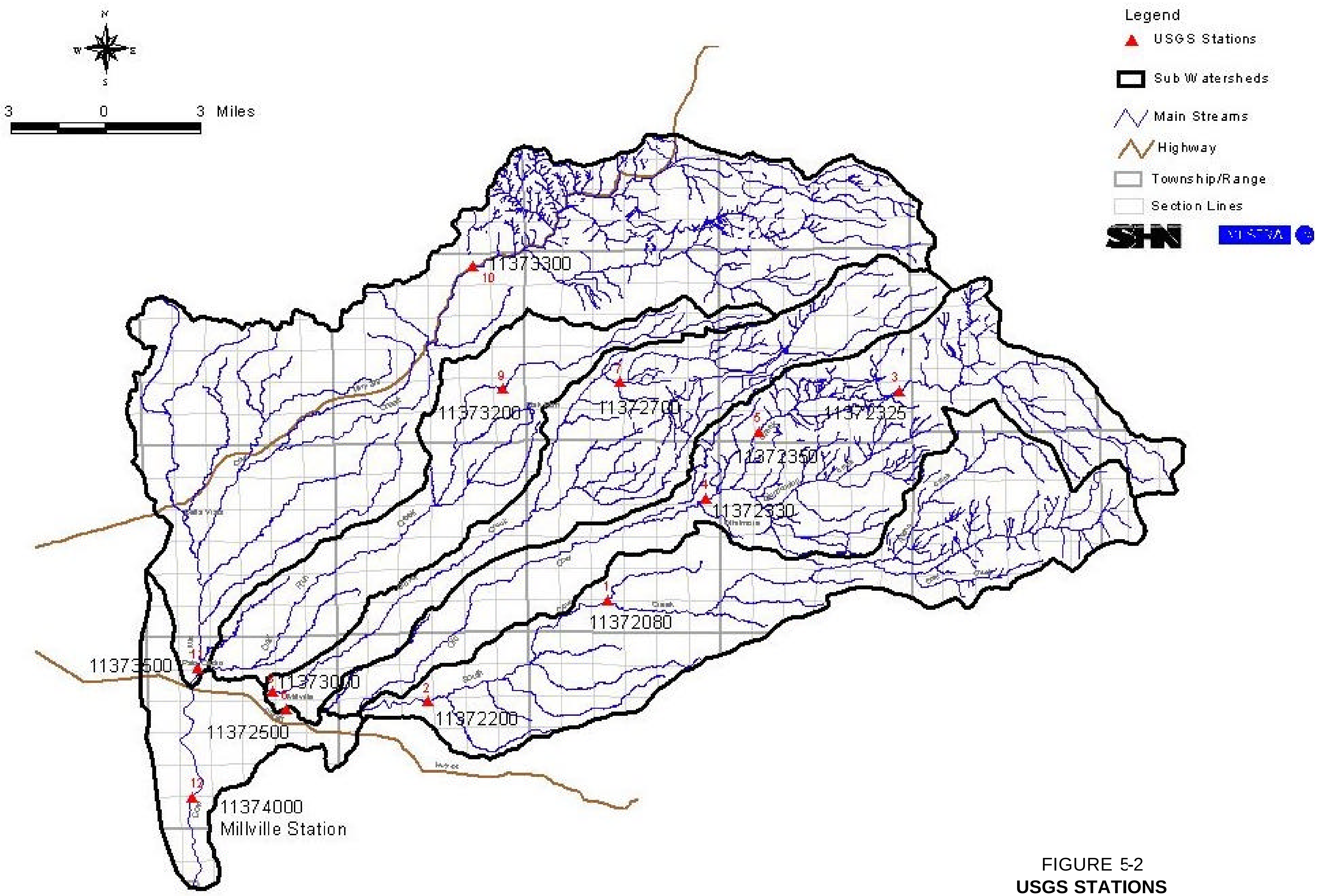
Photo 5-3: Kilarc Diversion on Old Cow Creek.

Photo 5-4: South Cow Diversion.



Reference: DFG Calwater 2.2 M. Hannaford

FIGURE 5-1
SUB-WATERSHEDS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA



Reference: USGS

FIGURE 5-2
USGS STATIONS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

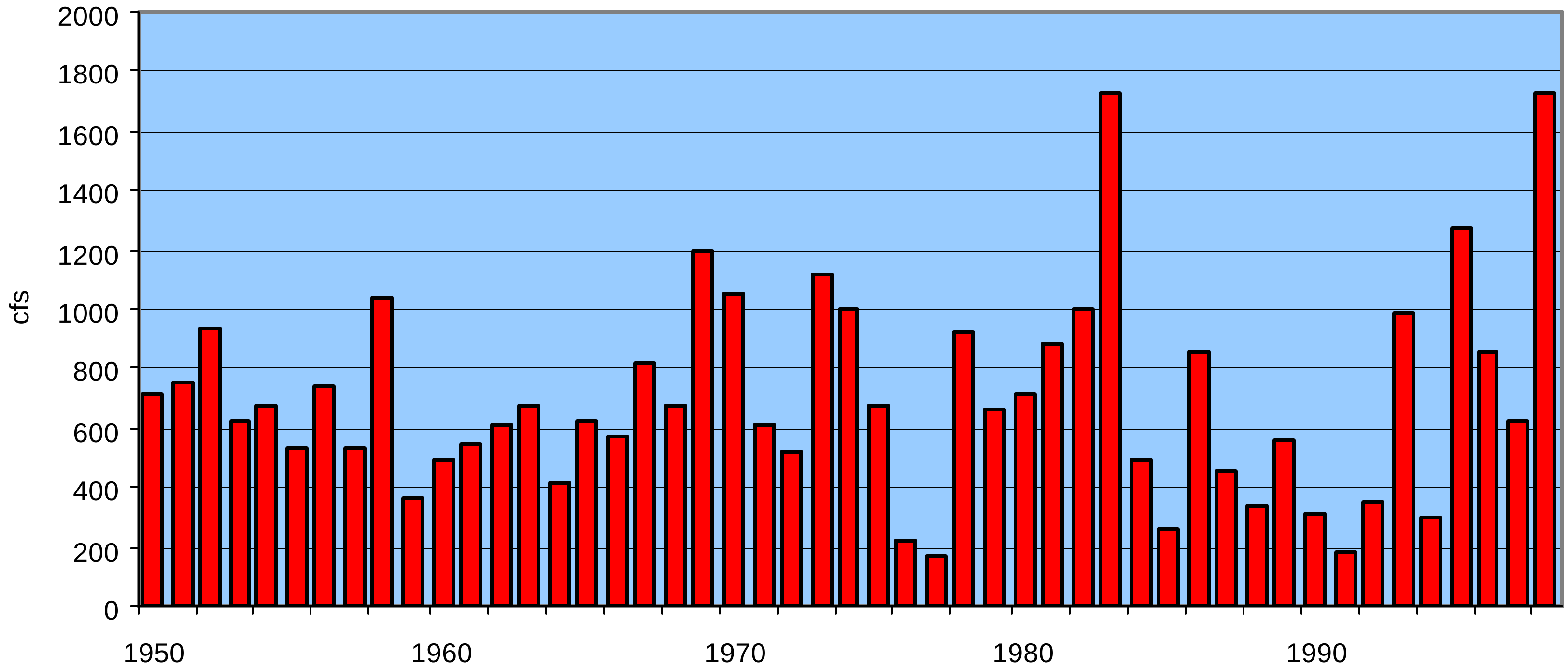


FIGURE 5-3

MEAN ANNUAL FLOWS – MAIN STEM COW CREEK

MILLVILLE GAGE

COW CREEK WATERSHED ASSESSMENT

SHASTA COUNTY, CALIFORNIA

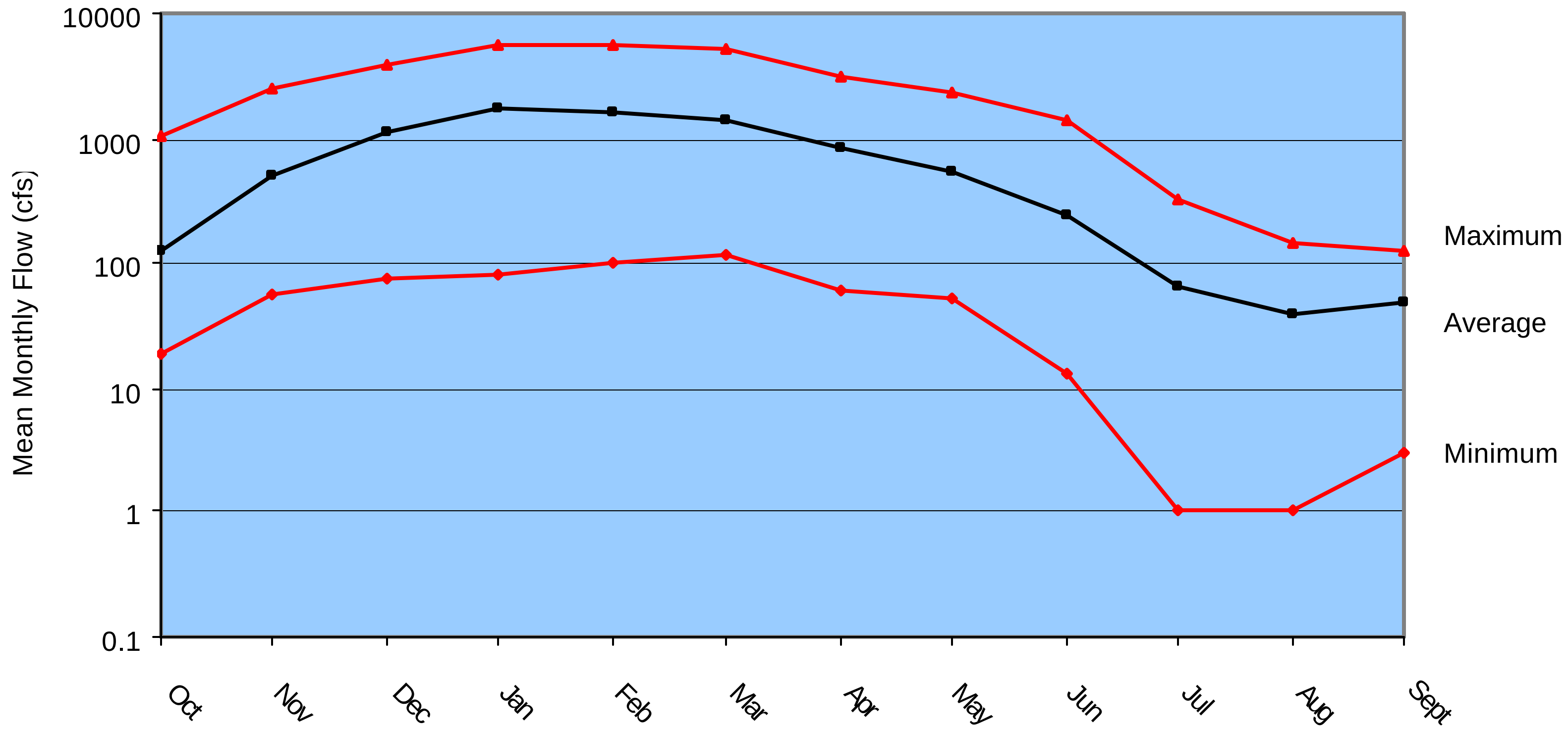


FIGURE 5-4
MONTHLY FLOWS – MAIN STEM COW CREEK
MILLVILLE GAGE
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

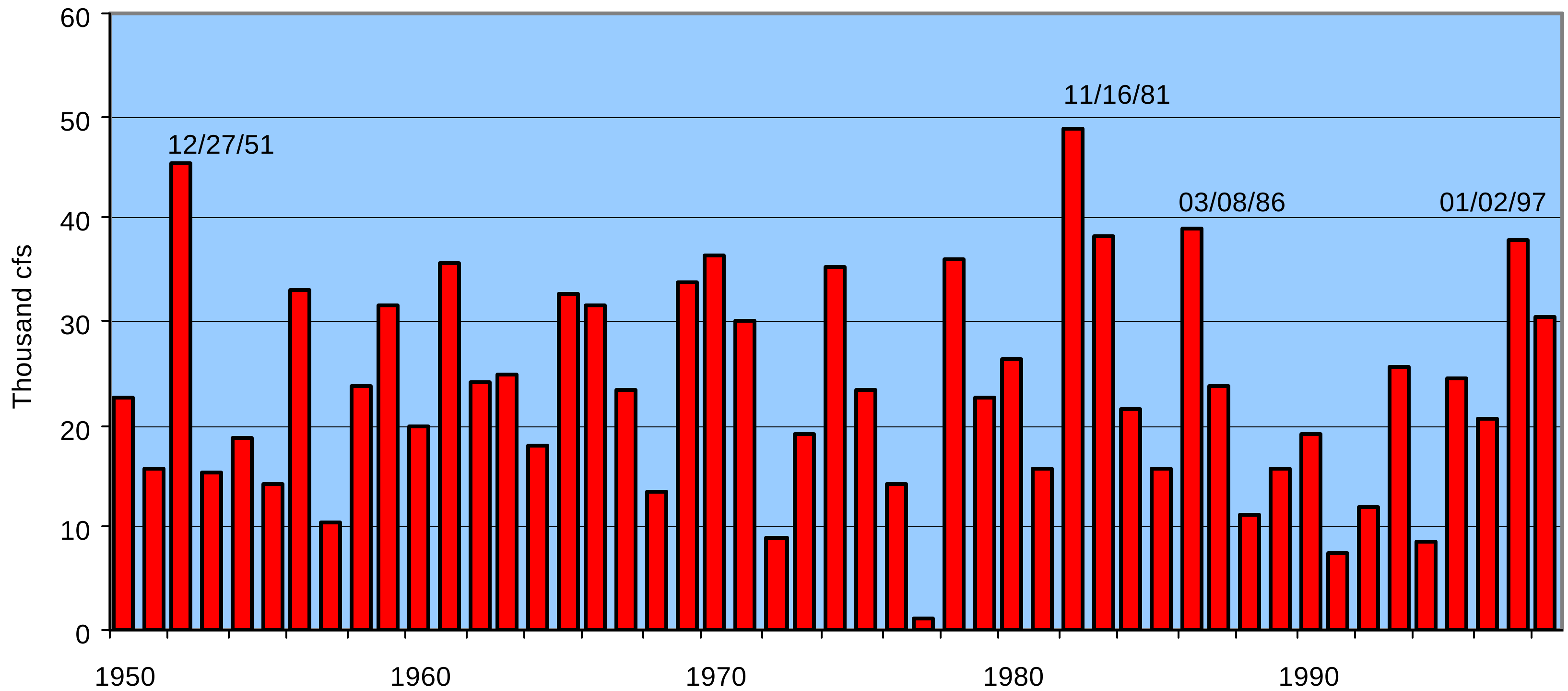


FIGURE 5-5
PEAK ANNUAL FLOWS – MAIN STEM COW CREEK
MILLVILLE GAGE
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

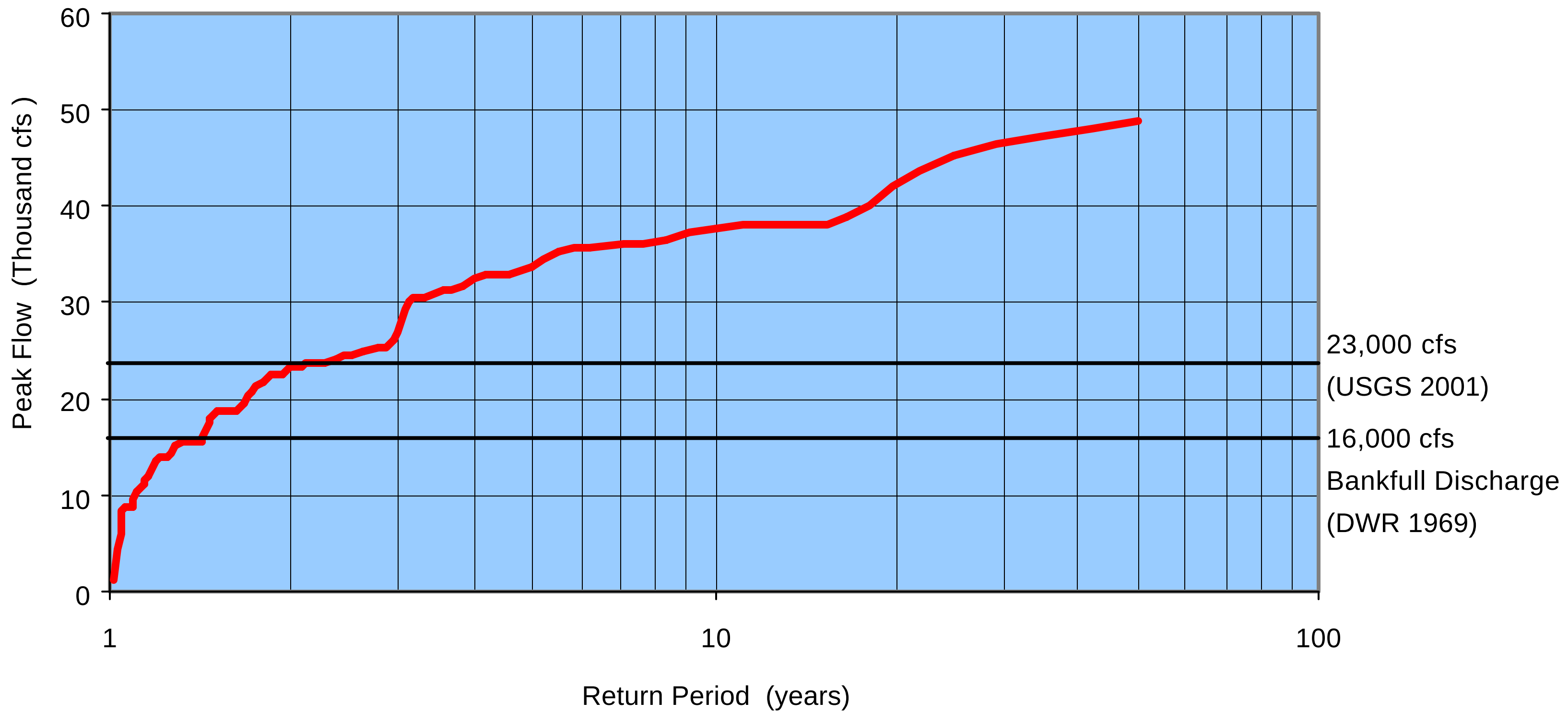


FIGURE 5-6

RETURN PERIOD – MAIN STEM COW CREEK

MILLVILLE GAGE

COW CREEK WATERSHED ASSESSMENT

SHASTA COUNTY, CALIFORNIA

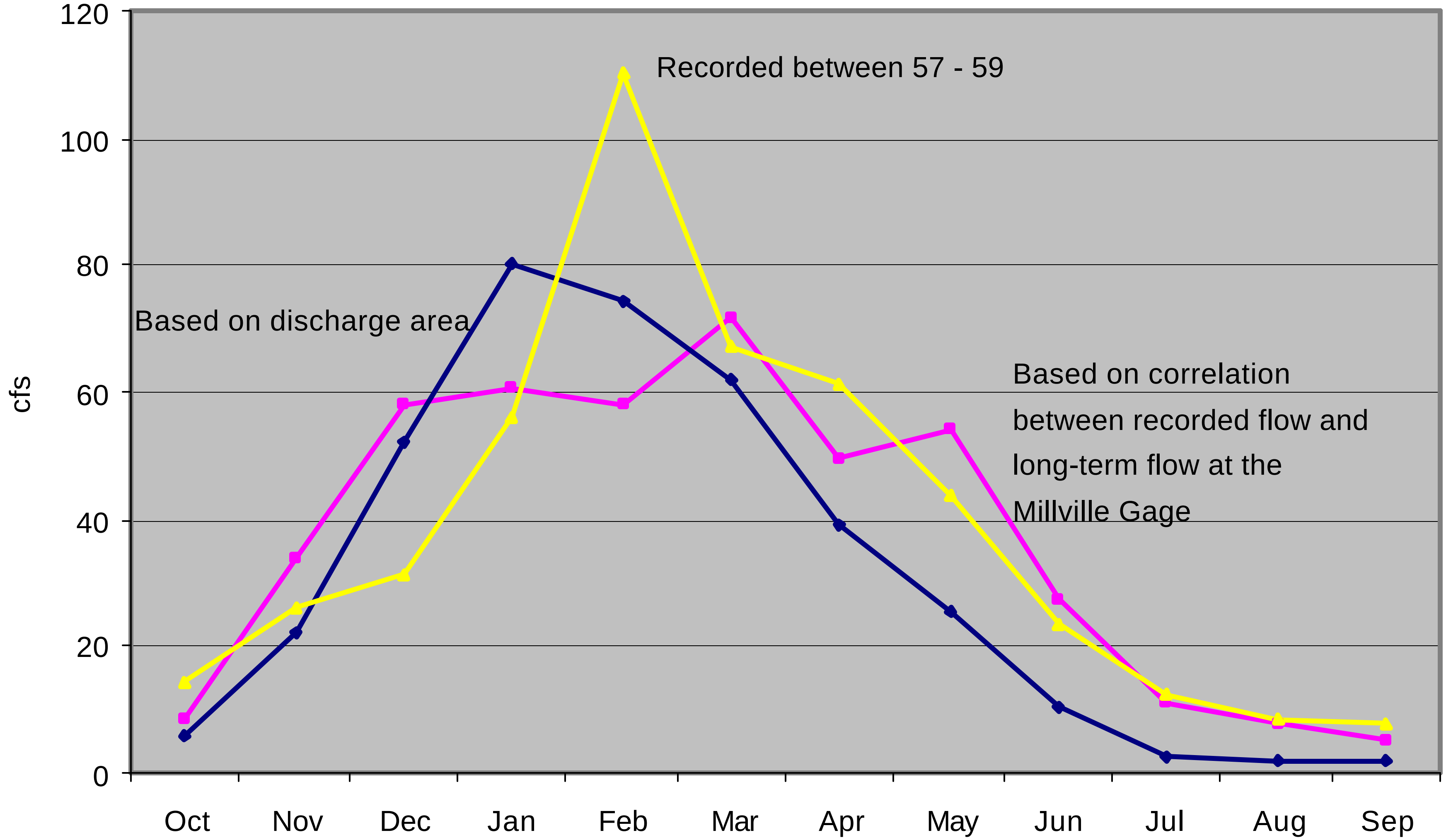
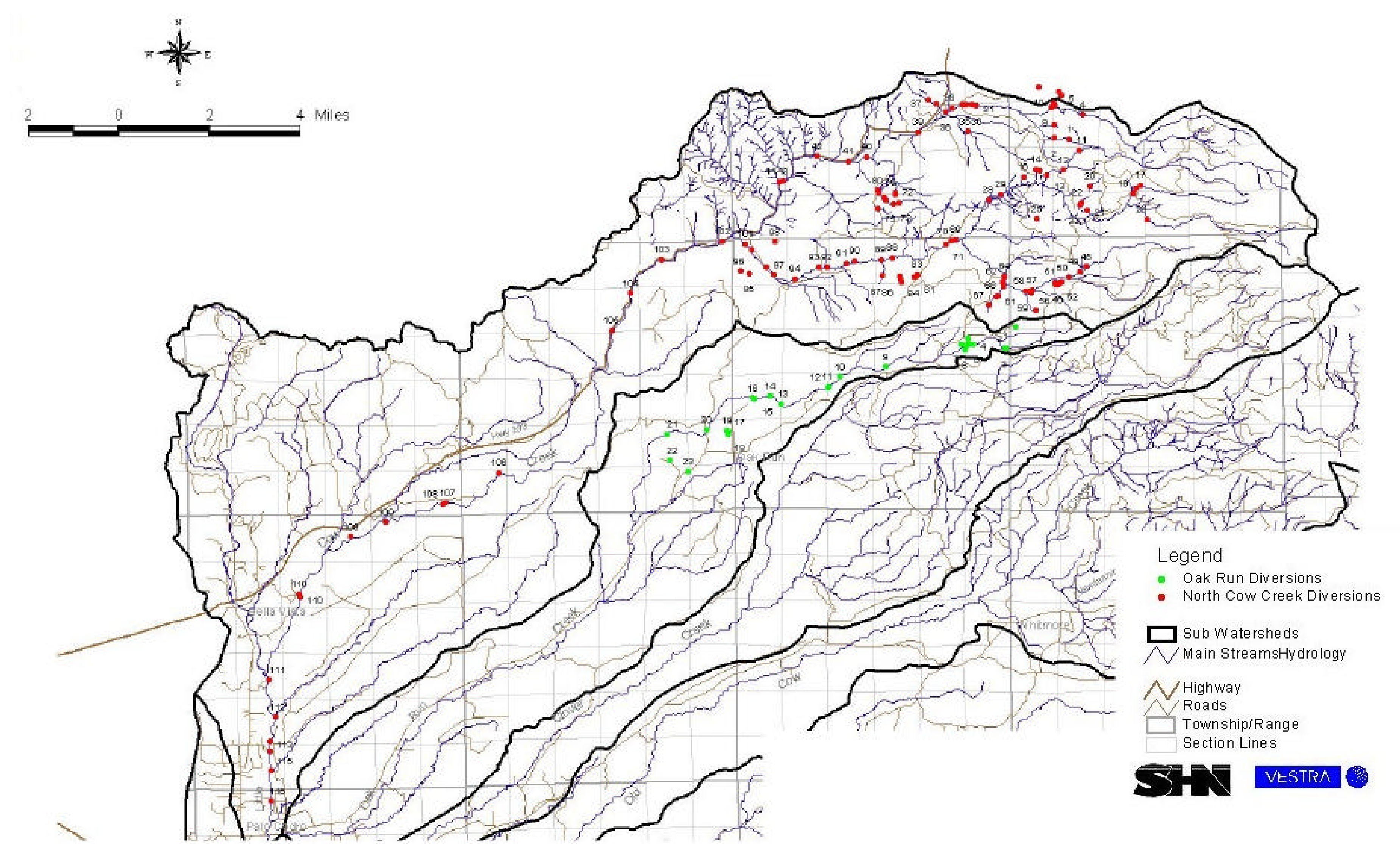


FIGURE 5-7
MEAN MONTHLY FLOW – CLOVER CREEK
USGS GAGE 11372700
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA



Reference: DWR 1923 Maps

FIGURE 5-8
OAK RUN & NORTH/LITTLE COW CREEK DIVERSIONS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

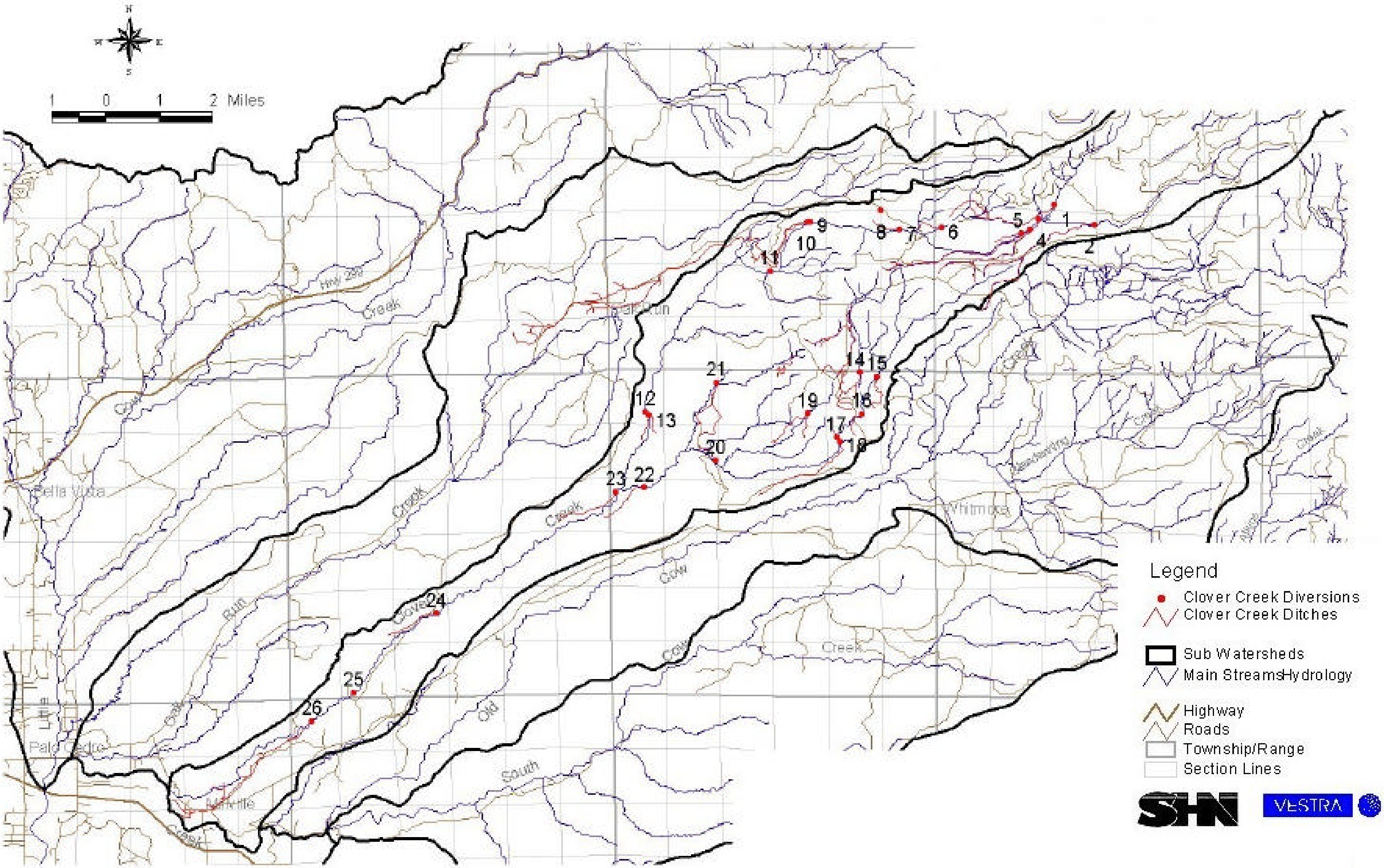


FIGURE 5-9
CLOVER CREEK DIVERSIONS & DITCHES
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: DWR 1927 Maps

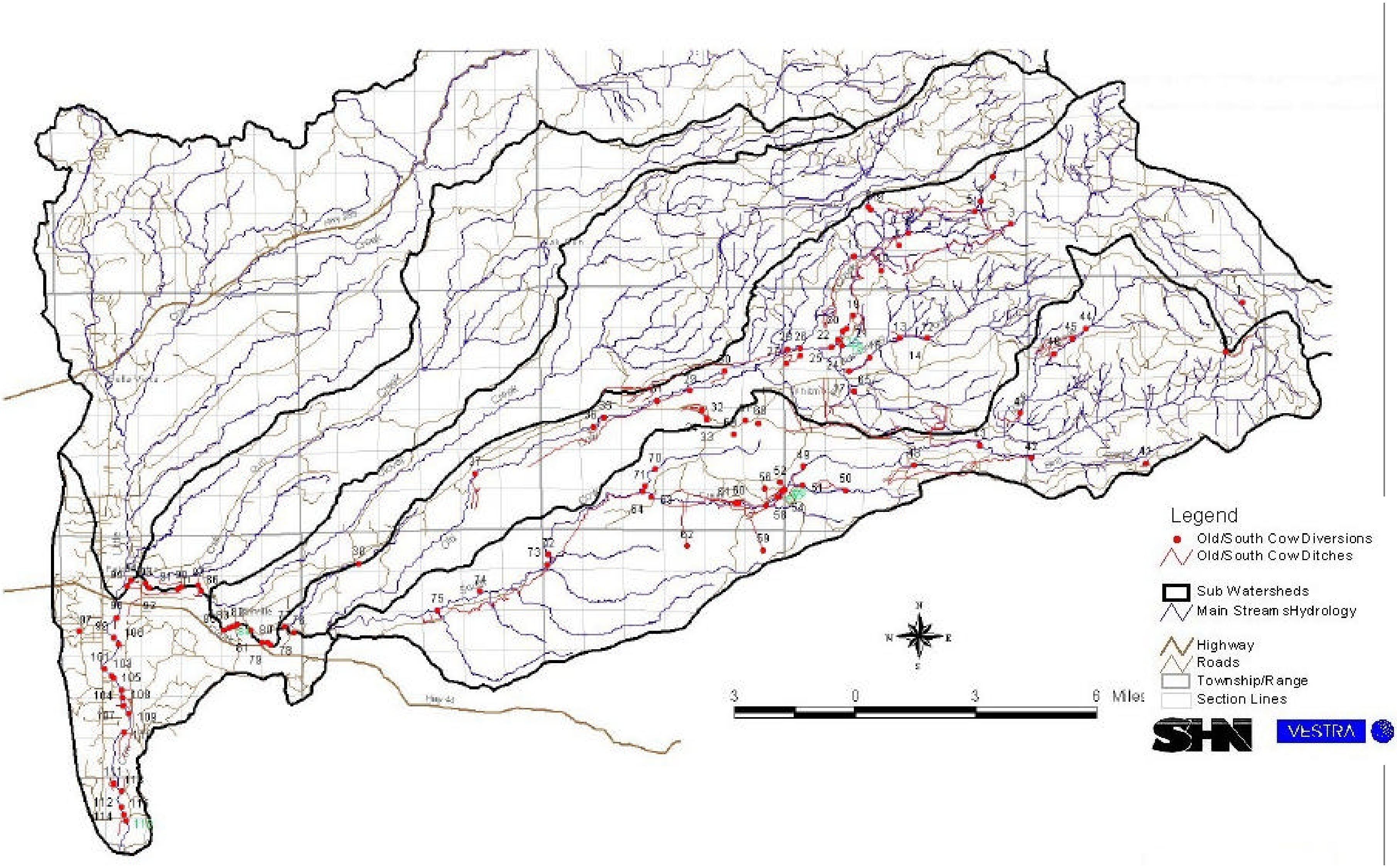


FIGURE 5-10
OLD COW & SOUTH COW CREEK DIVERSIONS & DITCHES (COW CREEK ADJUDICATION)
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: DWR 1969 Maps

Section 6
WATER QUALITY

Section 6
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Section 6
WATER QUALITY

WATER QUALITY STANDARDS

It is difficult to address the issue of water quality without an understanding of water quality standards, how standards are developed, and how they apply to our daily lives. This section presents a brief overview of the water quality standards applicable to the Cow Creek Watershed.

OVERVIEW

National water quality standards are set by USEPA through two primary bodies of law: the Federal Clean Water Act (CWA) and the Federal Safe Drinking Water Act. States may adopt more stringent standards than those adopted by the federal government, but may not adopt less stringent numbers than the federal standard. California passed the Porter-Cologne Water Quality Control Act, which provided a mechanism for adopting state specific water quality standards. The CWA requires that USEPA reviews all new or revised state standards. The State of California, through the State Water Resources Control Board and nine Regional Water Quality Control Boards, is required to adopt Water Quality Control Plans (Basin Plans) by the California Water Code (Section 13240). The Basin Plans are regional-specific plans that identify the "beneficial uses" of water bodies and set numeric criteria to protect the beneficial uses identified. Recently, California and USEPA adopted new toxicity standards for surface water discharges referred to as the "California Toxics Rule."

The RWQCB, Central Valley Region has adopted these water quality standards in "The Water Quality Control Plan (Basin Plan) for the Central Valley Region" as water quality objectives. The Basin Plans consist of a designation of the waters within a specified area of beneficial uses to be protected, and the establishment of water quality objectives to protect those uses, as well as a program of implementation needed for achieving these objectives.

The beneficial uses identified for Cow Creek include:

> Municipal and domestic supply, irrigation, stock watering, power generation, contact and non-contact recreation, warm and cold water habitat, spawning habitat for warm and cold water fisheries, migration for anadromous fisheries, wildlife habitat and navigation.

These beneficial uses will need to be balanced to meet all needs and uses of the watershed over time.

Water Quality Objectives, or standards, are set in the Basin Plans based on beneficial uses; both designated (potential/future) and existing. The Porter-Cologne Water Quality Control Act defines water quality objectives as "…the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area," (Water Code Section 13050(h)). In establishing water quality objectives, the CRWQCB considers, among other things, the following factors:

- Past, present, and probable future beneficial uses;
- Environmental characteristics of the hydrographic unit under consideration, including the quality of water available;
- Water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area;
- Economic considerations;

- The need for developing housing within the region;
- The need to develop and use recycled water.

The Basin Plan sets both numeric and qualitative standards. The numeric water quality standards for cadmium, copper and zinc were established in 1985 and were intended to "fully protect the fishery from acute toxicity since the standards are based on short term bioassays on the critical life stages of a sensitive species." These numeric values vary logarithmically with hardness; however, the actual values stated are those listed in the Basin Plan.

Under CWA §303(d), added by the 1987 amendments to the CWA, EPA and the states were required to identify water bodies that are not achieving water quality standards due to toxic releases and to develop a control strategy for the sources. A portion of Little Cow Creek below the Afterthought Mine is listed as impaired water pursuant to Section 303(d). When the Basin Plan is revised during the next biannual review, the RWQCB has stated that the lower reaches of Cow Creek may be listed as impaired for exceeding fecal coliform and temperature.

STANDARDS

For a complete discussion of each numeric limit please refer to the Basin Plan, which can be found at the RWQCB offices or on the Internet at http://www.swrcb.ca.gov/rwqcb5. A summary of Basin Plan Standards relevant to issues in Cow Creek is included in Table 6-1.

Table 6-1
Basin Plan Water Quality Summary

Bacteria Fecal Coliform	30-day average must not exceed 200/100ml or have greater than 10 percent in 30 days exceed 400/100ml.
Toxics	See new California Toxics Rule for NPDES discharges.
Trace Elements [(1)]	Arsenic 10 µg/l Barium 10 µg/l Cadmium 0.22 µg/l Copper 5.6 µg/l Cyanide 1.0 µg/l Iron 30 µg/l Manganese 5.0 µg/l Silver 10.0 µg/l Zinc 16.0 µg/l
Color	Waters should be free of discoloration.
Dissolved Oxygen	Warm water fishery 5.0 mg/l Cold Water Fishery 7.0 mg/l Spawning Fishery 7.0 mg/l 9.0 mg/l from June 1 to August 31 in the Sacramento River.
pH	Not be less that 6.5 or greater than 8.5 pH units.
Electrical Conductivity	<230 micromhos/cm
Temperature	<5° F over background, no increase which impacts beneficial uses.
Turbidity	Varies as a percentage over background.
Suspended & Settable Sediment	No increase that adversely impacts beneficial uses.

[(1)] These are dissolved concentrations that vary with hardness. The values presented above are at a hardness of 40 mg/l.

REFERENCE CONDITIONS

Limited data are available on water quality reference conditions within the Cow Creek Watershed. Based on historic accounts and interviews, it is assumed that prior to European settlement the water quality was a function of natural chemical and geologic processes.

WATER QUALITY GENERAL

The majority of the chemical and physical water quality data available for the Cow Creek Watershed are available from history and current DWR stations on Cow Creek. The station information, data collected, and years of operation are shown inn Table 6-2 and included in Figure 6-1**.** USGS has also collected data on flow and temperature within the Cow Creek Watershed, which are summarized in Table 6-3. Station locations are summarized in Figure 6-2. Additional data have been provided by individual studies within the watershed and data obtained form DFG, RWQCB and PG&E files.

TEMPERATURE

Temperature is a primary limiting factor for aquatic biota (Allen, 1995). Excessive temperatures can induce high metabolic rates and oxygen debt stress in fish and invertebrates. Temperature concerns in the Cow Creek Watershed are focused primarily on the effects to the anadromous fishery, predominately steelhead and chinook salmon**.** Different salmon species are known to have varying temperature requirements. Adult chinook salmon have exhibited poor survival when held at temperatures above 60 degrees F, and produce eggs less viable than when held at lower temperatures (DWR, 1988). Salmon are considered to be stenotherms because they can only tolerate a narrow range of temperatures. Table 6-4 outlines estimated temperature requirements for specific developmental stages of chinook salmon (Armour, 1991). Lethal temperature threshold for juvenile and adult salmon is approximately 25 degrees C (77 degrees F).

BACTERIA

There are a number of organisms that have been used to monitor the presence of harmful pathogens in streams. Fecal coliform has been widely used as an indicator for the presence of harmful pathogens in domestic wastewaters; therefore, studies characterizing water quality in streams have frequently used this indicator as well (EPA, 1999). Coliform bacteria are a natural element of aquatic food chains. Fecal coliform (*E. coli*) in surface and groundwater is a direct result of solid waste from mammals and can be a result of septic tank effluent leaking to water courses, or livestock, wildlife or human defecation.

The Basin Plan Water Quality Objective for fecal coliform in waters used for contact recreation is no more than 200 mpn/100 ml, based on a minimum of five samples in a 30-day period. No more than 10 percent of the total number of samples collected during a 30-day period shall exceed 400 mpn/100ml (RWQCB, 1998).

Data on coliform concentrations were limited to the Shasta College study (Hannaford, 2000) and RWQCB 1997 survey. The Shasta College study found that out of the nine sites studied from June 1999 to October 1999, three sites had consistently high fecal coliform concentrations. Clover Creek in the lower elevation reaches, and South Cow and Oak Run Creeks in the middle elevation reaches had fecal coliform levels that exceeded the RWQCB standards for recreational contact. The source of the fecal coliform contamination is unknown. It could be attributed to livestock waste, leaking septic systems, or other sources. The other six sites had fecal coliform levels within the RWQCB standards for recreational contact. These numbers were supported by the study conducted by the RWQCB in 1996 in which numerous locations along South Cow Creek exceeded 1600 mpn/100ml – well over the RWQCB criteria of 200mpn/100ml for contact recreation.

TABLE 6-2
DWR Stations

Tributary	Station #	USGS #	Elev. (ft)	Data	Years	Comment
Cow Creek (Millville)	A4-8301	N/A	490	T, PP, Min	12/21/70-12/23/82	Intermittent – Minerals, Turbidity
Little Cow (Palo Cedro)	A4-8350	1137500?	480	T, PP, Min	2/15/52, 10/30/52	Minerals
Little Cow (Swede Creek)	A4-8352	N/A	460			
Cow Creek (Millville)	A4-8110	1137400	410	T, PP, Min	2/13/55 5/25/84	
Cow Creek (Palo Cedro)	A4-8111	N/A	410	T, PP, Min	9/23/74 9/18/90	Intermittent Minerals
Cow Creek (Anderson)	A4-8101	N/A	380	T, PP, Min	11/30/73 3/3/83	Intermittent Minerals – Also 10/6/60 & 11/30/60
Clover Creek (Millville)	A4-8160	1137300?	480	T, PP, Min	1/18/74 12/23/82	Intermittent Minerals – Also 2/18/52, 10/30/52, & 3/29/55
Oak Run Creek (Near Millville)	A4-8202	N/A	480	T, PP, Min	1/18/74 12/23/82	Intermittent Minerals
Oak Run Creek (Near Oak Run)	A4-8200	N/A	1440	T, PP, Min	5/11/77 12/24/82	Intermittent Minerals, Additional Data Collected 2/8/52; 10/30/52
Clover Creek (Near Fern Road)	A4-8252	N/A	2680	T, PP, Min	5/11/77 12/24/82	Intermittent Minerals
Little Cow (Near Ingot)	A4-8400	1137330	1160			
Old Cow (Kilarc P.H.)	A4-8448	N/A	2600			
South Cow	A4-8555	1137208?	2600	T, PP, Min	5/11/77 12/24/82	Selected Minerals
South Cow (Millville)	A4-8500	1137220?	805	PH, Min., T		
Cow Creek (Palo Cedro)	A4-8112	N/A	440	PH, Min., T	2/2/52 10/30/52	
Cow Creek (Millville)	A4-8300	N/A	490			No Data

**T=Turbidity, PP=Physical Parameters, Min=Minerals

TABLE 6-3
USGS Stations

Tributary	Station #	DWR #	Elev. (ft)	Drain Area	Data	Years	Comment	Watershed
South Cow (Near Whitmore)	11372080	N/A	1560	--	F F F	5/25/84-10/27/85 12/7/85-4/24/86 6/19/86-9/30/99	Daily Flow Daily Flow Daily Flow	
South Cow (Near Millville)	11372200	N/A	610	77.3	T F F WQ	9/56-8/69 1955-1972 10/01/56-10/03/72 1966-1971	Periodic Temp Peak Flow Daily Flow	
Old Cow (Kilarc)	11372325	N/A	--	--	F F	1/8/83-1/9/95 6/6/95-9/30/99	Daily Flow Daily Flow	For fish passage Recorded by PG&E
Old Cow (Olsen P.H.)	11372330	N/A	1720	--	F F F	1/26/90-9/30/92 10/1/96-9/30/97 10/1/98-9/3/99	Daily Flow Daily Flow Daily Flow	Fish passage flows
Old Cow (Below Olsen P.H.)	11372350	N/A	2340	32.6	F F F F	1/26/90-9/30/92 10/1/96-9/30/97 10/1/98-9/3/99 1997-1997	Daily Flow Daily Flow Daily Flow Peak Flow	
Cow Creek (At Millville)	11372500	N/A	490	166	F	1912-1914	Peak Flow	
Clover Creek (Near Oak Run)	11372700	N/A	--	19	F F	5/17/57-9/30/59 1958-1959	Daily Flow Peak Flow	
Clover Creek (At Millville)	11373000	N/A	490	52.5	F	1912-1914	Peak Flow	
Oak Run Creek (Near Oak Run)	11373200	A4-8200	1400	11	F F T	5/13/57-9/30/66 1957-1976 5/57-9/68	Daily Flow Peak Flow Periodic Temp	
Little Cow Creek (Near Ingot)	11373300	No # Given	1140	608	F F T	10/1/57-9/30/65 1957-1964 7/57-3/65	Daily Flow Peak Flow Periodic Temp	
Little Cow (At Palo Cedro)	11373500	--	450	145	F	1912-1913	Peak Flow	
Cow Creek (Near Millville)	11374000	A4-8110	--	425	F T T	10/1/49-9/30/99 1937-1998 2/55-8/68 1064-9/68	Daily Flow Periodic Temp Temp Continuous	
Salt Creek (Near Bella Vista)	11373400	No # Given	--	--	T	12/57-6/63	Periodic Temp	

TABLE 6-4 Preferred Temperature Ranges for Chinook Salmon	
Species/Life Stages	**Temperature Range Requirements***
Chinook Salmon	
Adult migration	3.3-14.4 degrees C (38-58 degrees F)
Spawning	4.4-13.9 degrees C (40-57 degrees F)
Egg incubation / fry emergence	5.0-14.4 degrees C (41-58 degrees F)
Juvenile rearing	5.0-14.4 degrees C (41-58 degrees F)
Note: Adapted from Armour 1991. These are estimates based on field and laboratory studies. Actual site-specific values may vary.	*0.1 degrees C precision is an artifact of translating temperatures from Fahrenheit, as reported in the literature.

DISSOLVED OXYGEN

Maintaining appropriate levels of dissolved oxygen in receiving waters is one of the most important considerations for the protection of fish and aquatic life (EPA, 1999). The oxygen content in stream water comes from two primary sources:

1) Oxygen gas dissolving into the water at the surface and during turbulent flows (i.e. riffles);

2) Oxygen production during photosynthesis by algae and macrophytes (Hannaford, 2000).

The RWQCB guidelines state, "…the monthly median of the mean daily dissolved oxygen (DO) concentration shall not fall below 85% of saturation…" The EPA water criteria state that the DO concentrations should be a minimum of 8.0 mg/l to protect early life stages of freshwater aquatic life (i.e., anadromous fish). However, the Basin Plan sets a minimum limit for the Sacramento River and its tributaries of 9.0 mg/l for the protection of fisheries.

The DO data collected from the DWR station on the main stem of Cow Creek near Palo Cedro (A4-8111) from 1992 to 2000 indicated that DO levels were consistently at or near saturation. This is supported by the data collected by the RWQCB in 1996, where DO was found to be between 7.5 and 9.0 mg/l in all samples.

NUTRIENTS

The major sources of nutrients in streams are from storm runoff containing fertilizers, organic matter and detergents from improperly functioning septic systems, animal waste, and atmospheric deposition (EPA, 1999). There are a number of parameters used to measure the various forms of nitrogen and phosphorous found in streams. Ammonia (NH_3) nitrogen is the nitrogen form that is most readily toxic to aquatic life. Nitrate (NO_3) and nitrite (NO_2) are the inorganic fractions of nitrogen. Very little nitrite is typically found in streams or storm water runoff. Total phosphorous measures the amount of organic and inorganic phosphorous. Orthophosphate measures the phosphorous that is most immediately biologically available, and is typically the most common form found in streams.

Nutrient data are available from DWR stations along Cow Creek and samplings by the RWQCB show that nutrient values measured were typically within an acceptable range.

MINERALS

Water samples from Cow Creek Watershed have been analyzed from 1958 to 2000 for sodium, bicarbonate, boron, chloride, calcium, magnesium, potassium, sulfate, nitrate and dissolved solids concentrations (USGS). The objective of this sampling is to determine the ionic composition of water in Cow Creek.

These analyses show that the ionic composition of water in Cow Creek is influenced by precipitation in the winter, followed in summer by low periods of little or no rainfall. Thus, the wintertime diluted flows have low values of dissolved minerals that begin increasing in concentrations as the flows diminish in the summer. The results show that the ionic character of the water remains relatively the same even though the concentrations of the dissolved minerals increase or decrease inversely with the flow.

Though chemical concentrations vary throughout the year, they remain essentially the same for comparable flows for all analyses made throughout the period for which samples have been collected. October is characterized as a month of low flows and thus the samples have the highest concentrations.

Using a system that classifies water by its predominant cations and anions, expressed as milligram equivalents per liter, (obtained by dividing each of the concentration values in mg/1 by the combining weight of that ion), the water flowing from the Cow Creek drainage is identified as calcium-magnesium bicarbonate type.

Historic water quality data show that extremely high instantaneous flows in streams having unstable soil conditions frequently causes noticeable increases in the total dissolved solids (TDS) concentrations in runoff during the following years. Two of the three highest instantaneous flows measured in 26 years of record of the Cow Creek stream system occurred on December 1, 1960 and December 19, 1969. The storms that produced these high flows (35,000+ cfs) caused flooding throughout the watershed. Data showed no significant increase in TDS or any one specific parameter, indicating soils in the drainage area are fairly stable (DWR, 1975).

METALS

Arsenic, barium, cadmium, chromium (total), copper, iron, lead, manganese, zinc and selenium are the metals commonly referred to as minor elements and represent the base metals analysis conducted for most surface water evaluations. These metals are indicators of overall water quality. The concentrations of metals are usually taken as dissolved and toxicity to aquatic organisms varies with hardness of the water. The water in the Cow Creek Watershed is soft with a hardness ranging from 42 to 91, with an average of 67 based on data from DWR and RWQCB. Hardness increases slightly with low flows in late fall and is less in spring with storm and runoff flows.

The concentrations of minor elements within the watershed are generally within Basin Plan objectives, with the exception of a segment of little Cow Creek below the Afterthought Mine. The mine discharges acid rock drainage from portals and the creek in this area exceeds Basin Plan objectives for copper and zinc. The levels are below any human health values, but are in excess of the values adopted in the Basin Plan to protect sensitive life stages of anadromous fish.

ORGANIC COMPOUNDS

No historic analysis for organic compounds in the Cow Creek Watershed was found from the available data.

SEDIMENT/TURBIDITY

Sediment originates from many sources, including erosion of pervious surfaces, stream bank erosion, particles deposited from human activity, and the atmosphere. Elevated levels of sediment increase turbidity, reduce the penetration of light at depth, and limit the growth of desirable plants. Solids that settle out as bottom deposits contribute to sedimentation and can degrade and eventually destroy habitat for fish and bottom-dwelling organisms (EPA, 1999).

Studies addressing sediment and turbidity are limited for the Cow Creek Watershed. In order to conduct conclusive sampling for turbidity, long-term studies that evaluate flow, turbidity and precipitation must be undertaken. Turbidity has been sampled many times using grab sampling techniques. This discussion is based on the limited information available. DWR data reviewed referenced studies conducted by the USGS and Army Corps of Engineers in the late 70s and early 80s; however, this data was not available.

Turbidity is a measure of suspended particles and visible particulars that give water a cloudy appearance. Turbidity is measured in Nephelometric Turbidity Units (NTU's). Turbidity data are collected as a grab or batch sample and not continuously; therefore, data are reported as a range. Pulse events that may affect turbidity, such as storms, bank failure, run off, or shift in channel alignment, are often missed.

The Shasta College study collected turbidity data during low flow conditions in the summer of 1999, and during several storm flow events in the winter and spring of 2000. The results showed that there were no obvious differences among the tributary streams in the study. The following conditions were observed during the study:

- Summer low flow turbidity was consistently less than 1 NTU
- After minor rain storm events, turbidity ranged from 1-5 NTU
- During spring rain storm events, turbidity ranged from 5-20 NTU

A review of DWR data for the Cow Creek Watershed from 1992 to 1998 was in agreement with the Shasta College study. Only two years showed turbidity greater than 25 NTU. In 1995 the turbidity ranged from 1-35 NTU, and in 1997 the turbidity ranged from 1-80 NTU. Data on turbidity were limited to the Shasta College study (Hannaford, 2000) and historic microfiche data from DWR.

TRIBUTARY INFORMATION

No comprehensive water quality study of the Cow Creek Watershed is available. Most studies have been conducted for specific projects, such as PG&E hydroplant re-licensing, or in response to specific concerns such as Afterthought Mine. The following section attempts to summarize the data available by tributary. Please note certain data may not have been included since sources were unknown or poorly documented. In addition, older data did not include information on sampling protocols or methods used to collect and analyze samples, and may therefore be of limited value. The author acknowledges that the narrative appears to be redundant; but the section is presented to allow stakeholders to research specific tributary data.

LITTLE COW CREEK

Sources of data available for Little Cow Creek are included in Table 6-5.

Field measurements for dissolved oxygen, pH, conductivity, alkalinity and turbidity for the Little Cow Creek Tributary have all been within acceptable limits, with the exception of pH in the vicinity of the Afterthought Mine.

Table 6-5
Summary of Water Quality Data
Little Cow Creek

Agency	Station ID	Sampling Location	Data Collected	Period of Record	File Type
DWR	A4-8350	Palo Cedro	Nutrients	1952, 1982	Microfiche
			Minerals	1952, 1982	Microfiche
			Physical	1952, 1982	Microfiche
			Minor Elements	1971-1981	Microfiche
	A4-8352	Little Swede Rd.	Physical	1970	Microfiche
			Minor Elements	1970	Microfiche
	A4-8400	Near Ingot	Temperature	1952-1982	Microfiche
			Nutrients	1952-1982	Microfiche
			Minerals	1952-1982	Microfiche
			Physical	1952-1982	Microfiche
DFG		Phillips Road	Temperature	1992	Electronic
USGS	11373300	Near Ingot	Flow	1957-1965	Electronic
			Temperature	1957-1965	Electronic
	11373400	Near Bella Vista	Temperature	1957-1963	Electronic
	11373500	Palo Cedro	Flow	1912-1913	Electronic
Shasta College	Lower Cow Creek		Temperature, Fecal Coliform, Physical	1999-2000	Electronic
	Middle Cow Creek		Temperature, fecal coliform, Physical	1999-2000	Electronic
SHN	Little Cow Creek		Metals, Temp, Hardness	1998-1999	Electronic

Temperature

The following is a summary of historical water temperature data for Little Cow Creek.

- DWR has collected temperature data from approximately three stations within the Little Cow Creek Watershed. These stations are located at Palo Cedro, Swede Creek Road, and near Ingot. These stations are part of the DWR Water Quality and Measurement Program for collecting long-term basic data. A review of the data from 1952 through 1965 indicates that the temperature in Little Cow Creek near Ingot exceeded 25 degrees C several times during the summer months with a maximum temperature of 27.8 degrees C in June 1977. The Ingot site is located in the mid-elevation of the watershed and has an elevation of 1200 feet.

- USGS maintained two monitoring stations periodically. One station was on Little Cow Creek near Ingot, near the DWR station A4-8400, and was monitored 12 times from 1957 to 1965. The other station was on Salt Creek near Bella Vista, (near the DWR station A4-8350) and was monitored 21 times from 1958 to 1963. The maximum temperatures observed for the Ingot Station in the summer months was 22 degrees C, and the mean temperature observed during this period for the summer months was 19 degrees C. The Bella Vista station was not observed during the late summer months; however, during May and June the mean temperature was 21 degrees C, with a maximum of 27 degrees C observed in June.

- DFG files showed that PG&E maintained a station at Little Cow Creek and Phillips Road at an elevation of approximately 200 feet in the summer of 1992. The daily maximum water temperature observed was 22.6 degrees C (72.7 degrees F).

- Shasta College collected data from two stations on Little Cow Creek from 1999 through 2000 for a limited watershed assessment. Data from the Shasta College study indicated that during the summer months the maximum temperature in Little Cow Creek near Ingot in the middle reach was 24.6 degrees C, and the average temperature was 20.5 degrees C. In the lower reach of Little Cow Creek near Bella Vista (located at an elevation of approximately 600 feet), the stream temperatures exceeded 25 degrees C numerous times with the maximum temperature of 29.9 degrees C, and the average temperature of 25.5 degrees C.

- SHN collected data on Little Cow Creek from five stations located near the mouth of Afterthought Creek from August 1997 through May 1998 to assess impacts from the Afterthought Mine. Maximum summer temperatures occurred in September and averaged 70 degrees F in Little Cow Creek directly below the mine. These data, available at the offices of the RWQCB, present the only annual temperature study for the lower reaches of Little Cow Creek.

Dissolved Oxygen

Dissolved oxygen at the Ingot station ranged from 4.9 mg/l to 11.8 mg/l. The lower dissolved oxygen concentrations were observed in the summer months.

Nutrients

A summary of nutrient data for Station 8400 located near Ingot is provided in Table 6-6. Nutrient values monitored were below the state and federal MCLs.

TABLE 6-6
Nutrient Summary
Little Cow Creek

Nutrient	Range (mg/l)	CA Primary Drinking Water MCL (mg/l)
Total ammonia and organic nitrogen (NH3 + Org. N)	0.1-0.9	--
Dissolved Nitrite and Nitrate (NO2 + NO3)	0.02-0.24	10.0
Dissolved nitrate (NO3 as N)	0.01-0.14	10.0
Dissolved ammonia (NH3)	0.03	--
Dissolved orthophosphate (PO4)	0.00-0.02	--
Total Phosphorous (P)	0.02-0.21	--

Minerals

A summary of mineral data for Station 8400 located near Ingot is provided in Table 6-7. The mineral quality of Little Cow Creek near the Ingot station is good.

TABLE 6-7
Minerals Summary
DWR Ingot Station (A4-8400)
Little Cow Creek

Nutrient	Range (mg/l)	EPA Primary Drinking Water MCL (mg/l)	EPA Secondary Drinking Water MCL (mg/l)	Freshwater Aquatic Life MCL (mg/l)
Calcium (Ca)	6 - 15	--	--	--
Magnesium (Mg)	1.6 - 2.6	--	--	--
Sodium (Na)	2.0-9.6	--	--	--
Potassium (K)	0.6-0.8	--	--	--
Sulfate (SO4)	0.3-5.0	250	--	--
Chloride (Cl)	0.0-6.9		250	860
Total Hardness	21.0 to 76.0	--	--	--

Minor Elements

A summary of metals data for Station 8350 located near Palo Cedro is provided in Table 6-8. These data represent two monitoring events, one in January 1972, and the other in August 1977. The Palo Cedro sampling station is located downstream of Afterthought Mine. Arsenic and cadmium both exceeded the standards for drinking water and freshwater aquatic life. Copper and lead exceeded the Basin Plan Objective for freshwater aquatic life.

TABLE 6-8
Metal Summary
DWR Palo Cedro Station (A4-8350)
Little Cow Creek

Nutrient	Concentration (mg/l)	CA Primary Drinking Water MCL (mg/l)	CA Secondary Drinking Water MCL (mg/l)	Basin Plan Water Quality Objectives (mg/l)
Arsenic (As)	0.6	0.05	--	0.010
Cadmium (Cd)	0.01	0.005	--	0.022
Chromium (Cr)	--	--	--	--
Copper (Cu)	0.07	1.3	0.1	0.0056
Iron (Fe)	32	--	0.3	0.030
Lead (Pb)	0.01	0.015	--	--
Manganese (Mn)	0.71	--	0.05	0.005
Mercury (Hg)	--	0.002	--	--
Molybdenum (Mo)	--	--	--	--
Selenium (Se)	--	0.05	--	--
Zinc (Zn)	0.42	--	5.0	0.016

Afterthought Mine has been identified as a source of acid mine drainage by RWQCB, and the portion of Little Cow Creek impacted by discharge from the mine has been identified as a Section 303 impaired segment. Acid mine drainage contains metals that can be toxic to fish and other aquatic life and can adversely impact water supply and recreational uses. Drainage from Afterthought Mine originates when precipitation infiltrates into the underground workings and discharges through mine adits and fractures in the bedrock. A chemical reaction between the water and the sulfide minerals associated with the ore body causes the formation of sulfuric acid. The sulfuric acid dissolves metals such as copper, zinc and cadmium. The dissolved metals eventually discharge to the surface as acid mine drainage.

Agencies and the mine owners have conducted numerous investigations. The results of these are summarized in:

RWQCB Internal Memorandum, July 10, 1978 (data included in July 1985 report).

- California Regional Water Quality Control Board, *The Greenhorn and Afterthought Mines, A Plan for the Control and Abatement of Acid and Heavy Metal Pollution, Shasta County, California*, Memorandum Report, July 1985.

- California Department of Conservation and Central Valley Regional Water Quality Control Board, *Northern California Inactive Mine Drainage Survey for the South Dakota Mine Waste Study*, April 1994.

- SHN Consulting Engineers and Geologists, *Remedial Action Plan, Afterthought Mine*, prepared for Agricultural Management and Production Company, August 1998.

- California Regional Water Quality Control Board, *The Greenhorn and Afterthought Mines, A Plan for the Control and Abatement of Acid and Heavy Metal Pollution, Shasta County, California*, Memorandum Report, July 1985.

Studies were conducted in 1978 by DFG, and in 1984 by the RWQCB, of the Afterthought Mine that determined that copper levels in Little Cow Creek below Afterthought Mine exceed Basin Plan Water Quality Objectives intermittently throughout the year. The database includes seven sampling days in 1978 by the DFG and four sampling days by the RWQCB in 1984.

Based on the Board's heavy metal data, dissolved copper levels in Little Cow Creek below the mine are considerably higher than the Basin Plan Water Quality Objective of 5.6 µg/l. Dissolved zinc and cadmium levels, at times, exceed the objectives, which are 16 µg/l and 0.22 µg/l, respectively. The total metal concentrations in water sampled from Little Cow Creek 0.05 mile downstream from the mine generally exceed the Basin Plan dissolved metal maximums. In May 1982, copper and zinc concentrations were 53 and 23 times higher than Basin Plan maximums, respectively.

An inactive mine water quality survey was conducted as California's part of the South Dakota Mine Waste Study. The study was a joint effort of the Department of Conservation, Office of Mine Reclamation, and the Central Valley Regional Water Quality Control Board. The survey consisted of four rounds of sampling from April 29 to December 17, 1993. Sampling events occurred at high, medium, and low stream flow periods after an above-normal year of precipitation. Interpretation of the results is somewhat limited in nature due to the number of samples taken during each sampling event and staff resources available to review study results. Zinc, cadmium and copper, however, exceeded Basin Plan objectives.

Following the previous studies, the RWQCB requested the mine owner to initiate a site investigation to characterize discharge from the site and to evaluate remedial alternatives to reduce or eliminate the discharge. Site characterization activities were conducted at the site between August 1997 and June 1998. Receiving water locations were sampled monthly. The samples were analyzed for temperature, pH, electrical conductivity, hardness, total suspended solids, cadmium, copper, lead, mercury and zinc. Lead and mercury were not detected during the first six sampling episodes and were removed from the sampling program with agency approval. The results from the Little Cow Creek samples are summarized in Table 6-9.

TABLE 6-9
Afterthought Mine
Receiving Water Summary
Little Cow Creek

Little Cow Creek	**Copper (μg/l)**	**Zinc (μg/l)**	**Cadmium (μg/l)**
Average	4.8	35	<1.0
Maximum	9.3	78	<1.0
Receiving Water Limit	Avg. = 7.3 Max. = 10.6	Avg. = 20.3 Max. = 30.1	Avg. = 0.32 Max. = 0.54
Exceeded Criteria	1 of 8	6 of 8	0 of 8

Note: Receiving water limits vary depending on the hardness of the receiving water.

The extent of the downstream plume was determined to account for the observed distribution of contamination at 1,200 feet and 5,500 feet in Little Cow Creek during low flow conditions. Based on modeling, receiving water limits will be met within 900 feet of the discharge for cadmium, 1,700 feet for copper, and 6,500 feet for zinc.

OAK RUN CREEK

Data sources for Oak Run Creek are summarized in Table 6-10.

Field measurements for dissolved oxygen, pH, conductivity, alkalinity and turbidity for the Oak Run Creek Tributary have all been within acceptable limits.

TABLE 6-10
Summary of Water Quality Data
Oak Run Creek

Agency	Station ID	Sampling Location	Data Collected	Period of Record	Computer Files
DWR	A4-8200	Near Oak Run	Nutrients	1977-1981	Microfiche
			Minerals, Physical	1952, 1977-1982	Microfiche
			Temperature	1977-1982	Microfiche
	A4-8202	Millville	Nutrients	1977-1981	Microfiche
			Minerals	1977-1982	Microfiche
			Minor Elements	1972	Microfiche
			Physical	1974, 1977-1982	Microfiche
			Temperature	1977-1982	Microfiche
USGS	11373200	Near Oak Run	Temperature	1957-1968	Electronic
Shasta College	Lower Oak Run Creek		Temperature, Fecal Coliform, Physical	1999-2000	Electronic
	Middle Oak Run Creek		Temperature, Fecal Coliform, Physical	1999-2000	Electronic

Temperature

The following is a summary of historical water temperature data for Oak Run Creek.

- DWR has collected temperature data from approximately two stations within the Oak Run Creek Watershed. These stations are located near Oak Run and near Millville. These stations are part of the DWR Water Quality and Measurement Program for collecting long-term basic data. A review of the data from 1977 through 1982 indicates that the temperature in Oak Run Creek near Oak Run exceeded 25 degrees C several times during the summer months, with a maximum temperature observed of 26.1 degrees C in June 1977. The Oak Run Creek site is located in the mid-elevation of the watershed and has an elevation of 1440 feet. The Millville station also exceeded 25 degrees C several times in the summer months with a maximum temperature observed of 31.7 degrees C in June 1978. The Millville Station has an elevation of 480 ft.

- USGS maintained one monitoring station periodically. The station was on Oak Run Creek near Oak Run, near the DWR station A4-8200, and was monitored periodically 107 times from 1957 to 1968. The maximum temperature observed for the Oak Run Station in the summer months was 27 degrees C, and the mean temperature observed during this period for the summer months was 19 degrees C. The station elevation is 1420 feet.

- Shasta College collected data from two stations on Oak Run Creek from 1999 through 2000 for a limited watershed assessment. The stations were located on the lower and middle reaches of Oak Run Creek. Data from the Shasta College study indicated that during the summer months the temperature in the middle reach of Oak Run Creek near Oak Run averaged 17.2 degrees C, and the maximum temperature observed was 20.8 degrees C. In the lower reach of Oak Run Creek near Millville (located at an elevation less than 500 feet), the stream temperatures exceeded 25 degrees C numerous times, with an average temperature of 26.2 degrees C, and a maximum temperature of 32.1 degrees C.

Nutrients

A summary of nutrient data for Station 8200 located near Oak Run is provided in Table 6-11. Nutrient values monitored were below the water quality objectives.

TABLE 6-11
Nutrient Summary
Oak Run Creek

Nutrient	Range (mg/l)	EPA Primary Drinking Water, MCL (mg/l)
Total ammonia and organic nitrogen (NH3 + Org. N)	0.2-9.9	--
Dissolved nitrate (NO3 as N)	0.07-0.28	10.0
Dissolved ammonia (NH3)	--	--
Dissolved orthophosphate (PO4)	0.07	--
Total Phosphorous (P)	0.03-0.12	--

Minerals

A summary of mineral data for Station 8200 located near Oak Run is provided in Table 6-12. The mineral quality of Oak Run Creek near the Oak Run station is good.

Minor Elements

A summary of minor element data for Station 8202 located near Millville is provided in Table 6-13. This data represent one monitoring event in January 1972. Cadmium exceeded the MCL for drinking water. Copper and zinc exceeded the Basin Standard.

TABLE 6-12
Minerals Summary
DWR Oak Run Station (A4-8200)
Oak Run Creek

Nutrient	Range (mg/l)	CA Primary Drinking Water MCL (mg/l)	EPA Secondary Drinking Water, MCL (mg/l)
Dissolved Calcium (Ca)	3.4-9.3	--	--
Dissolved Magnesium (Mg)	2.0-4.3	--	--
Dissolved Sodium (Na)	2.0-4.8	--	--
Dissolved Potassium (K)	0.6-2.0	--	--
Dissolved Sulfate (SO4)	0.3-1.2	500	250
Dissolved Chloride (Cl)	1.0		250
Dissolved Boron (B)	0.1	--	--
Total Hardness	16	--	--
Dissolved Bromide (Br)	--	--	--

TABLE 6-13
Metals Summary
DWR Millville Station (A4-8202)
Oak Run Creek

Nutrient	Range (mg/l)	CA Primary Drinking Water MCL (mg/l)	CA Secondary Drinking Water MCL (mg/l)	Basin Plan Standards
Arsenic (As)	0.05	0.05	--	0.010
Cadmium (Cd)	0.01	0.005	--	0.022
Chromium (Cr)	--	--	--	--
Copper (Cu)	0.02	1.3	0.1	0.0056
Iron (Fe)	16	--	0.3	0.030
Lead (Pb)	0.01	0.015	--	--
Manganese (Mn)	0.58	--	0.05	0.005
Mercury (Hg)	--	0.002	--	--
Molybdenum (Mo)	--	--	--	--
Selenium (Se)	--	0.05	--	--
Zinc (Zn)	0.16	--	5.0	0.016

CLOVER CREEK

Data sources for Clover Creek are included in Table 6-14.

Field measurements for dissolved oxygen, pH, conductivity, alkalinity and turbidity for the Clover Creek Tributary have all been within acceptable limits.

Temperature

The following is a summary of historical water temperature data for Clover Creek:

- DWR has collected temperature data from approximately two stations within the Clover Creek Watershed. These stations are located near Fern Road and near Millville. These stations are part of the DWR Water Quality and Measurement Program for collecting long-term base data. A review of the data from 1977 through 1982 indicates that the temperature in Clover Creek near Fern Road did not exceeded 25 degrees C during the summer months. A maximum temperature of 22.7 degrees C was observed in June 1977. The Fern Road site is located in the mid-elevation of the watershed and has an elevation of 2680 feet. The Millville station exceeded 25 degrees C several times in the summer months with a maximum temperature of 33.3 degrees C being observed in June 1977. The Millville Station is located at an elevation of 480 feet.

- PG&E maintained a station at Clover Creek and Oak Run Road in the summer of 1992. The daily maximum water temperature observed was 28.8 degrees C (83.8 degrees F). Daily maximum temperatures exceeded 25 degrees C numerous times in August; however, the maximum mean daily temperature observed in August was 21.3 degrees C (70.3 degrees F). This station is located at an elevation of 2700 feet.

- Shasta College collected data from two stations on Clover Creek from 1999 through 2000 for a preliminary watershed assessment. The stations were located on the lower and middle reaches of Clover Creek. Data from the Shasta College study indicated that during the summer months, the temperature in the middle reach of Clover Creek near Fern Road, at an elevation of 2600 feet, averaged 12.5 degrees C, and the maximum temperature observed was 14.2 degrees C. In the lower reach of Clover Creek near Millville (located at an elevation less than 500 feet), the stream temperatures exceeded 25 degrees C numerous times with a daily mean temperature of 24.8 degrees C, and a maximum temperature of 28.0 degrees C.

TABLE 6-14
Summary of Water Quality Data
Clover Creek

Agency	Station ID	Sampling Location	Data Collected	Period of Record	Computer Files
DWR	A4-8160	Near Millville	Nutrients	1979-1981	Microfiche
			Minerals	1952- 1981	Microfiche
			Physical, Temperature	1952, 1977- 1982	Microfiche
	A4-8252	Near Fern Road	Nutrients	1977-1979	Microfiche
			Minerals	1977- 1982	Microfiche
			Physical, Temperature	1977-1982	Microfiche
USGS	11373700	Near Oak Run	Flow	1957-1959	Electronic
DWR		Oak Run Road	Temperature	1992	Electronic
Shasta College	Lower Clover Creek		Temperature, Fecal Coliform, Physical	1999-2000	Electronic
	Middle Clover Creek		Temperature, Fecal Coliform, Physical	1999-2000	Electronic

Nutrients

A summary of nutrient data for Station 8160 located near Millville is provided in Table 6-15. Nutrient values monitored were below the state and federal MCLs.

TABLE 6-15
Nutrient Summary
Clover Creek

Nutrient	Range (mg/l)	EPA Primary Drinking Water MCL (mg/l)
Total ammonia and organic nitrogen (NH3 + Org. N)	0.4-1.0	--
Dissolved nitrate (NO3 as N)	0.02-.29	10.0
Dissolved orthophosphate (PO4)	0.02-0.03	--
Total Phosphorous (P)	0.02-0.37	--

Minerals

A summary of mineral data for Station 8160 located near Millville is provided in Table 6-16. The mineral quality of Clover Creek near the Millville station is good.

TABLE 6-16
Mineral Summary
DWR Millville Station (A4-8160)
Clover Creek

Nutrient	Range (mg/l)	CA Primary Drinking Water MCL (mg/l)	CA Secondary Drinking Water MCL (mg/l)
Dissolved Calcium (Ca)	8.0-12.0	--	--
Dissolved Magnesium (Mg)	1.3-5.8	--	--
Dissolved Sodium (Na)	2.0-6.5	--	--
Dissolved Potassium (K)	1.1-2.4	--	--
Dissolved Sulfate (SO4)	4.0-8.9	500	250
Dissolved Chloride (Cl)	0.0-5.0		250
Dissolved Boron (B)	0.0-0.14	--	--
Total Hardness	27-83	--	--

OLD COW CREEK

Data sources for Old Cow Creek are included in Table 6-17.

Field measurements for dissolved oxygen, pH, conductivity, alkalinity and turbidity for the Old Cow Creek Tributary have all been within acceptable limits.

TABLE 6-17 Summary of Water Quality Data Old Cow Creek					
Agency	**Station ID**	**Sampling Location**	**Data Collected**	**Period of Record**	**Computer Files**
DWR	A4-8448	Near Kilarc Powerhouse	Nutrients	1977-1981	Microfiche
			Minerals, Physical, Temperature	1977-1982	Microfiche
USGS	11372325	Near Kilarc Powerhouse	Flow	1983-1999	Electronic
	11372330	Olson Powerhouse		1990-1999	
	11372350	Below Olson Powerhouse		1990-1997	
DFG		Fern Bridge	Temperature	1992	Electronic
Shasta College	Middle Old Cow Creek		Temperature, Fecal Coliform, Physical	1999-2000	Electronic
Roseburg Resources	33N02E29-#330	Old Cow Creek Mid	Temperature	1996-1998	Electronic
	33N02E20-#332	Old Cow Creek Upper			
	33N02E27-#338	Hunt Creek			

Temperature

The following is a summary of historical water temperature data for Old Cow Creek:

- DWR has collected temperature data from one station within the Old Cow Creek Watershed. This station is located near the Kilarc Powerhouse. This station is part of the DWR Water Quality and Measurement Program for collecting long-term basic data. A review of the data from 1977 through 1982 indicates that the temperature in Old Cow Creek near Kilarc Powerhouse exceeded 25 degrees C once during the summer months, with a maximum temperature observed of 26.1 degrees C in June 1977. The Kilarc Powerhouse site is located in the mid-elevation of the watershed at an elevation of 2600 feet.

- DFG files showed that PG&E maintained a station at Old Cow Creek and Fern Bridge Road in the summer of 1992. The daily maximum water temperature observed was 21.0 degrees C (69.8 degrees F). This station is located in the upper reaches of the Old Cow Creek Watershed near DWR station A4-8448 near Kilarc Powerhouse at an elevation of 2600 feet.

- Shasta College collected data from one station on Old Cow Creek from 1999 through 2000 for a limited watershed assessment. The station was located on the middle reaches of Old Cow Creek. Data from the Shasta College study indicated that during the summer months, the temperature in the middle reach of Old Cow Creek near Olson powerhouse, at an elevation of 2500 feet, averaged 17.2 degrees C, and the maximum temperature observed was 20.8 degrees C.

- Roseburg Resources Company collected data from three stations on Old Cow creek from 1996 to 1998. The maximum temperature observed on the upper and middle reaches of Old

Cow Creek was 19.4 degrees C (62.2 degrees F). The maximum temperature observed in Hunt Creek was 23.4 degrees C (74.1 degrees F). The Roseburg Resources Company stations are located in the mid to upper reaches of Old Cow Creek at elevations shown below:

Station 330 – 3590 feet
Station 332 – 4720 feet
Station 338 – 2990 feet

Nutrients

A summary of nutrient data for Station 8448 located near Kilarc Powerhouse is provided in Table 6-18. Nutrient values monitored were below the state and federal MCLs.

TABLE 6-18
Nutrient Summary
Old Cow Creek

Nutrient	Range (mg/l)	EPA Primary Drinking Water, MCL (mg/l)
Total ammonia and organic nitrogen (NH3 + Org. N)	0.02-0.7	--
Dissolved nitrate (NO3 as N)	0.01-0.13	10.0
Dissolved orthophosphate (PO4)	0.00-0.04	--
Total Phosphorous (P)	0.01-0.12	--

Minerals

A summary of mineral data for Station 8448 located near Kilarc is provided in Table 6-19. The mineral quality of Old Cow Creek near the Kilarc station is good.

TABLE 6-19
Mineral Summary
DWR Kilarc Powerhouse Station (A4-8448)
Old Cow Creek

Nutrient	Range (mg/l)*	EPA Primary Drinking Water MCL (mg/l)	EPA Secondary Drinking Water MCL (mg/l)
Calcium (Ca)	7.0	--	--
Magnesium (Mg)	3.0	--	--
Sodium (Na)	2.2-6.0	--	--
Potassium (K)	1.2	--	--
Chloride (Cl)	0.0-1.0		250
Boron (B)	0.1	--	--
Total Hardness	5-68	--	--

*All constituents are dissolved.

SOUTH COW CREEK

Data available for South Cow Creek are summarized in Table 6-20.

Field measurements for dissolved oxygen, pH, conductivity, alkalinity and turbidity for the Old Cow Creek Tributary have all been within acceptable limits.

Temperature

The following is a summary of historical water temperature data for Old Cow Creek:

- DWR has collected temperature data from two stations within the Old Cow Creek Watershed. These stations are located near Whitmore and Millville. The stations are part of the DWR Water Quality and Measurement Program for collecting long-term basic data. A review of the data from 1977 through 1982 indicates that the temperature in South Cow Creek near Whitmore, at an elevation of 2600 feet, did not exceed 25 degrees C during the summer months. A maximum temperature of 24.4 degrees C was observed in June 1977. At the South Cow Creek DWR station near Millville, the maximum temperature observed was 26.1 degrees C in August 1959, at an elevation of 480 feet.

- USGS maintained one monitoring station periodically on South Cow Creek near Millville, near the DWR station A4-8500, at an elevation of 400 feet. It was monitored periodically 147 times from 1957 to 1968. The maximum temperature observed for the South Cow Creek Station in the summer months was 31 degrees C, and the mean temperature observed during this period for the summer months was 22 degrees C.

- DFG files showed that PG&E maintained a station at South Cow Creek and Ponderosa Way in the summer of 1992. The daily maximum water temperature observed was 22.0 degrees C (71.6 degrees F). This station is located in the upper reaches of the South Cow Creek Watershed near DWR station A4-8555 near Whitmore at an elevation of approximately 1900 feet.

- Shasta College collected data from one station on South Cow Creek from 1999 through 2000 for the preliminary watershed assessment. The station was located on the lower reaches of South Cow Creek at an elevation of less than 500 feet. Data from the Shasta College study indicated that during the summer months the temperature in the middle reach of South Cow Creek near PG&E Cow Creek powerhouse averaged 21.7 degrees C, and the maximum temperature observed was 25.9 degrees C.

- Roseburg Resources Company collected data from two stations on South Cow Creek from 1996 to 1998. The maximum temperature observed on South Cow Creek, at an elevation of 650 feet, was 18.1 degrees C (64.6 degrees F). The maximum temperature observed in Glendenning Creek, at an elevation of 3520 feet, was 14.6 degrees C (58.3 degrees F). The Roseburg Resources Company stations are located in the mid reaches of South Cow Creek.

TABLE 6-20
Summary of Water Quality Data
South Cow Creek

Agency	Station ID	Sampling Location	Data Collected	Period of Record	Computer Files
DWR	A4-8500	Near Millville	Nutrients	1971-1972	Microfiche
			Minerals	1959	Microfiche
			Minor Elements	1977	Microfiche
			Physical, Temperature	1959	Microfiche
	A4-8555	Near Whitmore	Nutrients	1977-1980	Microfiche
			Minerals, Physical, Temperature	1977-1982	Microfiche
USGS	11372080	Near Whitmore	Flow	1984-1999	Electronic
	11372200	Near Millville	Flow	1983-1999	
			Temperature	1956-1968	
			Water Quality	1966-1971	
DFG		Ponderosa Way	Temperature	1992	Electronic
Shasta College	Middle South Cow Creek		Temperature, Fecal Coliform, Physical	1999-2000	Electronic
Roseburg Resources	32N01E02-#334	Glendenning Creek	Temperature	1996-1998	Electronic
	32N01E22-#336	South Cow Creek			

Nutrients

A summary of nutrient data for Station 8555 located near Whitmore is provided in Table 6-21. Nutrient values monitored were below the state and federal MCLs.

TABLE 6-21
Nutrient Summary
DWR Whitmore Station (A4-8555)
South Cow Creek

Nutrient	Range (mg/l)	EPA Primary Drinking Water, MCL (mg/l)
Total ammonia and organic nitrogen (NH3 + Org. N)	0.0-0.22	--
Dissolved nitrate (NO3 as N)	0.00-0.02	10.0
Dissolved orthophosphate (PO4)	0.00	--
Total Phosphorous (P)	0.00-0.11	--

Minerals

A summary of mineral data for Station 8500 located near Millville is provided in Table 6-22. The mineral quality of South Cow Creek near the Millville station is good.

TABLE 6-22
Mineral Summary
DWR Millville Station (A4-8500)
South Cow Creek

Nutrient	Range (mg/l)	CA Primary Drinking Water, MCL (mg/l)	CA Secondary Drinking Water, MCL (mg/l)
Calcium (Ca)	18-21	--	--
Magnesium (Mg)	4.9-8.1	--	--
Sodium (Na)	5.2-6.8	--	--
Potassium (K)	1.1-2.7	--	--
Sulfate (SO4)	0.0-0.6	500	250--
Chloride (Cl)	1.4-2.5		250
Boron (B)	0.02-0.06	--	--
Total Hardness	60-103	--	--

Metals

A summary of minor element data for Station 8500 located near Millville is provided in Table 6-23. This data represent one monitoring event in January 1972. Arsenic, cadmium, iron and manganese exceeded the drinking water standard.

TABLE 6-23
Metal Summary
DWR Millville Station (A4-8500)
South Cow Creek

Nutrient	Range (mg/l)	CA Primary Drinking Water, MCL (mg/l)	CA Secondary Drinking Water, MCL (mg/l)	Basin Plan Standards
Arsenic (As)	0.06	0.05	--	0.010
Cadmium (Cd)	0.01	0.005	--	0.022
Chromium (Cr)	--	--	--	--
Copper (Cu)	0.00	0.1	0.1	0.0056
Iron (Fe)	16	--	0.3	0.030
Lead (Pb)	0.00	0.15	--	--
Manganese (Mn)	0.37	--	0.05	0.005
Mercury (Hg)	--	0.002	--	--
Molybdenum (Mo)	--	--	--	--
Selenium (Se)	--	0.05	--	--
Zinc (Zn)	0.13	--	5.0	0.016

MAIN STEM COW CREEK

Data sources available for the main stem of Cow Creek are included in Table 6-24.

Field measurements for dissolved oxygen, pH, conductivity, alkalinity and turbidity for the main stem of Cow Creek have all been within acceptable limits.

TABLE 6-24
Summary of Water Quality Data
Main Stem Cow Creek

Agency	Station ID	Sampling Location	Data Collected	Period of Record	Computer Files
DWR	A4-8301	Near Millville	Nutrients, Minerals, Minor Elements, Physical, Temperature	1977-1980 1980 1977 1979-1982 1979-1982	Microfiche
	A4-8300	Near Millville	No Data		
	A4-8112	AB Little Cow	Minerals, Physical	1952	Microfiche
	A4-8111	Near Palo Cedro	Nutrients	1988	Microfiche
			Minerals, Physical, Temperature	1974-1990	
	A4-8110	Near Millville	Nutrients	1958-1981	Microfiche
			Minerals	1955-1981	
			Minor Elements	1961-1974	
			Physical, Temperature	1955-1984	
	A4-8101	Anderson	Nutrients	1977-1980	Microfiche
			Minerals	1960-1982	
			Physical	1960-1983	
			Temperature	1960-1983	
USGS	11372500	Near Millville	Flow	1912-1914	Electronic
	11374000	Near Millville	Flow	1949- 2001	Electronic
			Temperature	1955-1979	
Shasta College	Main Stem Low Cow Creek		Temperature, Fecal Coliform, Physical	2000	Electronic
	Main Stem Downstream		Temperature, Fecal Coliform, Physical	1999-2000	Electronic

Temperature

The following is a summary of historical water temperature data for Cow Creek.

- DWR has collected temperature data from five stations within the main stem of Cow Creek. These stations are located near Millville, Palo Cedro, Little Cow and Anderson. These stations are part of the DWR Water Quality and Measurement Program for collecting long-term basic data. A review of the data since 1982 indicates that the temperature in the main stem of Cow Creek near Palo Cedro, Millville, and Anderson had the following maximum temperatures: 26.0 degrees C observed in May 1985, 32.2 degrees C in July 1961, and 28.6 degrees C in July 1977. The main stem of Cow Creek is located at elevations less than 500 feet. DWR data, as summarized by Hannaford in the *Preliminary Water Quality Assessment of Cow Creek Tributaries*, are included as Figure 6-3, and text includes:

> Based on the temperature records for Cow Creek (continuous records from 1995-2000, and current field measurements) the water temperature in the Main Stem of Cow Creek exceeds preferred developmental thresholds for Chinook salmon approximately six months each year (roughly May – October). Furthermore, maximum peak temperatures frequently exceed lethal thresholds (~25 degrees C) for juvenile and adult fish in summer months. The upstream tributary input can account for the bulk of this warm water during the hot summer months. Because the flow in the Main Stem of Cow Creek is dominated by Old Cow Creek and South Cow Creek throughout the summer, temperatures are actually mediated; upstream average and maximum temperature in Little Cow Creek and Oak Run Creek exceeded those of the Main Stem downstream.

- USGS maintained one monitoring station periodically. The station was on Cow Creek near Millville, near the DWR station A4-8110, and was monitored periodically 252 times from 1955 to 1968. The maximum temperature observed for the main stem of Cow Creek Station in the summer months was 33 degrees C, and the mean daily temperature observed for this period during the summer months was 25 degrees C.

- Shasta College collected data from one station on the main stem of Cow Creek from 1999 through 2000 for the watershed assessment. The station was located at an approximate elevation of 400 feet. Data from the Shasta College study indicated that during the summer months the temperature in the lower reach of Cow Creek near Millville averaged 23.6 degrees C, and the maximum temperature observed was 26.3 degrees C.

Nutrients

A summary of nutrient data for Station 8110 located near Millville is provided in Table 6-25. Nutrient values monitored were below the state and federal MCLs.

TABLE 6-25
Nutrient Summary
DWR Millville Station (A4-8110)
Main Stem

Nutrient	Range (mg/l)	CA Primary Drinking Water MCL (mg/l)	CA Secondary Drinking Water MCL (mg/l)
Total ammonia and organic nitrogen (NH3 + Org. N)	0.4-1.0	--	--
Dissolved Nitrite and Nitrate (NO2 + NO3)	0.02-0.19	10.0	--
Dissolved nitrate (NO3 as N)	0.02-0.29	10.0	--
Dissolved orthophosphate (PO4)	0.00-0.05	--	--
Total Phosphorous (P)	0.02-0.37	--	--

Minerals

A summary of mineral data for Station 8500 located near Millville is provided in Table 6-26. The mineral quality of Cow Creek near the Millville station is good.

Minor Elements

A summary of minor element data for Station 8110 located near Millville is provided in Table 6-27. This represents data collected from 1955 to 1974. Copper and lead exceeded the Basin Plan Standard to protect freshwater aquatic life.

TABLE 6-26
Mineral Summary
DWR Millville Station (A4-8110)
Main Stem

Nutrient	Range (mg/l)	CA Primary Drinking Water MCL (mg/l)	CA Secondary Drinking Water MCL (mg/l)
Calcium (Ca)	6.0-20	--	--
Magnesium (Mg)	2.4-8.7	--	--
Sodium (Na)	2.4-13	--	--
Potassium (K)	0.6-2.3	--	--
Sulfate (SO4)	0.2-8.1	500	250
Chloride (Cl)	1.0-14		250
Boron (B)	0.0-0.7	--	--
Total Hardness	21-98	--	--

TABLE 6-27
Metal Summary
DWR Millville Station (A4-8110)
Main Stem

Nutrient	Range (mg/l)	EPA Primary Drinking Water MCL (mg/l)	EPA Secondary Drinking Water MCL (mg/l)	Basin Plan Standards
Arsenic (As)	0.00-0.01	0.05	--	0.010
Cadmium (Cd)	ND	0.005	--	0.022
Chromium (Cr)	ND	--	--	--
Copper (Cu)	ND-0.03	0.1	0.1	0.0056
Iron (Fe)	ND-0.17	--	0.3	0.030
Lead (Pb)	ND-0.01	0.15	--	--
Manganese (Mn)	ND-0.01	--	0.05	0.005
Mercury (Hg)	ND	0.002	--	--
Selenium (Se)	ND	0.05	--	--
Zinc (Zn)	ND-0.02	--	5.0	0.016

ND=Not Detected

CONCLUSIONS

Water quality parameters identified as being at levels of concern should be monitored to identify more specific problems and possible solutions that can be implemented to maintain the various beneficial uses identified within the watershed.

BACTERIA

Fecal coliform concentrations designated for protection of contact recreation are exceeded in portions of the watershed. The tributaries that exceeded contact recreational standards are Little Cow Creek, Oak Run Creek, Clover Creek, and South Cow Creek. The main stem is also suspect. No data are available to determine the origin of the fecal coliform (i.e. human vs. cattle *E. coli* strains). No documentation is available on the effects of fecal coliform on anadromous fish populations.

TEMPERATURE

Although chinook salmon adults and juveniles have access to the lower reaches of the tributaries (less than 2600 feet in elevation) much of this area may have an unsuitable temperature range during the months of May through October. The Shasta College study observed water temperature in the main stem of Cow Creek exceeded preferred thresholds for salmon from May to October (Hannaford, 2000). The rainfall events coincided with a sudden decrease in stream temperatures at all sites (field temperature results were less than 20 degrees C). The reaches above 2600 feet have lower summer temperatures; however, access to the higher reaches is limited to most salmon adults and juveniles by a steep gradient change and geologic features. The areas of the Cow Creek Watershed that have exhibited temperatures in excess of 25 degrees C during the period May to October are shown on Figure 6-4. Essentially, all of the available fish habitat below barriers in the Cow Creek Watershed may be temperature-limited from May to October.

DATA

Water quality data in the Cow Creek Watershed are inadequate to characterize water quality differences between tributaries, and are insufficient to evaluate long-term trends in watershed conditions that may result from future restoration activities. Available water quality data are for discrete locations and, in general, are greater than 20 years old and poorly documented. Additional monitoring is required to determine when and where specific problems exist before significant restoration efforts are undertaken.

ACTION OPTIONS

1. Further document water quality standard exceedances and determine source of fecal coliform in identified tributaries. Depending upon the source of fecal coliform, various solutions can be implemented to minimize impacts. Solutions can include: a.) Initiate a septic system prohibition and rehabilitation program; b.) Create treatment zones for uptake of nutrients and pathogens resulting from livestock and irrigation runoff.

2. Develop a baseline monitoring program to evaluate water quality throughout the watershed to identify areas of concern.

3. Develop a plan to identify factors contributing to elevated water temperatures, such as irrigation return flows, riparian community vegetation changes, or diversion of stream flow.

4. Evaluate the effectiveness of vegetation management alternatives to manage seasonal surface runoff and underflow. Evaluate the effectiveness of removal of upslope native and non-native species (blackberries) and brush thinning to increase flows in springs and in underflow for creek recharge.

5. Offer livestock and small animal operators increased opportunities to participate in voluntary cooperative water quality short courses. These courses are designed to help livestock operators understand the possible sources of livestock impacts to water quality and identify alternatives to reduce water quality impacts. Sources of technical and financial assistance are identified to assist landowners in reducing water quality impacts.

6. Encourage voluntary landowner participation in educational opportunities such as water quality short courses, field demonstrations and distribution of water quality "Fact Sheets" through the Cow Creek Watershed Management Group.

7. Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water quality impacts.

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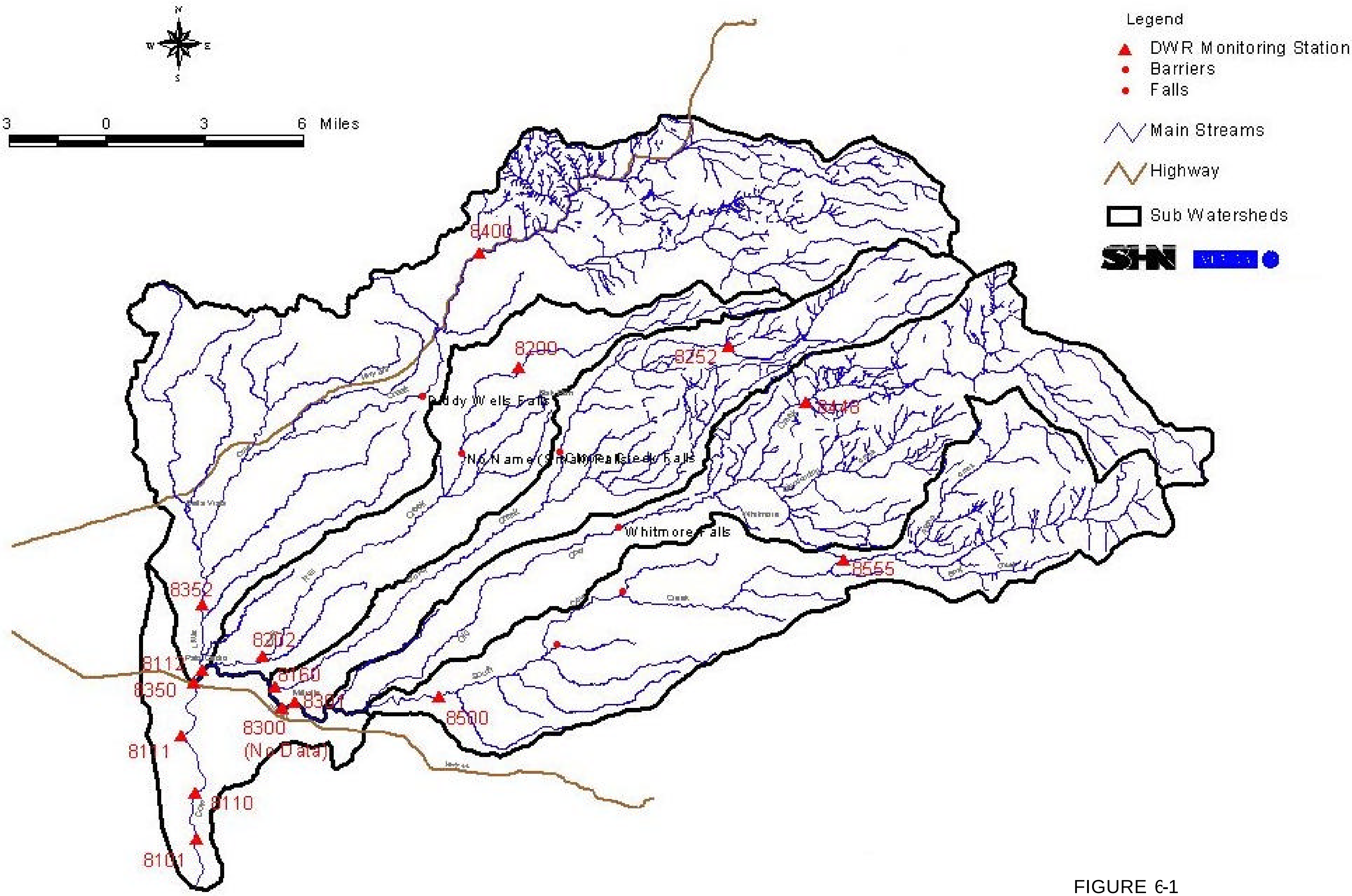


FIGURE 6-1
HISTORIC DWR MONITORING STATIONS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: DWR

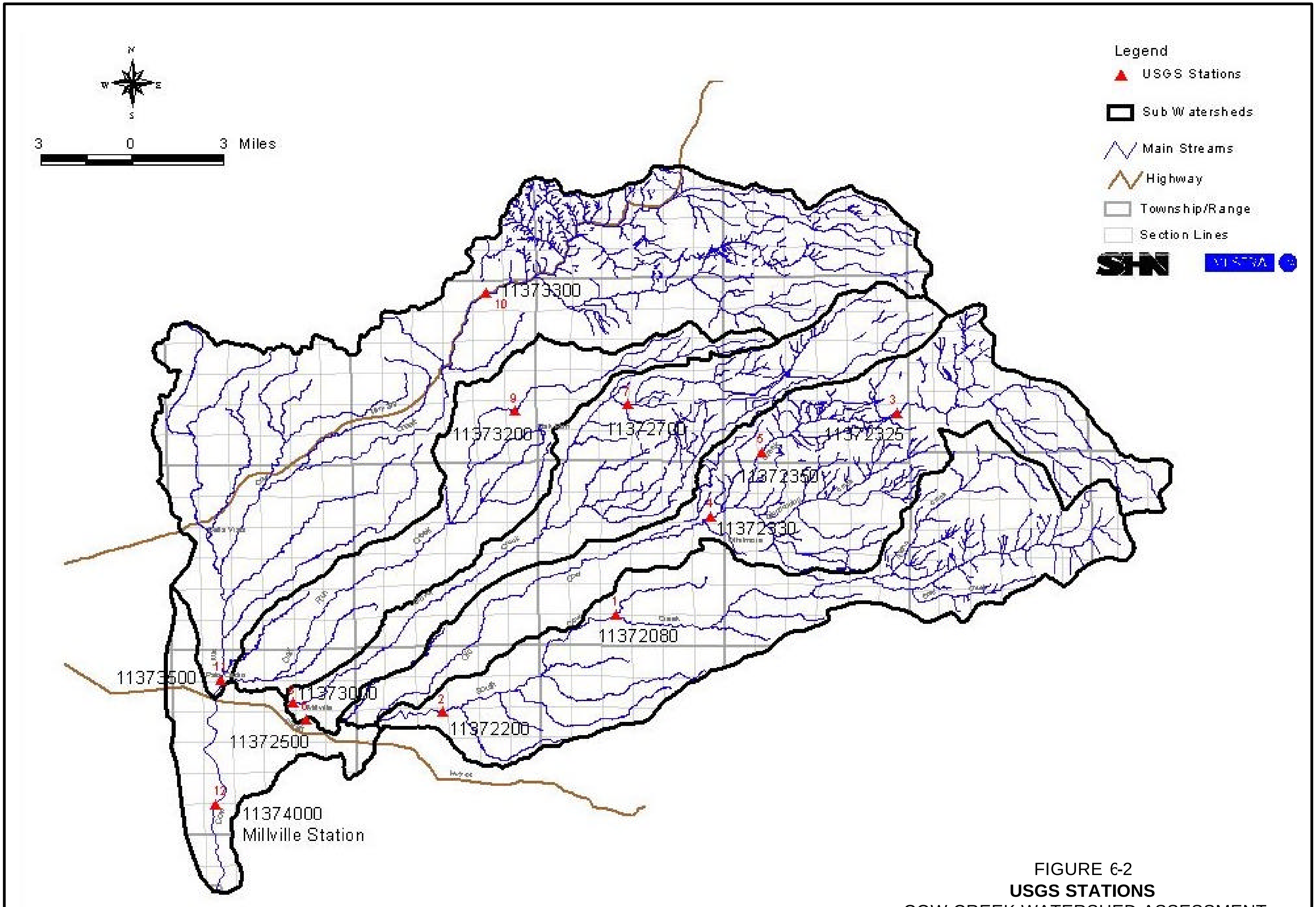
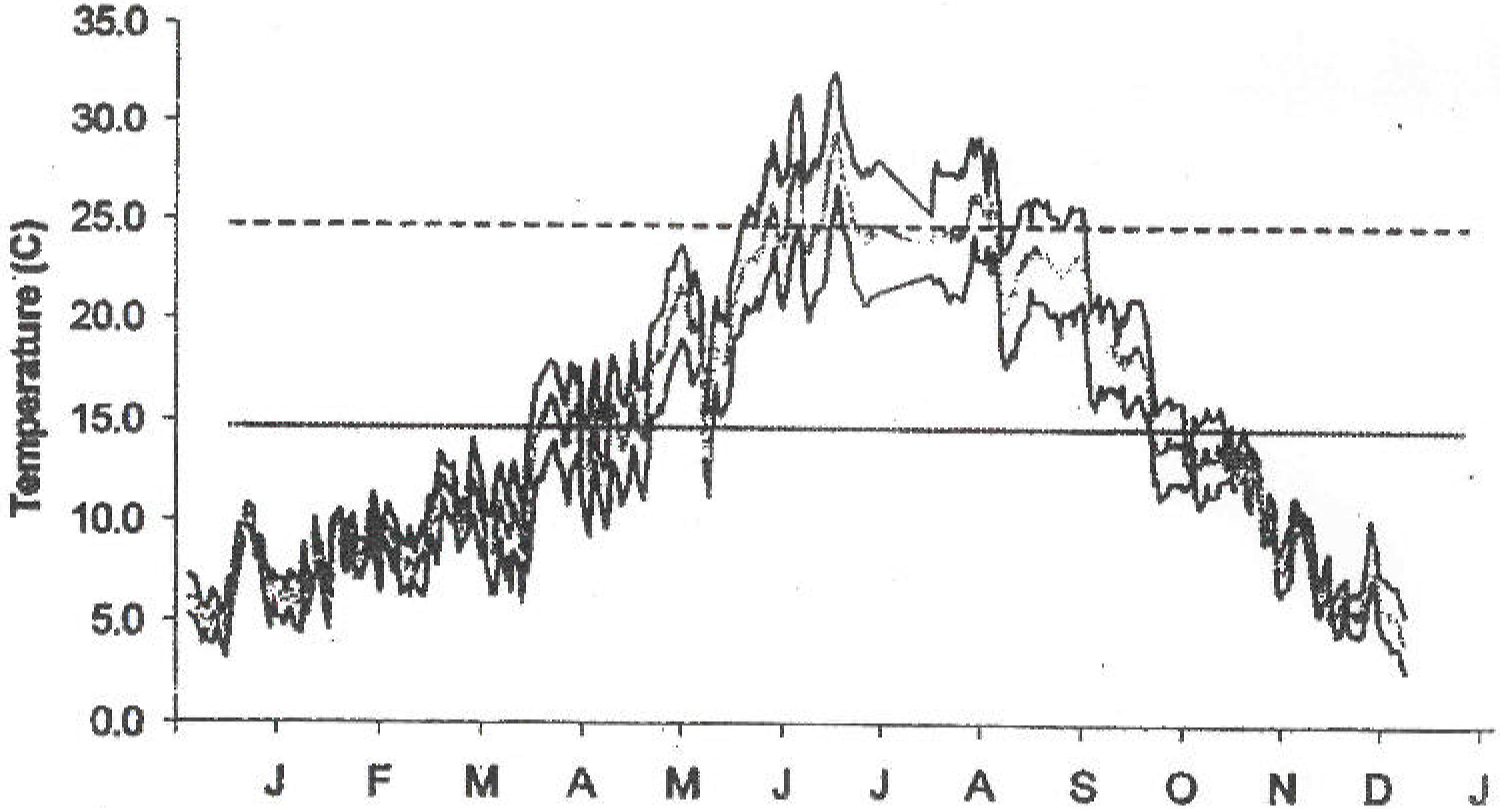


FIGURE 6-2
USGS STATIONS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: USGS



Daily range (maximum/minimum) and average water temperatures in 1999 for the Main Stem Cow Creek, near Palo Cedro. The dotted line is preferred developmental temperature, and the dashed line is lethal temperature thresholds for juvenile Chinook salmon (based on published data). Data for Jun 26 – Aug 9 are estimated because of sensor failure. Data source DWR.

FIGURE 6-3
DAILY RANGE (MAX/MIN) AND AVERAGE WATER TEMPERATURES IN 1999
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

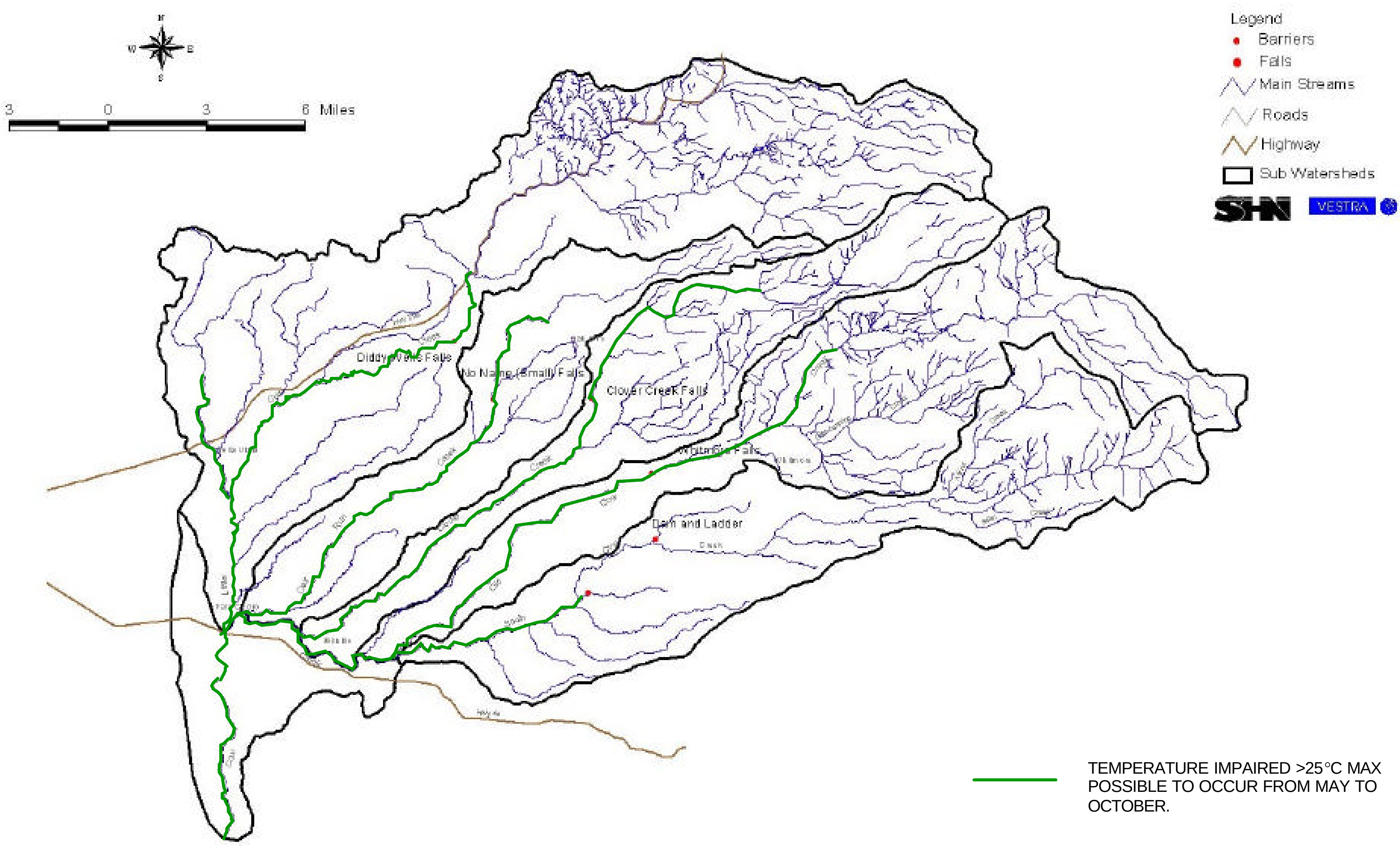


FIGURE 6-4
TEMPERATURE IMPAIRED SEGMENTS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: DWR

Section 7
BOTANICAL RESOURCES

Section 7
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Section 7
BOTANICAL RESOURCES

REFERENCE CONDITIONS

The vegetation of the Cow Creek Watershed has changed significantly since the arrival of the first white settlers. These changes include changes in species composition, diversity and density. The vegetation we see today is a far cry from the "natural" communities that existed before the arrival of the white settlements.

The two primary forces that have modified the natural vegetation in the Cow Creek Watershed are the introduction of non-native species and exclusion of naturally occurring and aboriginal fire in the ecosystem. Climate, grazing, timber management, and mining have also modified pre-European vegetation.

Beginning with seeds in the bellies of Spanish cattle through ornamental introduction of the twentieth century, the natural ecosystem of Cow Creek's vegetative communities has been bombarded by competition from non-native plants. In many instances, non-native species are well adapted to the climate of California, which resembles the Mediterranean climate of the native countries of most of the imported species. These non-natives are not only well adapted to California's climate, but lack the natural pests and diseases to control their growth and development. In addition, many are of minimal palatability to native wildlife. It was free sailing for the original non-native plant colonists.

Most of the weeds present in our ecosystem today were imported within the last 150 years. Common weeds should be differentiated from noxious weeds discussed later in this chapter. Noxious weeds are those which pose a serious commercial or ecological threat and whose control is regulated or watched with concern.

One hundred years of aggressive fire suppression has dramatically changed the character of all of the ecological communities in the Cow Creek Watershed. Historic grassland communities consisted of perennial bunch grasses, which required fire for regeneration. Foothill oak woodland and grassland communities required fire to limit the invasion of brush species, to clear duff for oak regeneration, and to rejuvenate forbs and perennial grass cover. Pre-European forests were open and park-like. Prior to the 20th century fire suppression efforts, lightning and native peoples ignited forests. Pre-settlement fire return intervals were generally less than 20 years throughout a broad zone extending from the foothills though the mixed conifer forests.

It is now widely accepted that early Native Americans used fire widely as a tool, both for hunting and to manage the resources needed for survival. This included the burning of grasslands to improve basket materials, burning of foothills to assist in hunting small game and to encourage new edible shoots, and burning in the coniferous forests to assist in hunting and to keep the forests open and passable. In addition, use of seeding and oak management to augment food supplies is documented (Anderson, 1993).

Reference characteristics of each of the primary vegetative communities found in Cow Creek are discussed below. Actual site-specific data are lacking with the exception of interviews and historical journals and letters. Much of the description below has been interpreted from areas similar to Cow Creek where historic community relationships have been documented.

VALLEY AND FOOTHILL GRASSLANDS

Before 1769, only native deer, elk and antelope grazed over grassland dominated by perennial species and best developed in the northern half of California. The drier soils of the plains and foothills supported a grassland community which included purple stipa, *(Stipa pulchra*), nodding stipa *(Stipa cernua*), pine bluegrass *(Poa scabrella),* blue wild rye *(Elymus glaucus),* California melic *(Melica californica),* small-flowered melic *(Melica imperfecta),* California Brome *(Bromus carinatus),* Junegrass *(Koeleria cristata),* and California Oatgrass *(Danthonia californica).* Big Squirreltail *(Sitanion jubatum)* was common on infertile soils where other grasses would be scarce. Creeping Wildrye *(Elymus triticoides),* Slender wheatgrass *(Agropyron trachycaulum),* Bearded wheatgrass *(Agropyron subsecundum),* Meadow barley *(Hordeum brachyantherum),* Deer grass *(Muhlenbergia rigens),* Pinegrass *(Calamagrostis rubescens),* and Prairie wedgegrass (*Sphenopholis obtusata*) were found on the rich loams at the edge of the tule marshes along the Sacramento River. In the marshes or at the edge of the rivers, perennials such as tufted hairgrass *(Deschampsia caespitosa),* Spike bentgrass *(Agrostis exarata),* Reed canarygrass *(Phalaris arundinacea),* Knotgrass *(Paspalum distichum),* Foxtail barley *(Hordeum jubatum),* common reed *(Phragmites australis),* rice cutgrass *(Leersia oryzoides),* and an annual, American sloughgrass *(Beckmannia syzigachne)* were abundant.

Hunt family letters document grasses so high as to touch the belly of a horse along Oak Run Creek. Species composition was not addressed. Star thistle and related weeds were not noted.

The character of the grassland was dramatically altered when European livestock entered southern California in 1769 with the Spanish soldiers and the missionary Fathers. Cereals and fruits were soon imported and grown around the missions established along the coast. Other plants were also introduced-some purposely and some accidentally. The accidents were the casual weeds which were transported in animal hair, packing materials, ship ballasts or in soil surrounding fruit cuttings. Most of these weeds were annuals, and many were grasses: Red Brome *(Bromus rubens),* Downy chess *(Bromus tectorum),* False foxtail fescue *(Festuca myuros),* European foxtail *(Festuca bromoides),* foxtail fescue *(Festuca megalura),* hare barley *(Hordeum leporinum),* Glaucous barley *(Hordeum glaucum),* Nitgrass *(gastridium ventricosum),* purple falsebrome *(brachypodium distachyon),* and silver hairgrass *(Aira caryophyllea).* The early Spaniards may have directly imported seeds of wild oats *(Avena fatua),* slender wild oats *(Avena barbata),* annual ryegrass *(Lolium multiflorum)* and perhaps even soft chess *(Bromus mollis),* and ripgut *(Bromus diandrus)* – as all of these species had proven their worth as animal forage elsewhere.

The important annual legume, Bur clover *(Medicago polymorpha)* and the filarees *(Erodium sp. E. botrys, E. obtusiplicatum, E. cicutarium, and E. moschatum)* were probably directly imported as proven and valuable sheep forage. Without a doubt, impurities, which were weedy species of far less forage value, were carried in the imported seed.

The forage and weedy annuals soon became well established in the mission areas and eventually spread inland as the animal grazing area advanced. Great herds of animals grazed around the missions and still greater numbers on the large ranchos. Many areas were overgrazed, which placed added stress on native vegetation. The aggressive, well-adapted European annuals fared well – so well that they eventually became dominant.

Cereal farming in the mid 1800s quickly removed additional native grassland. Later, more diversified and extensive agriculture removed still more native grassland. Improvement of the natural dry pastures in the last 50 years has introduced several high-yielding annual Clovers *(Trifolium* sp, *T. hirtum, T. subterraneum*, and *T. incarnatum)* along with a perennial, Harding grass (*Phalaris tuberosa var. stenoptera*). Both types of plants originate in the Mediterranean region. The current management practices of the valley and foothill ranges favor development of the best resident annual forage grasses or recommend seeding superior forage species. (See the following discussion on seed mixes). Scattered remnant areas of the California grassland still exist in isolated areas, but possibly not for long. Some species such as Prairie wedgegrass, pinegrass, Junegrass, small-flowered melic, and California oatgrass have long since disappeared from the Central Valley, but may be found in the surrounding foothill regions.

FOOTHILL COMMUNITIES

As with the reference condition grassland community summary, little evidence is available specific to the Cow Creek Watershed. Data presented are extrapolated from documentation from similar communities within the Sierra Nevada foothill communities.

As with the grassland communities, naturally occurring or aboriginal fire was a dominant feature. Burning was accomplished to meet the food and fiber needs of the aboriginal society. Acorns, young sprouts and pine nuts were key food elements from the foothill community and aboriginal peoples employed fire to maximize production of these elements. The general species composition of the woody component (trees and shrubs) has likely not changed significantly in the last 150 years and the actual species list remains the same. The size, density and relative dominance of the individual species has changed significantly. Stands are composed of smaller, denser trees. Brush species predominate in the understory and have made passage difficult, if not impossible throughout much of the area, affecting movement of both humans and animals. Dense monoculture stands of manzanita (*Arctostaphylos* sp.) are now common in the watershed.

As in the grassland community, the understory grasslands have been replaced by annual invaders that have, in addition to the suppression of fire, reduced the frequency and number of pine and oak regeneration.

California oak woodland communities have been impacted by changes in understory species, lack of fire, development pressure, over-grazing and harvesting. In 1986, the integrated hardwood range management program was initiated through numerous state agencies and the University of California. The goal of the program is to maintain and increase California's hardwood range resources.

CONIFEROUS FOREST

Coniferous forests in the Cow Creek Watershed have undergone significant changes in the last 100 years, as have the coniferous forests throughout California. While there are many factors that have contributed to change, the primary factor affecting the change in this community is likely the exclusion of fire. Climate, as well as resource management activities, have also changed forest composition.

Historically, these forests consisted of large mature individuals with only a grass understory. Undergrowth was minimal and consisted of small aggregations of individual regeneration. These forests were dominated by shade intolerant species such as ponderosa pine and sugar pine. White fir, Incense cedar and Douglas fir were incidental co-dominates. Today's forests are dominated by shade tolerant co-dominate trees and a dense understory of shade tolerant species, with significant fuel loading and fire danger.

No detailed accounts of the early forests specific to the Cow Creek Watershed were found. Similar ponderosa pine forests and other coniferous forests in California are described in the literature by Cooper, Muir and others. Excerpts from this literature follow.

Ponderosa pine forests of the Southwest were described by Cooper (1952), who notes that:

> …they used to be open, park-like forests arranged in a mosaic of discrete groups, each containing 10 to 30 trees of a common age. Small numbers of saplings were dispersed among the mature pines, and luxuriant grasses carpeted the forest floor. Fires, when they occurred, were easily controlled and seldom killed a whole stand…
>
> Today, dense thickets of young trees have sprung up everywhere in the forests. The grass has been reduced, and dry branches and needles have accumulated to such an extent that any fire is likely to blow up into an inferno that will destroy everything in its path. . . .
>
> Lightening is frequent in the ponderosa pine region, and the Indians set many fires there. Tree rings show that the forests used to burn regularly at intervals of three to 10 years. The mosaic pattern of the forest has developed under the influence of recurrent lightening fires. Each even-aged group springs up in an opening left by the death of a predecessor.

A similar mosaic of open even-aged stands was described in the Sierra Nevada by Muir:

> The inviting openness of the Sierra woods is one of their most distinguishing characteristics. The trees of all the species stand more or less apart in groves, or in small irregular groups, enabling one to find a way nearly everywhere, along sunny colonnades and through openings that have a smooth, park-like surface. . . .

Biswell (1968) characterizes pre-settlement forests as:

> California's primitive forests were kept open and park-like by frequent surface fires set by lightening and by the Indians. The forests were in a stable equilibrium, immune to extensive crown fires.

Few early photographs of Cow Creek are available; however, numerous historic photographs of the Walker family timber holdings to the south were reviewed. These photos depict the open pine forest with grass understory described by Cooper, Muir, and Biswell. Unfortunately, Walker family photo locations were not recorded to allow return to the same locations to show change over time.

The USFS, Bitterroot National Forest provides the best pictorial description of 80 years of change in a ponderosa pine forest. Although located in Montana, the forest type and species composition are extremely similar to the forests in the Cow Creek Watershed.

The photo series history, taken from the same location by the Bitterroot Ecosystem Management Research Project, USFS, shows the species and density changes resulting from fire exclusion. This six-photo series is included herein to depict the change that likely occurred over time in the Cow Creek Watershed.

Interviews with long-time residents and Walker timberland photos support the similarity of Cow Creek vegetation change to the Montana series. The exception is that the overall productivity of Cow Creek timberland is greater than in Montana so that the changes occurred more quickly and the documented vegetation seen in the 1989 photo likely occurred in Cow Creek by 1960.

Early pre-settlement fires were low intensity, creeping fires that consumed only dead, down materials. Fast moving crown fires, common today, only rarely occurred. Only infrequently did fire consume mature individual trees. Over a century of wildfire control and prevention has created forests that are smaller, younger, and denser. These new forests have undergone significant changes in species composition and structure. They are now multi-level stands with a ladder fuel structure. Fires that occur are immediately carried into the tree crowns by the ladder fuels. Once the tree crowns, the fires move quickly with great intensity and are all but impossible to control. Fires that do occur have become larger and more devastating.

Fuel increases are first documented by ranchers and timber managers. As late as the 1920s, ranchers continued to ignite understory vegetation as herds were driven from the high country in the fall. In addition, foothill grassland communities were burned to reduce encroaching brush and non-native species.

Livestock management and use has also played a key roll in development of the ecological communities we see today. Although actual numbers of livestock in the Cow Creek Watershed are poorly documented, extensive grazing by cattle and sheep is mentioned.

Between 1890 and 1920, cattle and sheep grazing reached a peak in Northern California. In the 15 years from 1880 to 1896, 20,000 – 80,000 head of sheep left California through the Noble Trail, with as many as 6,000 – 18,000 head per drive. Between 1870 and 1900, sheep were exported by the thousands to the Midwest from California. Muir described the aftermath of sheep passage:

> Incredible numbers of sheep are driven to the mountain pastures every summer, and their course is ever marked by desolation. Every wild botanic garden is trodden down, the shrubs are stripped of leaves as if devoured by locusts, and the woods are burned. Running fires are set everywhere, with a view to clearing the ground of prostrate trunks, to facilitate the movements of the flocks, and improve the pastures. The entire forest belt is thus swept and devastated from one extremity of the range to the other… Indians burn off the underbrush in certain localities to facilitate deer hunting. Mountaineers carelessly allow their campfires to run, so do lumbermen, but the fires of the sheepmen or *Muttoneers*, form more than ninety percent of all destructive fires that range the Sierra Forests.

By the 1920s the use of prescribed fire had been eliminated and grazing pressures greatly reduced.

EXISTING PLANT COMMUNITIES AND THEIR DISTRIBUTION

The Cow Creek Watershed has a diverse flora and a variety of plant community types, which are a result of the varying topography, substrate, and elevations found in the watershed. Elevations range from approximately 500 feet at the Sacramento Valley Floor to 6700 feet in the Latour State Forest, which is located in the southern portion of the Cascade Range. Native plant communities include:

- riparian forest
- wetlands (i.e., freshwater marsh, vernal pools, seeps, and montane wet meadows)
- valley and foothill grassland
- blue oak-foothill pine woodland
- chaparral
- coniferous forest

Source: USFS

Source: USFS

Source: USFS

Source: USFS

Source: USFS

Source: USFS

The vegetation types are generally divided by elevation. The higher elevations support coniferous forests. The middle elevations support foothill grassland, blue oak-foothill pine woodland, and chaparral. The lower elevations support valley and foothill grassland, and blue oak-foothill pine woodland, and have been most influenced by human development. Development is concentrated in the lower section of the Cow Creek drainage, especially near Highway 44, and the Palo Cedro area.

COMMUNITY TYPES AND DESIGNATIONS

The designations used for naming the plant communities within the watershed are based on the classification names used in the U.S. Geological Survey-Biological Resources Division's Gap Analysis Program (GAP). By using this analysis and the California Department of Fish and Game's *Preliminary Descriptions of the Terrestrial Natural Communities of California* (Holland, 1986) and *A Manual of California Vegetation* (Sawyer and Keeler-Wolf, 1995), the communities were grouped into general community types. Table 7-1 shows the relationship between the GAP plant community designations used in this narrative, Sawyer & Keller-Wolf, NDDB/Holland, and Cheatham &Haller. The vegetation map included in this section (Figure 7-1) depicts the distribution of the GAP vegetation types within the Cow Creek Watershed. Table 7-2 presents the number of acres of each vegetation community type.

TABLE 7-1
Plant Community Designations

<table>
<tr><th>GAP Sub-Community Type</th><th>Sawyer & Keeler-Wolf</th><th>Cheatham & Haller</th><th>NDDB/Holland</th></tr>
<tr><td colspan="4">Grasslands</td></tr>
<tr><td>Non-Native Grassland</td><td>California Annual Grassland Series</td><td>Cismontane introduced Grasses</td><td>Valley and Foothill Grasslands</td></tr>
<tr><td>Agricultural Lands</td><td>Not Represented</td><td>Not Represented</td><td>Not Represented</td></tr>
<tr><td colspan="4">Chaparral</td></tr>
<tr><td>Mixed Chaparral</td><td>Chaparral Whitethorn Series</td><td>Mixed Chaparral</td><td>Upper Sonoran Mixed Chaparral</td></tr>
<tr><td colspan="4">Riparian Forest</td></tr>
<tr><td>White Alder Riparian Forest</td><td>White Alder Series</td><td>Northern Riparian Woodlands</td><td>Riparian Forest</td></tr>
<tr><td colspan="4">Woodlands</td></tr>
<tr><td>Blue Oak Woodland</td><td>Blue Oak Series</td><td rowspan="4">Blue Oak Woodland</td><td>Cismontane Woodland</td></tr>
<tr><td>Foothill Pine Oak Woodland</td><td rowspan="3">Foothill Pine Series</td><td></td></tr>
<tr><td>Open Foothill Pine Woodland</td><td rowspan="2"></td></tr>
<tr><td>Non-Serpentine-Foothill Pine Woodland</td></tr>
<tr><td colspan="4">Mixed Conifer Forest</td></tr>
<tr><td>Westside Ponderosa Pine Forest</td><td>Ponderosa Pine Series</td><td>Westside Ponderosa Pine Forest</td><td>Lower Montane Coniferous Forest</td></tr>
<tr><td>Sierran Mixed Coniferous Forest</td><td>Mixed Conifer Series</td><td>Sierran Mixed Conifer Forest</td><td>Lower Coniferous Forest</td></tr>
<tr><td colspan="4">Conifer Forest</td></tr>
<tr><td>Red Fir Forest</td><td>Red Fir Series</td><td>Red Fir Forest</td><td>Upper Montane Coniferous Forest</td></tr>
<tr><td colspan="4">Wetlands</td></tr>
<tr><td>Wetlands</td><td>Sedge Series</td><td>Meadow and Swamps</td><td>Meadow and Seeps</td></tr>
</table>

TABLE 7-2 Vegetation Community Type Acres	
Community Type	**Est. Acres**
Grassland Community	
Agricultural Lands	1,694
Non-native Grassland	9,378
Native Grassland	
Chaparral	
Mixed Chaparral	3,877
Riparian Forest	
White Alder Riparian Forest	3,862
Woodlands	
Blue Oak Woodland	16,875
Foothill Pine-Oak Woodland	112,212
Open Foothill Pine Woodland	2,586
Non-serpentine-Foothill Pine Woodland	1,397
Conifer Forest Communities	
Westside Ponderosa Pine Forest	25,981
Sierran Mixed Conifer	93,690
Red Fir Forest	2,233
Wetlands	
Wetlands	899
Total Acres	**274,684**

Grassland Communities

The native grassland community has all but vanished from the California landscape due to the invasion of non-native competitors and the exclusion of fire. It is possible the community exists in isolated areas of the Cow Creek Watershed, but its existence has not been documented. It is discussed here briefly and in more detail under Reference Conditions.

Due to the similar vegetation that exists within non-native grasslands and agricultural lands within the Cow Creek Watershed, these were grouped together in the Grassland Community Type for this assessment. Both sub-communities are located in the lower portion of the watershed where traditional grazing and haying practices have been in place for over 100 years. Many of the non-native grasslands and agricultural lands intermingle with or are the understory of other communities, such as the blue oak-foothill pine community.

Native Grassland. California native grasslands included a large component of perennial bunch grasses and, in general, throughout most of the valley and foothill areas of the Sacramento Valley the native grass communities have been replaced by the non-native annual grasslands discussed below. No field surveys were completed for the mapping of the vegetation section. California native grasslands are often found only as remnant populations in remote areas. The native grassland community required fire for regeneration success and revitalization. In the absence of fire and annual non-native competitors, these communities have all but been removed from the watershed.

Should remnant communities exist, they would likely contain a mix of the following species: Purple needlegrass *(Nassella pulchra)*; California oatgrass *(Danthonia californica* var. *americana*) (at high elevations); Nuttall's fescue (*Vulpia microstachys*); big squirrel tail (*Elymus multisetus*);

bluedicks, *(Dichelostemma capitalum)* Indian soap root (*Chlorogalum pomeridianum* var. *divaricatum*); California brodiaea (*Brodiaea californica*); and wild onion (*Allium* spp.).

Other grasses and associated special include:
California fescue *(Festuca californica);* California melic *(Melica californica)*; Foothill needlegrass *(Stipa lepida)*; Nodding needlegrass *(Stipa cernua)*; One-sided bluegrass *(Poa secunda)*; Purple needlegrass *(Stipa pulchra)*; Tufted reedgrass (*Calamagrostis koelerioides)*; Soft chess *(Bromus hordeaceus).*

Non-Native Grassland. Non-native annual grassland occurs at lower elevations in the Sacramento Valley and extends into openings within blue oak-foothill pine in the foothill zone of the watershed. The foothill zone generally occurs below 2500 feet in elevation. Non-native grassland types include both native and non-native grasses.

Non-native annual grassland supports a variety of annual grasses and associated forbs. Dominant species include wild oats (*Avena* spp.), foxtail chess *(Bromus madritensis),* soft chess (*Bromus hordeaceus),* ryegrass *(Lolium perenne),* dogtail grass *(Cynosurus echinatus),* and ripgut brome *(Bromus diandrus).* Annual and perennial forbs are common associates and include filaree *(Erodium* spp.), California poppy *(Eschscholzia californica),* elegant brodiaea *(Brodiaea elegans),* and common brodiaea *(Brodiaea californica* var. *californica).*

Sensitive plants that can be found in grasslands include: Henderson's Bent Grass *(Agrostis Hendersonii),* Slender Orcutt grass *(Orcuttia tenuis*), and Ahart's Paronychia *(Paronychia Ahartii).* Scattered valley oaks *(Quercus lobata)* and interior live oaks *(Quercus wizlizenii)* are also found in this community. Non-native annual grassland is characteristically invaded by exotic species such as yellow starthistle *(Centaurea solstitialis),* Medusahead grass *(Taeniatherum caput-medusae,* Klamath weed *(Hypericum perforatum)* Dalmatian toadflax *(Linaria dalmatica)* and bull thistle *(Cirsium vulgare).*

Limited areas of vernal pools can be present within grasslands at lower elevations (see Sensitive Plant Communities Section). Locations have not been mapped, but are generally scattered throughout the lower watershed on more impermeable or poorly drained soils and may be mixed with other vegetation communities.

Agricultural Lands. Portions of the Cow Creek Watershed include agricultural lands that are predominately irrigated pasture for livestock and hayed fields. The composition of irrigated pasture lands vary by proposed use and elevation in the watershed. They include perennial ryegrass (*Lolium perenne*), crop barley (*Hordeum vulgare*), alfalfa (*Medicago saliva*), rose clover (*Trifolium hirtum*), and white clover (*Trifolium repens*). Much of the irrigated ground includes historic wet meadow areas of the upper foothills and forest areas.

Typical pasture seed mixes used in the watershed include combinations of orchard grass (Potomac), tetraploid perennial ryegrass, tetraploid annual ryegrass, Salina strawberry clover, broad-leaf trefoil, Landino clover, and tall fescue.

Typical dryland and erosion control mixes used historically and today include (all of which are non-native) barley, annual ryegrass, crimson clover, rose clover, Blando brome, smooth brome, subclover, fescue (creeping red and Faron tall), orchard grass, and subterranean clover.

Mixed Chaparral Community

The Chaparral Communities within the Cow Creek Watershed are predominantly Oregon Oak (shrub) and Whiteleaf manzanita. Table 7-3 lists special-status plant species that are associated with chaparral habitat including: Shasta clarkia (*Clarkia boreallis* ssp. *arida*), and Butte County fritillary (*Fritillaria eastwoodiae*). Chaparrals are fire-adapted communities - they do well following catastrophic fire and are often a transitional species for recovery of coniferous forests following fire in California. Many chaparral species have reproductive methods that are dependent on periodic and/or recurring fires. In the absence of fire, the stands often become overly dense resulting in cataclysmic fire. Also, in the absence of fire, certain chapparel species can be significant invaders to grassland and foothill oak woodland types. Some brush species become decadent and start to loose their nutritional value for browse species, such as deer. Such is true for much of the middle elevations of the Cow Creek Watershed. Dense expanses of whiteleaf manazanita are common throughout the elevational band from the valley floor to 3500 feet.

Oregon Oak (Shrub). This is the primary chaparral series in the Cow Creek Watershed. Oregon Oak *(Quercus garryana* var. *garryana*) is common in the foothills on upper slopes, usually rocky and steep. The Oregon Oak grows in thin soils, commonly at higher elevations than the tree form. Associated shrub species include greenleaf manzanita (*Arctostaphylos patula*), huckleberry oak (*Quercus vaccinifolia*), mountain whitethorn (*Ceanothus cordulatus*), pinemat manzanita (*Arctostaphylos nevadensis*), tobacco brush (*Ceanothus velutinus*), and/or wedgeleaf ceanothus (*Ceanothus cuneatus*).

Whiteleaf or Common Manzanita Chaparral. This is the secondary chaparral series in the Cow Creek Watershed. Whiteleaf manzanita *(Arctostaphylos viscida* ssp. *viscida)* is common and widespread in the foothills and the lower coniferous forest. In these areas it supports dense mature stands of even aged composition. The stands generally occur on shallow soils derived from ultra-mafic material (Sawyer and Keeler-Wolf 1995). Whiteleaf manzanita chaparral occurs at elevations from 500 feet to 3500 feet with exceptions at higher elevations as a result of recent fire. It dominates the Oregon oak community where water is scarce and summer temperatures are extreme. It is common on south facing slopes, especially in the Little Cow Creek drainages. Associated shrub species include chamise *(Adenostoma fasciculatum),* big manzanita *(Arctostaphylos manzanita),* buckbrush *(Ceanothus cuneatus),* mountain whitethorn *(Ceanothus cordulatus),* deerbrush *(Ceanothus integerrimus),* and scrub oak *(Quercus berberidifolia).*

Riparian Forest Community

White Alder Riparian Forest. The white alder (*Alnus rhombifolia*) riparian forest is the primary riparian forest community found in the Cow Creek Watershed. This riparian forest is found primarily along the sub-drainages within the watershed. Tree and shrub species are generally deciduous. White alder trees are common along the edges of streams and creeks from the valley floor into the lower coniferous forest, an elevation range of 500 to 4000 feet. The riparian corridor of this community is much narrower than other riparian communities common to the Sacramento Valley, due to the steep canyons, bedrock channels, and fast-flowing water common in the upper limits of the watershed. Common species include white alder, willow (*Salix* spp.), and valley oak. Secondary vegetation consists of blue oak, non-native annual grass, and buckbrush. Shasta snow wreath, a special-status plant, is associated with the riparian forest community.

The riparian forest community has been significantly affected by the colonization of non-native invasive species, specifically Himalayan blackberry, Johnson grass *(Sorghum halepense),* and fig *(Ficus carica).* Isolated populations of Giant reed *(Arundo donax)* are documented along the mainstem of Cow Creek near developed areas. Scotch Broom and Tree of Heaven are also riparian invaders. Many areas of white alder forest type have been converted to blackberry scrub.

Mixed Riparian Forest. The mixed riparian forest was likely the dominant type of riparian community along the lower reaches of the tributaries and the mainstem of Cow Creek. Today, remnant areas remain. Historically this community contained western sycamore *(Platanus racemosa)*, Fremont cottonwood *(Populus fremontii)*, yellow willow *(Salix lasiandra)*, and California black walnut *(Juglans hindsii)*. There is often an understory of box elder *(Acer negundo)*, red willow *(Salix laevigata)*, and sandbar willow *(Salix exigua)*. Understory species include California blackberry *(Rubus ursinus)*, mugwort *(Artemisia douglasiana)*, love grass *(Eragrostis pectinacea* var. *pectinacea)*, blue elderberry *(Sambucus mexicana)*, California mutton-willow *(Cephalanthus occidentalis)*, mule fat *(Baccharis salicifolia)*, and lianas of California wild grape *(Vitis californica)*, pipe vine *(Aristolochia californica)*, and virgins bower *(Clematis ligusticifolia)*.

This riparian forest has been significantly impacted by development especially in the mainstem area near Palo Cedro and the invasion of non-native species.

Like the white alder community, the mixed riparian forest community has been significantly affected by Himalayan blackberry, Johnson grass *(Sorghum halepense)*, fig *(Ficus carica)*, and Giant reed *(Arundo donax)*, which have been documented along the main stem of Cow Creek near developed areas. Scotch Broom and Tree of Heaven are also riparian invaders.

Woodland Communities (Blue Oak-Foothill Pine Woodland)

There are four different sub-communities within this general community type, including Blue Oak Woodland, Foothill Pine Oak Woodland, Open Foothill Pine Woodland, and Non-Serpentine Foothill Pine Woodland. For the purposes of this narrative, the four sub-communities have been grouped into Blue Oak-Foothill Pine Woodland, based on the similarities of the species within each sub-community. All four sub-communities consist of blue oak and foothill pine as the predominant species, with variations of the third primary species, whiteleaf manzanita, interior live oak, and buckbrush. The attached vegetation map designates areas dominated by all four sub-communities.

This plant community occurs on foothill slopes in the watershed from the valley floor to over 3500 feet in elevation depending on aspect. The community is widely distributed and is found as a nearly continuous belt in that elevational band. The blue oak-foothill pine community is generally found on rocky or exposed shallow soils. The community is dominated by two overstory species, blue oak (*Quercus douglasii*) and gray pine *(Pinus sabiniana*). Species may develop mixed stands or may occur in relatively pure stands. Blue oak and foothill pine have a high tolerance for drought. Frequent fires favor the establishment of blue oak, a stump sprouting species, over foothill pine. Foothill pine prefers to regenerate following fire and, due to the low release nature of its cone is sometimes considered a semi-serotinous species. Foothill pine may regenerate as isolated individuals or in dense stands resulting from regeneration following fire.

The understory is now characterized by non-native annual grasses and forbs, (non-native grassland section). In the absence of fire, a dense shrub community may develop including interior live oak (*Quercus wislizenii* var. *wislizenii)*, California buckeye *(Aesculus californica)*, whiteleaf manzanita, poison oak, and California redbud (*Cercis occidentalis*). These species will become decedent, over time, without recurring fire and will lose their nutritional value for browse species such as deer (DFG comments on DWA, 2001). Drier, harsher sites tend to support chaparral and grass understory, and more mesic sites are characterized by locally abundant occurrences of black oak (*Quercus kelloggii*) and poison oak (*Rhus diversiloba*).

Special-status plants associated with the Woodland Communities include: Ahart's Paronychia (*Paronychia ahartii*), Bellinger's Meadowfoam (*Limnanthes floccosa* ssp. *bellingeriana*), Shasta Clarkia (*Clarkia borealis* ssp. *arida*), and Butte County fritillary (*Fritillaria eastwoodiae).*

The total area of blue oak woodlands has been greatly reduced throughout California. The reduction is blamed on development, grazing, and firewood harvesting. Invasion of non-native grassland species, all adapted competitors for limited soil moisture, and continued exclusion of fire are also likely contributors. Natural regeneration of blue oaks has been widely recognized as a statewide problem; however, the problem is not documented in the Cow Creek Watershed (Standiford, et. al., 1996). For a further discussion of oak woodlands, see the Sensitive Plant Communities Section below.

Mixed Conifer Forest

Westside ponderosa pine forest and Sierran mixed conifer forest make up the mixed conifer forest communities within the Cow Creek Watershed. Mixed conifer forests are the most common forest types in the watershed. Special status plant species that may occur in the coniferous forest include the Butte County fritillary and Shasta snow wreath.

Westside Ponderosa Pine Forest. This forest community occurs from approximately 2000 feet above the foothill zone to over 5000 feet in elevation. Soils are generally deep and well-drained; ponderosa pine *(Pinus ponderosa)* is the dominant tree in the overstory. Additional species include incense cedar (*Calocedus decurrens),* sugar pine (*Pinus lambertiana*), Douglas fir (*Pseudotsuga menziessi*) and white fir (*Abies concolor*). The ponderosa pine forest was predominately an even-aged climax forest community dominated by homogenous single-aged stands of mature trees. This ecological community has been significantly affected by human influences of the last 100 years. General knowledge concludes that prior to 1850, the westside ponderosa pine type dominated the forest community of the Cow Creek Watershed extending from 2500 feet to over 5500 feet in elevation in almost pure even-aged old growth stands. The exclusion of fire beginning in 1920 and subsequent logging in 1950 have shaped the forest community we see today. The natural regeneration of ponderosa pine has been replaced by more shade tolerant and fire intolerant species such as white fir and Douglas fir. In many instances forest managers have reverted to even-aged management techniques which include planting to ensure ponderosa pine regeneration.

Sierran Mixed Conifer Forest. Sierran mixed conifer forest is now widely distributed within the watershed from 3000 to 6000 feet in elevation. This mixed conifer forest has replaced much of the area once dominated by ponderosa pine forests. Historically the type was confined to moist sites having north-facing or east-facing slopes and well-drained soils. More recently, exclusion of fire has resulted in the conversion of ponderosa pine forests to mixed conifer forests. Ponderosa pine, incense cedar, Douglas fir and white fir are the shared dominant species in the tree overstory. Secondary species include sugar pine, and black oak.

Conifer Forest Community (True Fir)

Red fir forest occurs in the eastern portion of the watershed, in the Latour State Forest at an elevation of about 5000 feet and higher. Soils tend to be coarse and well drained, but moist. The dominant tree species are white fir and red fir, which may form pure stands or may include lodgepole pine (*Pinus contorta*) and Jeffery pine *(Pinus ponderosa jefferyi)*. Cool temperatures and a shortened growing season limit forest growth. Understory vegetation is generally less than other forest types.

Wetland Community

Many different types of wetland communities occur throughout the Cow Creek Watershed. These include freshwater marsh, vernal pools, seeps, montane wet meadows, bogs, and fens. Artificial wetlands such as irrigation ditches, ponds, and stock ponds are also abundant. These artificial wetlands provide habitat for local and migrant wildlife. Because fieldwork has not been undertaken to map the vegetation of the watershed, many wetland areas are unknown, and many locations remain to be determined and studied. Some general descriptions of the major wetland types that are likely to occur in the watershed are described below.

Freshwater Marsh Freshwater marshes occur along the edges of lakes, ponds, sloughs, and creeks located at lower elevations of the watershed where the water becomes slow flowing, warm, and shallow. The water often contains a low level of dissolved oxygen. This zone supports emergent (raised above the water) vegetation and algae, and is referred to as the lentic zone. Lentic zones also occur in areas having standing water such as agricultural ponds, sloughs, and reservoirs. Many small habitats for freshwater marsh species have been artificially created by irrigation systems. Common freshwater marsh species include broad-leaved cattail (*Typha latifolia),* hard stemmed tule (*Scirpus acutus* var. *occidentalis*), emersed bur reed *(Sparganium emersum),* slender rush (*Juncus tenuis),* Mexican rush (*Juncus balticus* var. *mexicanus*), ample leaved sedge (*Carex ampifolia),* and leafy bracted dwarf rush *(Juncus capitatus).*

Vernal Pools. Vernal pools are seasonal bodies of water that form in shallow depressions following winter rains. Vernal pools are characterized by long-term inundation during the growing season, desiccation during the fall, and a flora dominated by native annual species that have adapted to both aquatic and terrestrial habitats, and stress associated with yearly climatic differences. The vernal pools have been documented in the poorly drained soils in the vicinity of Millville (Millville plains) and elsewhere as isolated individuals in areas of poor drainage or hardpan conditions. Plant species associated with vernal pools include: Fremont's goldfields *(Lasthenia fremontii),* hairy sidalcea, *(Sidalcea hirsuta*), Ahart's paronchia *(Paronchia ahartii),* Green's tuctoria *(Tuctoria greenei),* hairy orcutt grass (*Orcuttia* pilosa), slender orcutt grass *(Orcuttia tenuis),* Green's popcorn flower *(Plagiobothrys greenei),* dwarf wooly marbles *(Psilocarphus brevissimus* var. *brevissimus),* and Hoover's spurge *(Chamaesyce hooveri).*

Seeps. Seeps or springs often occur in wet areas within grasslands and meadows. These are usually associated with changes in geologic material fractures or faults. This wetland vegetation type is characterized by perennial herbaceous plant species that are associated with the permanently moist or wet soil (Holland, 1986), and consists of sedges *(Carex* sp.), rushes *(Juncus* sp.), and a variety of grass species. These areas are important to wildlife for summer water and sources of food. Invasion by Himalayan blackberry has significantly reduced the frequency and number of these areas. The exclusion of fire and increased density of vegetation along the geologic fringes which generally produce seepage and springs, and associated increase in transpiration has likely resulted in a lowering of the water table resulting in fewer springs and seeps.

Montane Wet Meadows. This herbaceous plant community occurs at upper elevations generally above 4000 feet. Hydrophytic sedges are common and may include ample-leaved sedge, golden-fruited sedge *(Carex aurea),* slender-beaked sedge (C. *athrostachya),* and Nebraska sedge (C. *nebracensis).* Additional species may include tufted-hair grass *(Deschampsia caespitosa* ssp. *cespitosa),* meadow barley *(Hordeum brachyantherum* ssp. *brachyantherum),* Mexican rush, Sierra rush *(Juncus nevadesis),* buttercups *(Ranunculus* spp.), Drummond's cinquefoil *(Potentilla drummondii* ssp. *drummondii),* tinker's penny *(Hypelicunu anagalloides),* common monkeyflower *(Mimulus guttatus),* brown-headed rush, mountain self heal *(Prunella vulgaris* var. *lanceolata),* and western bistort *(Polygonum bistortoides).* The soils are less acidic and nutrient rich compared to bogs and fens. Invasion of meadow edges by willow, alder, lodgepole pine and numerous brush species due to lack of fire and grazing has reduced the extent of this community throughout California and this is also likely the case in the Cow Creek Watershed.

Bogs and Fens. Bogs and fens develop in sites having blocked or limited drainage, and the water pH ranges from strongly acidic (bog) to alkaline or neutral (fen). Bogs and fens have not been mapped in the Cow Creek Watershed. Representative plant species in sphagnum bogs include Douglas' spiraea *(Spiraea douglasii),* Laborador-tea *(Ledum g1andlosum),* Sphagnum moss spp., sedges *(Carex* spp.), rynchospora moss *(Rynchosposa* sp.), and western blueberry *(Vaccinium uliginosum)* (Holland, 1986). Fens are similar to bogs, but have a higher diversity of species and more large shrubs. Species characteristic of fens include: California myrtle *(myrica californica),* tinker's penny *(Hypericum anagalloides),* buck bean *(Menyanthes trifoliata),* spike rush, and western lady fern *(Athryium felix-femina* var. *cyclosorum*).

SENSITIVE BOTANICAL RESOURCES

SPECIAL-STATUS PLANT SPECIES

Special-status plant species are species that are legally protected under the State and Federal Endangered Species Acts or other regulations, and species considered sufficiently rare by the scientific community so that they may qualify for official protection.

Special-status plant categories:

- Plants listed or proposed for listing as threatened or endangered under the Federal Endangered Species Act (50 CFR 17.12 [listed plants] and various notices in the Federal Register [proposed species]);
- Plants listed or proposed for listing by the State of California as threatened or endangered under the California Endangered Species Act (14 CCR 670.5);
- Plants listed under the California Native Plant Protection Act (California Fish and Game, Code, Section 1900 et seq.);
- Plants that meet the definitions of rare or endangered under CEQA (State CEQA Guidelines, Section 15380);
- Plants considered by CNPS to be "rare, threatened, or endangered in California" (Lists lb and 2 in Skinner and Pavlik, 1994);
- Plants listed by CNPS as plants about which more information is needed to determine their status and plants of limited distribution (lists 3 and 4 in Skinner and Pavlik, 1994), which may be included as special-status species on the basis of local significance or recent biological information.

Review of available literature and searches of the Natural Diversity Database and the CNPS Inventory of Rare Plants resulted in eight special-status plant species that are either known to occur or that are suspected to occur in the Cow Creek Watershed (Table 7-3). The special-status plant species list is based on a review of special-status plants listed as occurring in Shasta County by the CNPS (Skinner and Pavlik 1994) and an assessment of their elevational distributions and habitat requirements (Munz and Keck 1973; Hickman 1968), and the California Natural Diversity Database (CNDDB 1996).

TABLE 7-3 Special-Status Plants					
Species	**Scientific Name**	**Legal Status***	**Distribution****	**Habitat****	**Quadrangle Codes*****
		Federal/Stat/CNPS (R-E-D)			
Northern Interior Cypress	McNab Cypress	Not Listed	Varied	On rocky, clay, strongly acid soil	MC, CG
Shasta Snow-Wreath	Neviusia Cliftonii	--/--/1B (3-2-3)	Shasta County	Lower montane coniferous forest, riparian woodland. Endemic to Shasta County	MC, DR
Silky Cryptantha (Ribbed Cryptantha)	Cryptantha crinita	--/--/1B (3-2-3)	Shasta and Tehama Counties	Gravelly soils usually found in non-wetland areas.	PC
Four Angled Spike Rush	Eleocharis quadrangulata	--/--/2 (3-2-1)	Shasta, Tehama, Butte Counties	Freshwater wetlands and marsh habitats	PC
Ahart's Paronychia	Paronychia Ahartii	--/--/1B (3-2-3)	Butte, Shasta, and Tehama Counties	Well-drained, rocky outcrops, often vernal pool edges, and volcanic uplands; <1640 feet	PC, CG, IW,
Henderson's Bent Grass	Agrostis Hendersonii	--/--/3 (3-2-2)	Butte, Calaveras, Merced, and Shasta Counties	Valley and foothill grasslands, vernal pools.	PC, OR
Slender Orcutt Grass	Orcuttia Tenuis	FT/SE/1B (2-3-3)	Widespread but spotty from eastern Shasta County, Plumas, Lassen and Lake Counties, and the Sacramento Valley	Bottoms of vernal pools typically underlain by volcanic substrates; 100 to 5780 feet	PC
Shasta Clarkia	Clarkia Borealis SSP Arida	--/--/1B (3-3-3)	Shasta County	Cismontane woodland. Endemic to Shasta County	CG, DR, OR
Butte County Fritillary	Fritillaria Eastwoodiae	--/--/3 (?-2-3)	Butte, Shasta, Yuba and Tehama Counties	In openings on dry beaches and slopes in chaparral, woodland, and lower coniferous forest communities; 1600 to 4920 feet	IW, HG, VI, WM, MM
Bellinger's Meadowfoam	Limnanthes Floccosa SSP Bellingeriana	--/--/1B (3-2-2)	Shasta County	Meadows and seeps, cismontane woodland, and damp, stony flats.	BV, OR

Listings of species are frequently updated, with new plants being added or removed from categories at various times.

Table 3 KEY

***CNPS Status:**

List 1B: These plants (predominately endemic) are rare through their range and are currently vulnerable of have a high potential for vulnerability due to limited of threatened habitat, few individuals per population, or a limited number of populations. Lisa 1 B plants meet the definitions of Section 1901, Chapter 10 of the CDF & G code.

List 2: Rare, threatened, or endangered plant species in California, but more common elsewhere.

List 3: This is a review list of plants that lack sufficient data to assign them to another list.

List 4: List 4 is a watch list of plants with limited distribution in the state that have low vulnerability and threat at this time. These plants are uncommon, often significant locally, and should be monitored.

CNPS R-E-D Code

To increase the refinement of assigning plants to categories, CNPS uses scheme that combines three complementary elements that are scored independently. These components are:

Rarity- which addresses the extent of the plant, both in terms of numbers of individuals and the nature and extent of distribution

Endangerment- which embodies the perception of the plant's vulnerability to extinction for any reason

Distribution- which focuses on the overall range of the plant

R (Rarity)

1- Rare, but found in sufficient numbers and distributed widely enough that the potential for extinction is low at this time.

2- Distributed in a limited number of occurrences, occasionally more if each occurrence is small.

3- Distributed in one to several highly restricted occurrences, or present in such small numbers that it is seldom reported.

E (Endangerment)

1- Not endangered.

2- Endangered in a portion of its range.

3- Endangered throughout its range.

D (Distribution)

1- More or less widespread outside California.

2- Rare outside California.

3- Endemic to California.

*** State List:**

SE = endangered

SR = rare

ST = threatened

***Federal List:**

FE = endangered

FT = threatened

PE = Federally proposed endangered

PT = Federal proposed threatened

Candidate = sufficient data to support listing

**** Habitat requirements and distribution of special-status plants were determined by reviewing information from Hickman (1993), Skinner and Pavlik (1994).**

***** Quadrangle Codes**

MC = Montgomery Creek

PC = Palo Cedro

CG = Clough Gulch

IW = Inwood

OR = Oak Run

WM = Whitmore

JB = Jack's Backbone

MM = Miller Mtn.

HG = Hagaman Gulch

VI = Viola

DR = Devils Rock

BV = Bella Vista

HP= Hatchet Mtn. Pass

DOCUMENTED OCCURRENCES

Special-status plant species have known occurrences in eleven of the thirteen quadrangles located within the watershed: Palo Cedro, Clough, Inwood, Hagaman Gulch, Viola, Devils Rock, Bella Vista, Oak Run, Whitmore, and Miller Mountain. Three quadrangles in particular, Palo Cedro, Oak Run, and Clough have the greatest number of special status species (Table 7-3). The greater number of special-status plant species in these three quadrangles may be attributed to the increased development in these areas which resulted in species surveys. It may also be due to the presence of vernal pools and their associated sensitive plant species including: Ahart's paronchia, slender orcutt grass, and Henderson's bent grass. Note that focused field surveys for special status plant species have not been conducted in the watershed, so additional population areas and/or other sensitive plant species may be present.

Additional occurrences of special status plant species include: Butte County fritillary *(Fritillaria eastwoodiae)*, Shasta snow wreath *(Neviusia cliftonii*), Interior cypress (*McNab Cypress*), and Bellinger's meadowfoam (*Limnanthes floccosa* ssp. *Bellingeriana*). These additional occurrences are in varied quadrangle locations.

The NDDB also provides information on threats to special-status plant species. Threats to special status species recorded within the watershed include damage from agriculture, cattle grazing, human activities, and competition with invasive non-native plant species. Many of the species occur in areas of development, like the Palo Cedro and Oak Run quadrangles. Of these the greatest likely threats in the Cow Creek watershed area are development, competition, invasion of non-native plants, and changes in ecology due to exclusion of fire.

SENSITIVE PLANT COMMUNITIES

Sensitive habitats are defined by local, state, or federal agencies as those habitats that support special status species, provide important habitat values for wildlife, represent areas of unusual or regionally restricted habitat types, and/or provide high biological diversity. The following vegetation types occurring within the Cow Creek Watershed are considered by public agencies to be sensitive habitats:

- riparian forest
- blue oak foothill pine woodland
- native grassland
- freshwater marsh
- vernal pools
- other wetlands

Wetland/Riparian

In general, the wetland, riparian and native grassland/prairie plant communities are considered sensitive habitat due to their high wildlife value, limited distribution, and decreasing acreages statewide. These sensitive habitats have been significantly reduced from their historical distributions. Wetlands are a significant resource that are under the protection and jurisdiction of the CDFG and the U. S. Army Corps of Engineers, and are subject to a no net loss policy.

Vernal Pools

Vernal pools are considered a unique type of wetland that should be preserved, as they typically support uniquely adapted or locally rare plant and animal species. Vernal pools rank the highest globally for numbers of endemic plant species. The number of vernal pools in the Sacramento Valley that were historically present have been reduced and/or fragmented by agriculture and urbanization (Holland, 1978) and it can be assumed the same is true for similar areas in the Cow Creek Watershed.

Freshwater Marsh Habitats

Freshwater marsh habitats as they now exist represent only fragments of what was historically present in California. Past agricultural practices have converted marsh habitat into farmland by draining, diking, and leveling. Since much of the Cow Creek Watershed has been converted into agricultural lands during historical periods, it can be assumed that natural freshwater marsh habitats that may have been in the area, are no longer in existence. However, many small habitats for freshwater species may have been created by irrigation systems and diversions in the watershed.

At the State level, riparian plant communities are considered sensitive habitat and have been identified by CDFG as habitat of special concern (Wetlands Resource Policy, California Department of Fish and Game Commission, 1987). Riparian habitat is valuable because it supports a high density and diversity of wildlife species and because it is a diminishing resource.

Blue Oak Woodlands

Blue oak woodlands have been greatly reduced in extent throughout California by various activities. Blue oak woodland regeneration is considered a statewide problem. The reasons for poor blue oak regeneration are complex, and are under research. No single factor or cause is responsible for the poor blue oak regeneration problem. A number of factors including animal grazing, acorn depredation, plant competition, and environmental extremes can affect recruitment success, depending on site conditions.

As losses of blue oak woodlands continue, the relative importance of undeveloped stands will increase. In response to the decline of all oak woodland types, CDF, CNPS, and TNC have identified the conservation and management of oak woodlands as major issues.

NOXIOUS WEEDS AND EXOTIC PESTS

There are many different definitions of noxious weeds and plant pests. In general, they are non-native plants that have been introduced to North America from other countries and have spread to compete with our native plant communities. Unlike our native plant species, these non-native invaders may have no natural predators such as insects or diseases to control their numbers. There are literally hundreds of non-native plant pests that freely reproduce in the wildlands of North America. These weeds destroy our wildlife habitat, and native and artificial forage through increased groundwater consumption and decreased recreational and commercial activities. Many of these plant species are not palatable and may even be toxic to native wildlife.

Plant pests are defined by law, regulation and technical organizations, and are regulated by many different sources, which include the California Department of Food and Agriculture (CDFA), United States Department of Agriculture, and the California Exotic Pest Plant Council. Recently, California formed the California Noxious Weed Control Project Inventory (CNWCPI) to begin to address the issue of invasive weeds on a larger scale. These groups are discussed briefly below.

The California Department of Food and Agriculture has developed an action-oriented pest-rating system for use in the state. The rating assigned to a pest by CDFA does not necessarily mean that one with a low rating is not a problem, but the rating is meant to designate a certain type of response by CDFA or County Agricultural Commissioners.

If a plant is found to probably be "troublesome, aggressive, intrusive, detrimental, or destructive to agriculture, silviculture, or important native species, and difficult to control or eradicate", the Department will designate the plant as a noxious weed.

At the time that CDFA lists a species, it also receives a rating of A, B, C, D, or Q. These ratings reflect CDFA's view of the statewide importance of the pest, the likelihood that eradication or control efforts would be successful, and the present distribution of the pest within the state. The ratings are not laws, but are policy guidelines that indicate the most appropriate action to take against a pest under general circumstances.

Current definitions of the CDFA's pest ratings are included in Table 7-4.

TABLE 7-4
CDFA's Pest Rating

A	An "A" rated organism is one of known economic importance subject to state-county enforced action involving eradication, quarantine regulation, containment, rejection or other holding action.
B	An organism of known economic importance subject to eradication, containment, control or other holding action at the discretion of the individual county agricultural commissioner, or an organism of known economic importance subject to state endorsed holding action and eradication only when found in a nursery.
C	An organism subject to no state enforced action outside of nurseries except to retard spread, generally at the discretion of a commission or an organism subject to no state enforced action except to provide for pest cleanliness standards in nurseries.
Q	An organism requiring temporary "A" action pending determination of a permanent rating. The organism is suspected to be of economic importance but its status is uncertain because of incomplete identification or inadequate information.
D	No action.

USDA PLANT PROTECTIONS AND QUARANTINE PROGRAM

The USDA regulates federally listed noxious weeds. These are defined under the Federal Noxious Weed Act of 1974 (7 USC 2802(c)) and administered under 7 CFR 350. Listed noxious weeds can be moved into or through the United States under permit only. The federal list is divided into: (a) aquatic weeds, (b) parasitic weeds, (c) terrestrial weeds. The federal list is limited to weeds of significant economic importance and is smaller than the State of California umbrella.

CALIFORNIA EXOTIC PEST PLANTS COUNCIL (CalEPPC)

The Exotic Pest Plant Council is composed of a group of technical experts that developed a list of plant pests specific to California's wildlands. The CalEPPC list is based on information submitted by land managers, botanists and researchers throughout the state, and on published sources. The list highlights non-native plants that are serious problems in wildlands (natural areas that support native ecosystems, including national, state and local parks, ecological reserves, wildlife areas, national forests, BLM lands, etc.). Plants that fall into the following categories are not included in the list:

- Plants found mainly or solely in disturbed areas, such as roadsides and agricultural fields.
- Plants that are established only sparingly, with minimal impact on natural habitats.

CalEPPC list categories include:

- **List A:** Most Invasive Wildland Pest Plants; documented as aggressive invaders that displace natives and disrupt natural habitats. Includes two sub-lists: List A-1: widespread pests that are invasive in more than three Jepson regions, and List A-2: regional pests invasive in three or fewer Jepson regions.
- **List B:** Wildland Pest Plants of Lesser Invasiveness; invasive pest plants that spread less rapidly and cause a lesser degree of habitat disruption; may be widespread or regional.
- **Red Alert:** Pest plants with potential to spread explosively; infestations currently small or localized. If found, alert CalEPPC, County Agricultural Commissioner, or California Department of Food and Agriculture.
- **Need More Information:** Plants for which current information does not adequately describe nature of threat to wildlands, distribution or invasiveness. Further information is requested from knowledgeable observers.
- **Annual Grasses:** New in this edition; a preliminary list of annual grasses, abundant and widespread in California, that pose significant threats to wildlands. Information is requested to support further definition of this category in next List edition.
- **Considered But Not Listed:** Plants that, after review of status, do not appear to pose a significant threat to wildlands.

CALIFORNIA NOXIOUS WEED CONTROL PROJECTS INVENTORY (CNWCPI)

The California Interagency Noxious Weed Coordinating Committee is a group of sixteen state and federal agencies meeting quarterly, in conjunction with stakeholders, to coordinate activities with respect to noxious weed control. To date, the main project of the CNWCPI has been to create an Internet accessible database, to act as a clearinghouse for noxious weed control projects in California. The database contains information on noxious weed control and distribution in California.

The project has been led by a database sub-committee of the MOU Group and California Department of Food and Agriculture staff. A grant from the Bureau of Land Management enabled the contracting of the technical Internet database development work to the Information Center for the Environment at UC Davis. Reference information includes project information such as project contacts, target weed species, and type of control method, as well as monitoring information, including project goals and monitoring data. The database is intended for use by agencies, academicians, consultants, project designers, and implementers.

LISTED WEEDS IN COW CREEK WATERSHED

A detailed inventory of noxious weeds has not been completed for the Cow Creek Watershed. Plant pests and ranking listed by the California Department of Food and Agriculture that are known to exist in Shasta County are included in Table 7-5. When personal communication confirms the location in the Cow Creek Watershed, this is noted in the table. A summary of plants known to exist in Cow Creek is included in Table 7-7 at the end of this section. Also included at the end of the section are photographs of Table 7-7 plants.

Table 7-6 includes a list of invasive wildland pests from the CalEPPC. Plants noted to be verified in Cow Creek are referenced in the table.

TABLE 7-5
CDFA Noxious Weeds

Rank	Latin Name	Common Name	Found in Shasta Co.	Verified in Cow Creek
A				
	Carduus nutans	musk thistle	x	
	Centaurea diffusa	diffuse knapweed	x	
	Centaurea maculosa	spotted knapweed	x	X
	Centaurea squarrosa	squarrose knapweed	x	X
	Chondrilla juncea	skeletonweed	x	
	Hydrilla verticillata	hydrilla	x	
	Linaria genistifolia ssp *dalmatica*	Dalmation toadflax	x	
	Onopordum acanthium	Scotch thistle		X
B				
	Acroptilon repens	Russian knapweed		
	Aegilops	goatgrass		
	Cardaria chalepensis	lens-podded hoarycress	x	
	Cardaria draba	heart-podded hoarycress	x	
	Cardaria pubescens	globe-podded hoarycress		
	Cirsium arvense	Canada thistle	x	
	Elytrigia repens	quackgrass	x	
	Isatis tinctoria	Dyer's woad	x	
	Lepidium latifolium	perennial peppercress	x	
	Lythrum salicaria	purple loosestrife	x	
	Salvia aethiopis	Mediterranean sage	x	X
C				
	Carduus pycnocephalus	Italian thistle	x	X
	Carduus tenuiflorus	slenderflower thistle	x	
	Centaurea solstitialis	yellow starthistle	x	X
	Convolvulus arvensis	field bindweed	x	
	Cuscuta spp. except *C. reflexa*	dodder	x	
	Cynodon spp and *hybrids*	bermudagrass	x	X
	Cytisus scoparius	Scotch broom	x	X
	Genista monspessulana	French broom	x	
	Hypericum perforatum	Klamath weed	x	X
	Iva axillaris	poverty weed	x	
	Malvella leprosa	alkali mallow	x	
	Polygonum amphibium var. *emersum*	kelp	x	
	Salsola tragus	common Russian thistle	x	
	Sorghum halepense	Johnson grass	x	X
	Taeniatherum caput-medusae	medusahead	x	X
	Tribulus terrestris	puncturevine	x	X

TABLE 7-6 CalEPPC List of Invasive Pests				
Rank	**Latin Name**	**Common Name**	**Found in Shasta Co.**	**Verified in Cow Creek**
Red Alert: Species with potential to spread explosively; infestations currently restricted				
	Centaurea maculosa	spotted knapweed	x	
	Hydrilla verticillata	hydrilla	x	
	Lythrum salicaria	purple loosestrife	x	
List A-1 = Most Invasive Wildland Pest Plants; Widespread				
	Arundo donax	giant reed, arundo	x	X
	Bromus tectorum	cheat grass, downy brome	x	X
	Centaurea solstitialis	yellow starthistle	x	X
	Cortaderia selloana	pampas grass	x	X
	Cytisus scoparius	Scotch broom	x	X
	Genista monspessulana	French broom	x	
	Lepidium latifolium	perennial pepperweed, tall whitetop	x	
	Rubus discolor	Himalayan blackberry	x	X
	Taeniatherum	medusahead	x	X
	Tamarix chinensis, T. gallica, T. parviflora & T. ramosissima	tamarisk, salt cedar	x	X
List A-2 = Most Invasive Wildland Pest Plants; Regional				
	Ailanthus altissima	tree of heaven	x	X
	Cardaria draba	white-top, hoary cress	x	X
	Elaeagnus angustifolia	Russian olive	x	
	Ficus carica	edible fig	x	X
	Mentha pulegium	pennyroyal	x	
List B = Wildland Pest Plants of Lesser Invasiveness				
	Carduus pycnocephalus	Italian thistle	x	
	Centaurea melitensis	tocalote, Malta starthistle	x	
	Cirsium arvense	Canada thistle		X
	Cirsium vulgare	bull thistle	x	X
	Conium maculatum	poison hemlock	x	
	Hypericum perforatum	Klamath weed, St. John's wort	x	X
	Myriophyllum aquaticum	parrot's feather	x	
	Phalaris aquatica	Harding grass	x	X
	Robinia pseudoacacia	black locust	x	
	Spartium junceum	Spanish broom	x	
	Vinca major	periwinkle	x	X
Need more information				
	Descurainia sophia	flixweed, tansy mustard	x	
	Isatis tinctoria	dyers' woad	x	
	Ludwigia uruguayensis	water primrose	x	
	Pinus radiata cultivars	Monterey pine	x	
	Pyracantha angustifolia	pyracantha	x	X
	Salsola tragus	Russian thistle, tumbleweed	x	
	Salvia aethiopis	Mediterranean sage	x	X
Annual Grasses				
	Aegilops triuncialis	barbed goatgrass	x	
	Avena fatua	wild oat	x	
	Bromus diandrus	ripgut brome	x	

Considered, but not listed				
	Dipsacus sativus, D. fullonum	wild teasel, Fuller's teasel	x	
	Medicago polymorpha	California bur clover	x	X
	Melilotus officinalis	yellow sweet clover	x	X
	Nerium oleander	oleander	x	X
	Silybum marianum	milk thistle	x	X
	Xanthium spinosum	spiny cocklebur	x	X

DISCUSSION

The scope of this report does not allow a detailed discussion of all non-native plant pests that may be found in Cow Creek. The invasive plant species now established were generally introduced 50 – 100 years ago and eradication is difficult, if not impossible.

Non-native plants have resulted in significant changes to the grassland and riparian communities in the Cow Creek Watershed. These invasive plants have replaced many native species. The invasion of riparian areas by *Ailanthus altissima* and *Rubus discolor* has significantly changed the ecology of riparian areas in the watershed, reducing access, increasing water demand and reducing woody deadfall.

Brief discussions of selected non-native invaders that were identified as problems in the watershed by agency staff or addressed during reference conditions interviews follow in Table 7-7. Photos of specific invaders follow after this section.

CONTROL

Eradication is the complete elimination of a species from a given area. Once eradication is complete, no more work is required and the species cannot spread unless it is reintroduced. Unfortunately once a population is established, eradication of invasive weeds is all but impossible. The best scenario is ongoing management of the invasive plant to reduce impacts, encourage native species and control spread.

Physical Control

Manual. Physical control of large areas is generally labor intensive, but effective for small populations or in areas of sensitivity. Physical methods can be a selective process, only targeting pest species. However, this type of control does disturb soil or damage nearby vegetation, promoting the weedy species to germinate and establish a new population.

Physical methods range from hand pulling of weeds to the use of hand or power tools to uproot or cut plants. There are also attachment for bulldozers and tractors to clear and uproot woody plants. Brush rakes or blades may be mounted on the front of the bulldozer, and brushland disks or root plows may be pulled behind. Mowing can also prevent seed formation on tall weeds and deplete food reserves of shoots and roots.

Prescribed Fire. Fire can be an effective way to reduce weed invasion; this is particularly true for shubby weeds and in native communities that evolved with fire. Fire may also help the effectiveness of certain herbicides in areas of old vegetation and litter, to allow the herbicide to reach the living leaves and stems of the target plants. Prescribed burns may promote certain invasive, non-native species. Some non-native and biennial species are likely to be favored in the years immediately following a burn. Hot fires can also sterilize the sol, volatilize important nutrients and kill microorganisms on which native plants rely. Removal of vegetation by burning can also increase soil erosion.

Conducting a prescribed fire is not a simple or risk-free task. Good logistical planning, careful timing with respect to weather, and coordination with air quality agencies are all required to carry out an effective and safe burn. For small areas or for individual plants, blowtorches or flamethrowers can also be used. This method has been proven effective for thistles in several areas. Scotch broom has also been eradicated by the use of a flamethrower to heat-girdle the lower stems.

Mulching. Mulching excludes light from weeds and prevents them from photosynthesizing. Commonly used mulching is hay, grass clippings, manure, sawdust, wood chips, rice hulls, and black film. The most effective mulching technique is the films, providing uniform cover and preventing weeds from breaking through. Mulching can be expensive and is only practical for smaller areas.

Biological Control

Biocontrol involves the use of animals, fungi, or other microbes that consume a target species. Frequently non-native success in a new environment may be due to the absence of their natural predators and pathogens. Successful control programs result in permanent establishment of control agents and permanent reduction in target species populations. However, a control agent may attack desirable species as well as the pest it was to control. It is very important to find a control agent that is species-specific, and once the agent is identified it may take an extended period of time to see results. In order to get an agent established it may take repeated releases.

Competition and Restoration. Using native plants to outcompete alien weeds can be a potentially powerful control method. Native plants can be planted into the habitat and cared for until they are well established. This may be possible in grasslands or native forest communities that are currently occupied by alien grasses and forbs.

Grazing. Grazing animals may be used to selectively control or suppress weeds, but could also promote certain invaders. Cattle, sheep, goats, geese, chickens and grass carp have been used to graze undesirable plant species in many areas. Grazing must continue until the seedbank is gone, otherwise the suppressed plants may quickly regain dominance. Sometimes the spreading of weed seeds occurs using grazing as a control method, spreading the seed through droppings.

Chemical Control

Herbicides are chemicals that kill or inhibit plant growth. This method can be extremely effective when used for certain species. The effectiveness of any herbicide may vary with climate and environmental conditions, and the tolerance of a species to a particular herbicide. When using herbicides, the environmental risks should be considered, including drift, volatilization, persistence, groundwater contamination, and harmful effects on animals.

CONCLUSIONS

The vegetation matrix in the Cow Creek Watershed has changed significantly in the last 100 years. Changes have resulted primarily from:

- Intensive grazing or conversion of habitat;
- Exclusion of fire;
- Non-native plant substitution; and,
- Land management (development and timber harvest).

The current vegetative matrix from the valley to the highest elevations is denser both vertically and horizontally.

Although general vegetative mapping is available from many sources, the resolution is insufficient to address needs for management input or to assess success of inputs. Inventory of the following is needed:

- Non-native invasive plants;
- Riparian health and mapping;
- Brush density in foothill grassland areas; and,
- Brush and ladder fuel density in coniferous forests.

ACTION OPTIONS

From review of information available about the watershed, discussions with local residents and agency personnel, it is clear the additional information is needed to develop long-term plans for the watershed. Missing or incomplete information needs to be gathered to fully describe the existing conditions and potentially illustrate vegetative trends in the watershed. To faciliate this, the following recommendations are included:

1. Inventory the following to better address conditions and vegetation changes over time:

    - Non-native invasive plants;
    - Riparian health and mapping;
    - Brush density in foothill grassland areas; and,
    - Brush and ladder fuel density in coniferous forests.

2. Refined inventory, potentially with CDF and private timberland owners, of brush invasion into conifer forests. Considerable brush vegetation is masked by the conifer overstory, making the brush component of the watershed seem smaller than it really is.

3. Inventory the watershed for invasive non-native plant species and noxious weeds to assist in developing management strategies for either eradication or management. Additionally, strategies for preventing other exotic species from entering the watershed can be developed, as well as initiating educational programs.

4. Develop educational awareness programs for the public on identifying non-native invasive plants with recommended controls plans.

5. Develop a riparian vegetation mapping and inventory program to identify riparian communities and areas where native communities could be re-established.

6. Utilize the VMP and Range Improvement process to increase the use of prescribed fire.

7. Develop proactive control programs for non-native invasive plants such as cooperative projects with landowners and government agencies.

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TABLE 7-7
Significant Invasive Plants Known to Exist in Cow Creek Watershed by Wildland Community

Riparian Invaders	Type	Location	Reproduction	Risk	Control Strategy	Source
Arundo donax Giant Reed	Reed	Isolated in main stem Cow Creek	Vegetative rhizome or parts	High, voracious competitor	Herbicide on method – do not burn	Sub-Indian continent – In LA by 1820 – Spreading north major problem.
Ailanthus altissima Tree of Heaven	Tree	Isolated locations main stem and in LCC and Tributaries – in developed areas	Seeds and root sprouts	Moderate	Herbicide or grazing. Burning not effective.	Eastern China. Introduced as shade tree. Planted in 1890. Ubiquitous.
Cortaderia selloana Pampas grass	Shrub/ grass	Isolated in developed areas near Palo Cedro and along MS Cow Creek and Lower Cow Creek	Seeds, but sprouts after fire and by plant parts	Low to moderate. Isolated populations	Herbicide. Following burning will sprout, grazing effective in N.Z.	Native to Argentina and Brazil. Introduced to CA in 1874. Planted in SCS in LA in 1946 for veg control.
Rubus discolor Himalayan blackberry	Vine	Ubiquitous throughout the watershed	Seeds spread by bird and mammals and vegetatively	Serious problem. Invades pasture area; inhibits wildlife access to streams; replaces native plants, low water yield	Difficult to control. Manual removal and repeated herbicide and burning and grazing.	Introduced to NA by Luther Burbank in 1885 as cultivar from native Western Europe.
Fiscus carica Edible fig	Tree	Lower reaches of watershed; maybe elsewhere	Seeds and vegetatively	Moderate	Difficult to control; basal treatment. Herbicide effective	Native to Arabia. Introduced to LA by missionaries in 1769.
Tamarix Salt Cedar	Woody shrub	Isolated in lower reaches of watershed	Seeds and vegetatively	Moderate	Herbicide or gr azing	Central Asia and near east. Planted widely for erosion control in LA.
Vinca Major Periwinkle	Vine	In isolated areas and near historic residences	Vegetatively	Low	Herbicide	Northern Africa imported as ornamental and medicinal herb.

Grasslands and meadows	Type	Location	Reproduction	Risk	Control Strategy	Source
Bromus tectorum Cheat grass	Grass	Ubiquitous in watershed	Seeds	High	Herbicides, plant competition, spring burning, mechanical	Native to No. Africa. Introduced to LA in 1860s. Ubiquitous- has significantly displaced native plants.
Centaurea solstitialis Yellow starthistle	Forb	Ubiquitous below 6,000 ft.	Seeds	High	Herbicide, burning, grazing, biological limited success	Significant competitor and invader; significantly lowers forage quality and yield in pastures and range condition.
Cirsium Vulgare Bull thistle	Forb	Isolated to disturbed areas	Seeds	Moderate	Easily controlled with herbicide; bio tried, but no success	Introduced from Europe and N. Africa. Common in forest areas and clear cuts; displaces native forage. Common in disturbed areas.
Cirsium Arvense Canada thistle	Forb	Isolated to disturbed areas	Seeds	Moderate	Herbicide	Introduced from SW Europe. Serious pest to cultivated agriculture. Usually found in disturbed areas and along roads.
Hypericum Perforatum Klamath Weed	Forb	Isolated individual	Seed	Moderate	Herbicide	
Phalaris aquatica Harding grass	Grass	Numerous locations in grasslands	Seeds	Moderate	Herbicide	Field planting forage crop.
Taeniatherum caput-medusae Medusahead	Grass	Everywhere – has resulted in losses of <40-75% carrying capacity	Seeds	High – serious problem throughout watershed	Herbicide, burning prior to seed dispersal, in early spring grazing (sheep)	Introduced from the Mediterranean in the late 1800s. Has reduced grazing capacity on some ranches from 40 to 75% (Whiston 2000).

Giant Reed (*Arundo donax*):
Type: Reed
Location: Isolated in main stem Cow Creek
Reproduction: Vegetative rhizome or parts
Risk: High risk, voracious competitor
Control: Herbicide on method – do not burn
Source: Sub-Indian continent – In LA by 1820 – Spreading north major problem.

Tree of Heaven (*Ailanthus altissima*):
Type: Tree
Location: Isolated locations main stem and in LCC and Tributaries – in developed areas
Reproduction: Seeds and root sprouts
Risk: Moderate
Control: Herbicide or grazing. Burning not effective.
Source: Eastern China. Introduced as shade tree. Planted in 1890. Ubiquitous.

Pampas grass (*Cortaderia selloana*):
Type: Shrub/grass
Location: Isolated in developed areas near Palo Cedro and along MS Cow Creek and Lower Cow Creek
Reproduction: Seeds, but sprouts after fire and by plant parts
Risk: Low to moderate. Isolated populations
Control: Herbicide. Following burning will sprout, grazing effective in N.Z.
Source: Native to Argentina and Brazil. Introduced to CA in 1874. Planted in SCS in LA in 1946 for veg control.

Himalayan Blackberry (*Rubus discolor*):
Type: Vine
Location: Ubiquitous throughout the watershed
Reproduction: Seeds spread by bird and mammals and vegetatively
Risk: Serious problem. Invades pasture area; inhibits wildlife access to streams; replaces native plants, low water yield
Control: Difficult to control. Manual removal and repeated herbicide and burning and grazing
Source: Introduced to NA by Luther Burbank in 1885 as cultivar from native Western Europe.

Edible fig (*Fiscus carica*):
Type: Tree
Location: Lower reaches of watershed; maybe elsewhere
Reproduction: Seeds and vegetatively
Risk: Moderate
Control: Difficult to control; basal treatment. Herbicide effective
Source: Native to Arabia. Introduced to LA by missionaries in 1769.

Salt Cedar (*Tamarix*):
Type: Woody shrub
Location: Isolated in lower reaches of watershed
Reproduction: Seeds and vegetatively
Risk: Moderate
Control: Herbicide or grazing
Source: Central Asia and near east. Planted widely for erosion control in LA.

Periwinkle (*Vinca Major*):
Type: Vine
Location: In isolated areas and near historic residences
Reproduction: Vegetatively
Risk: Low
Control: Herbicide
Source: North Africa; imported as ornamental and medicinal herb.

Cheat grass (*Bromus tectorum*):
Type: Grass
Location: Ubiquitous in watershed
Reproduction: Seeds
Risk: High
Control: Herbicides, plant competition, spring burning, mechanical
Source: Native to N Africa. Introduced to LA in 1860s. Ubiquitous-has significantly displaced native plants.

Yellow starthistle (*Centaurea solstitialis*):
Type: Forb
Location: Ubiquitous below 6,000 ft.
Reproduction: Seeds
Risk: High
Control: Herbicide, burning, grazing, biological limited success
Source: Significant competitor and invader; significantly lowers forage quality and yield in pastures and range condition.

Bull thistle (*Cirsium Vulgare*):
Type: Forb
Location: Isolated to disturbed areas
Reproduction: Seeds
Risk: Moderate
Control: Easily controlled with herbicide; bio tried, but no success
Source: Introduced from Europe and N. Africa. Common in forest areas and clear cuts; displaces native forage. Common in disturbed areas.

Canada thistle (*Cirsium Arvense*):
Type: Forb
Location: Isolated to disturbed areas
Reproduction: Seeds
Risk: Moderate
Control: Herbicide
Source: Introduced from SW Europe. Serious pest to cultivated agriculture. Usually found in disturbed areas and along roads.

Klamath Weed (*Hypericum Perforatum*):
Type: Forb
Location: Isolated individual
Reproduction: Seed
Risk: Moderate
Control: Herbicide
Source: Imported from Europe as a medicinal herb (St. Johnswort).

Harding grass (*Phalaris aquatica*):
Type: Grass
Location: Numerous locations in grasslands
Reproduction: Seeds
Risk: Moderate
Control: Herbicide
Source: Forage plant introduced as livestock pasture seed.

Medusahead (*Taeniatherum caputmedusae*):
Type: Grass
Location: Everywhere – has resulted in losses of <40-75% carrying capacity
Reproduction: Seeds
Risk: High – serious problem throughout watershed
Control: Herbicide, burning prior to seed dispersal, early spring grazing (sheep)
Source: Introduced from the Mediterranean in the late 1800s. Has reduced grazing capacity on some ranches from 40 to 75% (Whiston 2000).

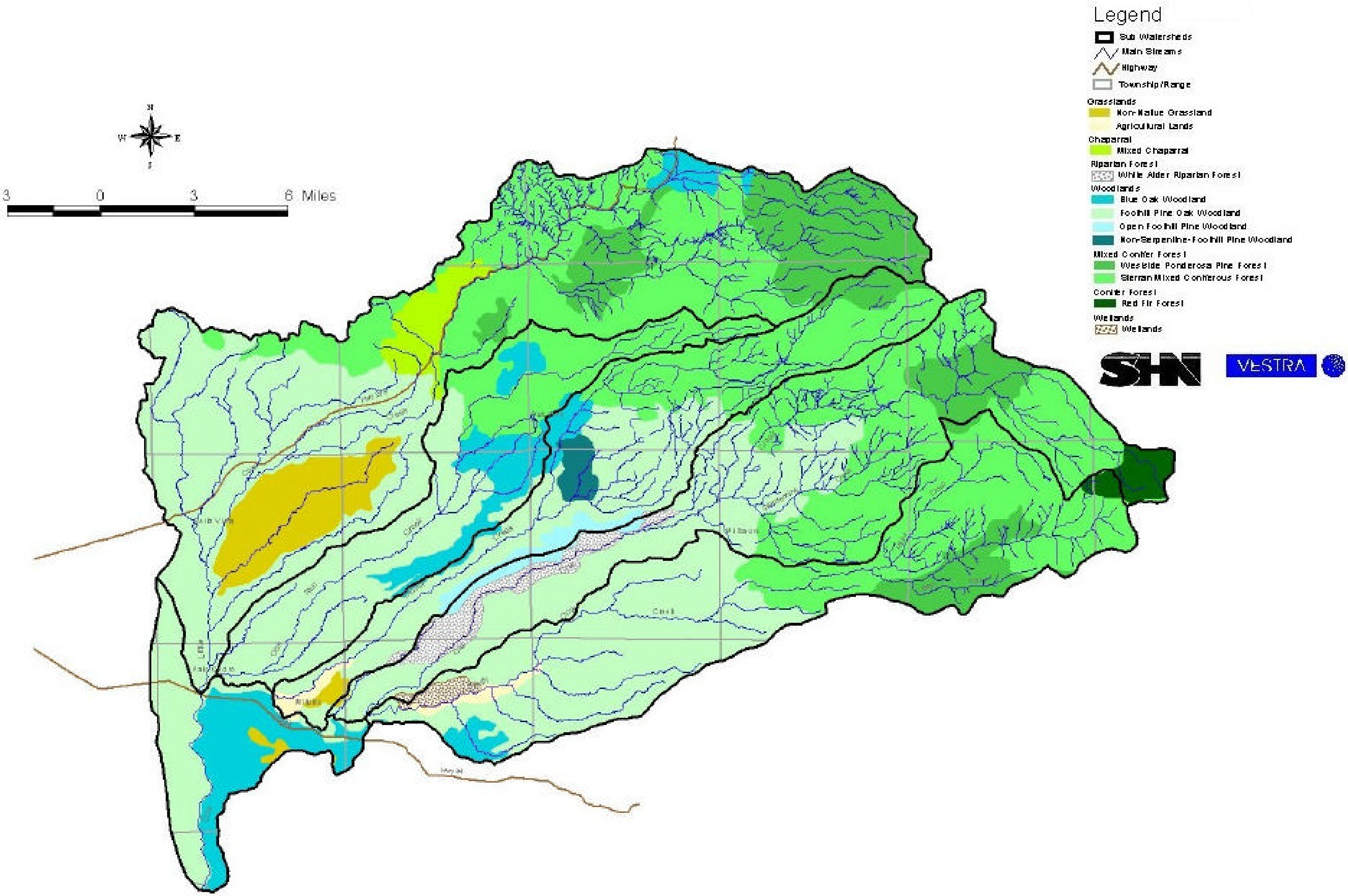

FIGURE 7-1
VEGETATION
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: UC Santa Barbara GAP Analysis

Section 8
WILDLIFE RESOURCES

Section 8
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Section 8
WILDLIFE RESOURCES

REFERENCE CONDITIONS

No data are available to address reference conditions for wildlife in the Cow Creek Watershed. Wildlife populations are tied to the habitat types in which they live. Certain conclusions can be reached by reviewing the vegetation history in Section 7, and historic observations in Section 2.

WILDLIFE HABITATS

The Cow Creek Watershed supports a wide variety of vegetation types that have led to a diverse mix of wildlife habitats and associated animals. For a detailed discussion of vegetation making up these habitat types, see Section 7. Managed agricultural lands in the lower portion of the landscape change to blue oak and foothill pine communities at mid-elevations. These merge into mixed conifer and red fir at the upper elevations of the watershed. Riparian habitats are found along the major streams in the watershed and numerous small water developments can be found throughout, in support of agriculture and around residences. These water sources, while generally small, can play an important part of wildlife migration and distribution strategies by providing water year-round.

The designations used for naming the wildlife habitat communities within the watershed are based on the vegetation classification used in the U.S. Geological Survey-Biological Resources Division's Gap Analysis Program (GAP), and the Wildlife Habitat Relationship System (WHR). Using the GAP analysis, SHN grouped vegetation types into general community types. From these community types, SHN utilized the WHR System to define the WHR habitat types (Mayer and Laudenslayer, 1988). Table 8-1 shows the crosswalk between the wildlife community, WHR type and the GAP vegetation designation used in this analysis. The WHR map for the Cow Creek Watershed is included as Figure 8-1.

TABLE 8-1
Crosswalk of Wildlife Habitat Designations

Wildlife Communities	WHR Types	GAP Vegetation Designation	Approx. Acres
Grasslands Community	Native Grassland/Prairie Annual Grassland	Non-Native Grassland	3,877
	Irrigated Pasture/Cropland	Agricultural Lands	1,694
Chaparral Community	Montane Chaparral	Mixed Chaparral	9,405
Riparian Forest Community	Valley Foothill Riparian	White Alder Riparian Forest	3,863
Woodlands Community	Blue Oak-Foothill Pine	Blue Oak Woodland	16,848
	Blue Oak-Foothill Pine	Foothill Pine Oak Woodland	112,212
	Blue Oak-Foothill Pine	Open Foothill Pine Woodland	2,586
	Blue Oak-Foothill Pine	Non-Serpentine- Foothill Pine Woodland	1,397
Mixed Conifer Forest Community	Sierran Mixed Conifer	Westside Ponderosa Pine Forest	25,981
	Sierran Mixed Conifer	Sierran Mixed Coniferous Forest	93,690
Conifer Forest Community	Red Fir Forest	Red Fir Forest	2,233
Wetlands Community	Wet Meadow	Wetlands	898

*May not total 274,684 due to rounding error.

The types of wildlife found in an area are dependent on the vegetative and related habitat occurring in an area. A general discussion of habitat types and a list of common species likely to occur in the habitat type follow in this section. A complete listing of all potential species by habitat type can be found by accessing the Wildlife Habitat Relationship Database through DFG. Although not specific to the Cow Creek Watershed, the database will provide a general overview of potential occurrence of species in the watershed.

GRASSLAND COMMUNITY (ANNUAL GRASSLANDS, PASTURE)

Annual Grasslands

In the Cow Creek Watershed, non-native annual grasslands are represented by the Annual Grassland WHR type. These are generally open habitats with annual grass plant species. In the watershed, these habitats are predominantly located near the agricultural lands and around established residences. Numerous small fields and pastures can be found mixed in with other vegetation types and, therefore, are not displayed as individual units. Predominant adjacent habitat types include the Blue Oak-Foothill Pine type, but annual grasslands can also be found adjacent to Conifer Forests. Uses vary, but generally provide open space, and light grazing for cattle and horses.

Significant numbers of wildlife species utilize grasslands as their primary or secondary foraging regime. These uses are enhanced when these grasslands are interspersed with trees or shrubs and when adjacent to other habitats. By being in association with other habitat types (vegetation communities), a more diversified habitat is created. Wildlife populations are then supported that utilize the grasslands for feeding, as well as adjacent trees and shrubs for cover and/or nest sites. This mosaic of open grassy areas surrounded by brush or forest increases the wildlife species richness of the grasslands, especially at the edges of the grassland where shrubs predominate.

Grasslands provide an important foraging resource for a wide variety of wildlife species. The grasses and forbs produce an abundance of seeds and attract numerous insects, providing food for herbivorous, granivorous, and insectivorous wildlife. Bluebirds, meadowlarks, rabbits, ground squirrels, mice and voles are commonly found in this habitat. Consequently, predators such as hawks, owls, coyote, fox, skunk and snakes are also attracted to these areas.

The condition of the grasslands in the Cow Creek Watershed varies greatly due to management practice (irrigation and grazing). Grasslands are generally productive habitats for small mammals, providing abundant food and cover. Some grassland with limited grazing or extensive irrigation provide beneficial wildlife habitat. Other grasslands that are overgrazed, or that maintain a high density of animals year-round, do not provide the foraging material needed by prey base (rodents) for carnivorous animals. On over-grazed lands, star thistle and other noxious or invasive weed species can replace both native and non-native grasses that provide a forage base for small mammals, eventually eliminating this grassland habitat. Typical animal species found in this type of habitat include:

- Barn swallows (*Hirundo rustica*)
- Western blue bird (*Sialia mexicana*)
- Western meadowlark (*Sturnella neglecta*)
- American robin (*Turdus migratorius*)
- Red-tailed hawks (*Buteo jamaicensis*)
- Turkey vultures (*Cathartes aura*)
- Coyote (*Canis latrans*)
- Striped skunk (*Mephitis mephitis*)
- Bat species (*Chiroptera spp.*)
- Columbia Black-tail deer (*Odocoileus hemionus columbianus*)
- California vole (*Microtus californicus*)
- Western harvest mouse (*Reithrodontomys megalotis*)
- California ground squirrel (*Spermophilus beecheyi*)

- Botta's pocket gopher (*Thomomys bottae*)
- Western fence lizard (*Sceloporus occidentalis*)
- Western spotted skunk *(Spilogale gracilis)*
- Common garter snake (*Thamnophis sirtalis*)
- Western rattlesnake (*Crotalis viridis*)

Pasture

A mix of agricultural lands in the Cow Creek Watershed comprises a component of wildlife habitat known as Pasture (WHR, 1999). Vegetation in this type varies greatly and is generally a mix of perennial grasses and legumes. In the Cow Creek Watershed, the predominant pasture uses are irrigated hay fields and pastures for grazing. Irrigation of these pasture lands is a combination of flood and sprinkler irrigation, as well as taking advantage of high water tables for seasonal uses. Significant water developments are also found here, benefiting wildlife.

The location of these pasture lands are generally found in the lower portion of the watershed where traditional grazing and haying practices have been in place for over 100 years. However, there are pastures and ranches located in other portions of the watershed that have this same habitat type. Low rolling hills interspersed with conifer and brush species lie between established ranches and residential development. Species associated with the Annual Grassland series are generally found here, along with other migrant species that tend to associate with cyclical agricultural practices such as migratory waterfowl. Species commonly seen in the area include:

- California vole (*Microtus californicus*)
- Western harvest mouse (*Reithrodontomys megalotis*)
- California ground squirrel (*Spermophilus beecheyi*)
- Botta's pocket gopher (*Thomomys bottae*)
- Western fence lizard (*Sceloporus occidentalis*)
- Common garter snake (*Thamnophis sirtalis*)
- Western blue bird (*Sialia mexicana*)
- Western meadowlark (*Sturnella neglecta*)
- American robin (*Turdus migratorius*)
- Red-tailed hawks (*Buteo jamaicensis*)
- Turkey vultures (*Cathartes aura*)
- Canada Goose (*Branta canadensis*)
- American kestrel (*Falco sparverius*)
- Coyote (*Canis latrans*)
- Columbia Black-tail deer (*Odocoileus hemionus columbianus)*

CHAPARRAL COMMUNITY (MONTANE CHAPARRAL)

While no wildlife species is restricted to the montane chaparral type, this habitat plays an important role for many wildlife species. Abundance and diversity of wildlife in this chaparral habitat depends on the plant community structure, physical factors such as precipitation and geology, plant community successional stage, plant cover, proximity to openings, amount of habitat edge, and the proximity to water sources. These characteristics are primarily a function of habitat disturbances such as fire and manipulation by man, with fire being the most important factor. Montane chaparral has a variety of plant structures from low growing groundcover to brush that can grow to over nine feet tall. Habitats that are more open are frequented by wildlife species that use open areas for foraging adjacent to the more dense hiding and cover areas. The ceanothus vegetation type in the Watershed is adjacent to other habitat types (coniferous forests, blue oak-foothill pine) creating a mosaic of high value to wildlife.

Wide varieties of reptiles make use of chaparral habitat and prey on populations of rodents and invertebrates. Dense and low-growing vegetation provide for cover while small openings and rock outcrops can provide sunning and display sites. Numerous mammal and bird species live in chaparral habitats as well, utilizing dense vegetation for cover and adjacent openings as foraging sites. Deer populations can be especially dependant on chaparral habitats for thermal cover, escape cover and fawning, as well as providing significant winter range.

Use by deer populations is controlled by the age and density of the vegetation as well as the amount of desired browse species. Younger, more open vegetation of desirable browse species (ceanothus, mahogany) will attract deer readily and is an important part of winter range habitats. Older, denser stands generally do not provide quality browse opportunities, either from changes in species mix or from excessive browsing that "hedges" the desirable species. Typical wildlife species found in the mixed chaparral include:

- Northern alligator lizards (*Gerrhonotus coeruleus*)
- Western rattlesnake (*Crotalus viridis*)
- Gopher snake (*Pituophis melanoleucus*)
- California mountain kingsnake (*Lampropeltis zonata*)
- Scrub jay (*Aphelocoma coerulescens*)
- Fox sparrow (*Passerella iliaca*)
- California quail (*Callipepla californica*)
- Red-tailed hawks (*Buteo jamaicensis*)
- Black-tailed jackrabbit (*Lepus californicus*)
- Bushy-tailed woodrat (*Neotoma cinerea*)
- Coyote (*Canis latrans*)
- Columbia Black-tail deer (*Odocoileus hemionus columbianus*)

RIPARIAN FOREST COMMUNITY (VALLEY FOOTHILL RIPARIAN)

The Valley Foothill Riparian habitats provide food, water, migration and dispersal corridors, nesting and thermal cover for numerous wildlife species of amphibians, reptiles, birds, and mammals (Mayer and Laudenslayer, 1988). Lowland riparian habitats, like those that occur in the Cow Creek Watershed, can be home to hundreds of different species of amphibians and reptiles, resident and migratory birds, and mammals in both permanent and transient populations. This riparian habitat type is generally limited to Old Cow Creek, but remnants can be found in other locations within the watershed.

One of the highest levels of wildlife species richness and diversity in California is associated with riparian habitats. Factors contributing to the high wildlife value include the presence of surface water, the variety of niches provided by the high structural complexity of the habitat, the condition of the associated upland habitat, and the abundance of plant growth. Where streamside pools and low-flow shallows are found, these can provide breeding habitat for a variety of species of frogs, toads, and newts. Other species of salamanders and newts will utilize adjacent moist, terrestrial habitats underneath fallen logs and leaf litter for breeding and refuge.

Where deciduous trees are prevalent, the abundant insects these plants attract will create areas especially suitable for neo-tropical migrants that feed on the numerous insects to replenish their migratory fat reserves. Residents (winter wren, Swainson's thrush, and song sparrow) are more abundant in riparian habitats than in adjacent forests. American dippers, herons, belted kingfishers, and waterfowl utilize the near shore areas of rivers and creeks. Swifts, swallows, and flycatchers can be found hawking their insect prey over water. Red-shouldered hawks utilize riparian trees for nesting.

Numerous mammal species (raccoon, skunks, opossum, weasel, gray fox) are likely to access the creeks for drinking and foraging on rodents, amphibians, and insects. The riparian habitat also provides movement corridors and water sources for black-tailed deer and birds as well. Bats species are also associated with this riparian habitat type. Typical species associated with this habitat include:

- Long-eared myotis (*Myotis evotis*)
- California myotis (*Myotis californicus*)
- Hoary bat (*Lasiurus cinereus*)
- Western aquatic garter snake (*Thamnophis couchii*)
- Western skink (*Eumeces skiltonianus*)
- Wilson's warbler (*Wilsonia pusilla*)
- California newt (*Taricha torosa*)
- Red-shouldered hawks (*Buteo lineatus*)
- Raccoon (*Procyon lotor*)
- Western spotted skunk *(Spilogale gracilis)*
- Striped Skunk (*Mephitis mephitis)*
- Opossum (*Didelphis virginiana*)
- Weasel (*Mustela spp.)*
- Gray fox (*Urocyon cinereoargenteus*)
- Coyote (*Canis latrans*)
- Columbia Black-tail deer (*Odocoileus hemionus columbianus*)
- Northwestern pond turtle (*Clemmys marmorata)*

WOODLANDS COMMUNITY (BLUE OAK-FOOTHILL PINE)

Within this WHR designation, there are four different vegetation sub-communities; however, due to their similar habitats, they have been grouped into the Woodland Community (Blue Oak -Foothill Pine WHR) for the purposes of this report.

The lack of an understory or mix of age class in the lower Cow Creek Watershed oak habitat is typical of oak habitats statewide and is thought to be a result of management practices that suppress oaks from regenerating. The lack of oak regeneration is attributed to flood and fire suppression, and to management practices which result in over-grazing (Zeiner, et al., 1990) or the timing of grazing.

Acorns buried by scrub jays, western gray squirrels, and California ground squirrels are likely to germinate because they root better and are less likely to be eaten by other species (Zeiner, et al., 1990). Although mature oak woodlands are valuable to wildlife, oak woodland habitats with a mix of age classes and plant heights allow a greater diversity of wildlife and important cover required by many species. Valley oak woodlands that are not overgrazed will develop a partial shrub layer of poison oak, coffeeberry, toyon, and ground cover.

Oak woodlands provide significant habitats for the conservation of many bird and mammals species. Important habitat features of oak woodlands include acorn production and the presence of cavity-bearing trees. Acorns provide an important seasonal food, and are important for the survival of many species of wildlife in the fall and winter. Animals that are dependent on acorns as a seasonal food source include: deer, squirrels, birds, black bears, and non-native feral pigs.

Cavity-nesting birds and small to medium-sized mammals depend on the natural cavities associated with mature oak trees. Mature oak trees often have broken limbs that contain some degree of decay and are then excavated by birds and mammals for nest and roosting sites. These cavities receive high levels of use by secondary cavity-nesting birds (woodpeckers, owls, tree swallow and purple martin). The insects associated with oaks are prey for several birds (bushtit, kinglets, and warblers). California towhee (Pipilo crissalis) and sparrows will forage for insects on the ground beneath the oaks. Common species include:

- Northern flicker (*Colaptes auratus*)
- Scrub-jay (*Aphelocoma coerulescens*)
- Tree swallow (*Tachycineta bicolor*)
- Violet-green swallow (*Tachycineta thalassina*)
- Purple martin (*Progne subis*)
- Bushtit (*Psaltriparus minimus*)
- Cooper’s hawk (*Accipter cooperii*)
- California quail (*Callipepla californica*)
- Wild turkeys (*Meleagris gallopavo*)
- Western gray squirrel (*Sciurus griseus*)
- Black bears (*Ursus americanus*)
- Columbia black-tail deer (*Odocoileus hemionus columbianus)*
- Feral pigs (*Sus scrofa*)

MIXED CONIFER FOREST COMMUNITY (SIERRAN MIXED CONIFER)

Two different vegetation sub-communities make up the WHR designation; the Westside Ponderosa Pine and Sierran Mixed Conifer. Due to the similar nature of the habitats these vegetation types provide, they have been grouped into the Sierran Mixed Conifer WHR type.

Mixed conifer forest of the Sierra Nevada support approximately 355 animal species (Mayer and Laudenslayer, 1988). Species of Special Concern known to occur in the mixed conifer forest of the upper Cow Creek Watershed include: pine marten, spotted owl, and peregrine falcon. The bald eagle and osprey occur as transients over this area. The abundance of water in the Cow Creek Watershed enhances the value of the mixed conifer forest for wildlife. This mosaic of running water, Douglas fir, ponderosa pine, white fir, chaparral, meadow, and oak woodland in the upper watershed enhances the wildlife habitat by creating a wide variety of habitats and ecotones.

The value of the mixed conifer forest to wildlife varies with the degree of canopy cover, density, and the diversity of understory plant species. Wildlife species diversity and abundance are highest where vegetation is highly stratified, offering a greater variety of niches for forage, nesting and denning sites, and resting and hiding cover. Areas where the mixed conifer forests intergrade with scrub communities create a mosaic of habitats that is highly stratified and offers a high value to wildlife.

Some of the important food plants for wildlife that occurs in these forest types includes: California hazelnut, ceanothus, tan oak, gooseberry/current, black oak manzanita, madrone, coffeeberry, blackberry, and poison oak. These plants provide seasonal wildlife foods (berries and nuts), which are consumed by many bird and mammal species.

Significant habitat features include the presence of cavity bearing trees. Mature, fire burnt and wind-damaged trees provide natural cavities that are important resources for cavity-nesting birds and small and medium-sized mammals. Mature and older forests typically contain snags (standing dead trees) that are valuable resources for mammals and woodpeckers, which prefer dead trees, and limbs for excavation of roost and nest sites. Snags receive high levels of use by secondary cavity-nesting birds (chickadees and wrens). Snags also support wood-boring insects that provide food for bark-gleaning insectivorous birds. Bird species richness and abundance is highest in the mixed conifer forest where the understory is stratified and dense.

Carnivorous birds, such as the great horned owl and western screech owl nest in mixed conifer forest and prey on rodents that are active at night. In addition, there are five diurnal raptors, all of which are state Species of Special Concern, which are known to nest in the mixed conifer and evergreen forests (goshawk, golden eagle, white-tailed kite, Cooper's hawk, and sharp-shinned hawk). Both the goshawk and sharp-shinned hawk forage on birds in closed canopy forests, while the Cooper's hawk forages on birds in the habitat edges or in open woodlands. White-tailed kites and golden eagles forage on small mammals and reptiles in adjacent grasslands or open woodlands, and can generally be seen soaring over the habitat edges. Golden eagles have been known to take larger prey, such as young fawns, and are often opportunistic, foraging on recent road-kill.

Another important feature of the mixed conifer forest is the abundance of fallen woody debris (needles, limbs, and logs). Woody debris adds structural complexity to the forest habitat and is important as cover, nesting and denning sites, roosting, and foraging substrate for wildlife. Woody debris provides habitat for prey base (rodents) of many carnivorous animals. Downed wood also helps moderate temperatures and moisture, creating microclimates suitable for amphibians and reptiles. While aquatic reptiles typically spend their terrestrial existence in rodent burrows in grasslands, they may also take refuge under woody debris in adjacent forests. The mixed conifer forest also supports a high diversity of reptiles due to the abundant prey and cover provided by understory vegetation and fallen woody material.

Increasing numbers of mammal species are found in the mixed conifer type and in the Cow Creek Watershed. Several species of voles, mice, squirrels, and skunks are found here. In addition, mammals such as the dusky-footed woodrat, black-tailed deer, bobcat, gray fox, mountain lion, and black bear use these habitat areas. Furbearers, such as the pine marten (*Martes americana*) and fisher (*Martes pennanti*) utilize the denser reaches of the forest for most of their life. The presence of the fisher has not been confirmed in the Cow Creek Watershed (Latour SYP, 1995). Species typically found in these forests and in the Cow Creek Watershed include the following:

- Common kingsnake (*Lampropeltis getula*)
- Pileated woodpecker (*Dryocopus pileatus*)
- Harry woodpecker (*Picoides villosus*)
- California spotted owl (*Strix occidentalis occidentalis*)
- Cooper's hawk *(Accipiter cooperii*)
- Northern goshawk (*Accipiter gentilis*)
- White-tailed kite (*Elanus leucurus*)
- Golden eagle (*Aquilla chrysaetos*)
- Bald eagle (*Haliaeetus leucocephalus*)
- Northern flying squirrel (*Glaucomys sabrinus*)
- Douglas' squirrel (*Tamiasciurus douglasii*)
- Broad-footed mole (*Scapanus latimanus)*
- Dusky-footed woodrat (*(Neotoma fuscipes)*
- Deer mouse (*Peromyscus spp)*.
- Striped skunk *(Mephitis mephitis)*
- Western spotted skunk *(Spilogale spp.)*
- Virginia opossum *(Didelphis virginiana)*
- Pine marten (*Martes americana*)
- Bobcat (*Lynx rufus*)
- Gray fox (*Urocyon cinereoargenteus*)
- Mountain lions *(Felis concolor)*
- Black bear (*Ursus americanus)*
- Columbia black-tail deer (*Odocoileus hemionus columbianus)*
- Bats species (*Chiroptera spp.*)

CONIFER FOREST COMMUNITY (RED FIR)

Wildlife species diversity is relatively low in the red fir forests, which is generally comprised of an even-aged forest of a single species. Heavy shade and a thick layer of duff tend to inhibit understory vegetation, limiting the variety of wildlife (Mayer and Laudenslayer, 1988*)*. Red fir forests are located at higher elevations in the watershed and are typically snow-covered throughout the late-fall to early-spring months, providing limited seasonal habitat for numerous wildlife species. While the overall species diversity is low, these forests are considered extremely important for over 50 species of birds and mammals that use these areas for both summer and winter habitats. In the Cow Creek Watershed, several Species of Special Concern utilize this habitat, such as the northern goshawk, Sierra Nevada red fox, pine marten and great gray owl. Some of the species found here include:

- Pileated woodpecker (*Dryocopus pileatus*)
- Blue grouse (*Dendragapus obscurus)*
- Great gray owl (*Strix nebulosa*)
- Northern goshawk (*Accipiter gentilis*)
- Pine marten (*Martes americana*)
- Sierra Nevada red fox (*Vulpes vulpes necator*)
- Black bear (*Ursus americanus)*
- Columbia Black-tail deer (*Odocoileus hemionus columbianus)*

WETLAND COMMUNITY (WETLAND MEADOW)

Wet meadows in the watershed are limited and generally found at the lower elevations near streams; however, there are isolated meadows at mid and upper elevations. While the wet meadow is considered a relatively simple assemblage of vegetation types with absent or limited tree cover, it plays an important role in wildlife habitat. Since these vegetation types remain wet year-round, they attract differing types of wildlife, both as resident and transient populations. While generally too wet for most rodent species, avian species are attracted to these sites because of the associated nesting and feeding habitat, as well as some water snakes, frogs and other amphibians, and bats. Deer and other grazing animals are also attracted to these areas because of their abundant forage and water.

Types of species associated with wet meadows include:

- Striped racer (*Masticophis lateralis*)
- Frogs (*Rana spp*.)
- Mallard (*Anas platyrhynchos*)
- Yellow-headed blackbird (*Xanthocephalus xanthocephalus*)
- Red-winged blackbird (*Agelaius phoeniceus*)
- Columbia black-tail deer (*Odocoileus hemionus columbianus*)
- Bat species (*Chiroptera spp.*)

MISCELLANEOUS COMMUNITIES

Cliffs and Rock Outcrops

The rock outcrops and cliffs in the Cow Creek Watershed, especially throughout the canyon reaches, can provide excellent habitat value as nesting and foraging perches for the following species: American peregrine falcon *(Falco peregrinus anatum),* prairie falcon *(Falco mexicanus),* golden eagles *(Aquila chrysaetos),* turkey vultures *(Cathartes aura),* ravens (*Corvus corax*), American kestrel *(Falco sparverius),* and many bat species. Other birds (barn swallow, Cooper's hawk, red-tailed hawk) and some mammals (ringtail cats, *Basssariscus astutus*) most likely use this habitat as well. A comprehensive survey of suitable cliffs with nest sites has not been completed, but there are two confirmed locations of nesting peregrine falcons in the watershed (NDDB, 2000). The adjacent riparian corridors of Cow Creek and the tributaries to Cow Creek provide foraging areas for the peregrine falcon, which preys on a variety of bird species.

Vernal Pools

Vernal pools (seasonal ponds) are located in the lower reaches of the Cow Creek Watershed. Vernal pools are of high wildlife value for waterfowl, shore birds, mammals, predatory birds, reptiles, and amphibians. Vernal pools in the Cow Creek Watershed are located in grasslands and may be occasionally subject to flooding, high water tables, and poor drainage. Vernal pool invertebrate species include: vernal pool tadpole shrimp (*Lepidurus packardi*), vernal pool fairy shrimp (*Branchinecta lynchi*), California linderiella (*Linderiella occidentalis*), and snails. These invertebrate species have evolved reproductive strategies that are dependent on the elimination of surface water through seasonal drying.

Vernal pools are used as watering holes for many mammals, and as foraging and nesting areas for many birds. Small rodent populations may rely on the presence of vernal pools for seasonal water. Migratory waterfowl and shorebirds feed on the invertebrate and amphibian species of the vernal pools. Representative species utilizing vernal pools in southern Shasta and northern Tehama Counties include: deer mice, Botta's pocket gopher, black-tailed jackrabbit, great egret, great blue heron, greater yellowlegs, and mallard.

SENSITIVE WILDLIFE HABITATS

Sensitive habitats are defined by local, state or federal agencies as those habitats that support special status species, provide important habitat values for wildlife, represent areas of unusual or regionally restricted habitat types, and provide high biological diversity. The following plant communities occur in the Cow Creek Watershed and are considered sensitive wildlife habitats: freshwater marshes, perennial and annual ponds, riparian woodlands, oak woodlands, red fir forest, rock outcrops, and old growth red fir or old growth mixed conifer forest.

ROCK OUTCROPS

The occurrence of ledges and crevices in the rock cliffs of the Cow Creek Watershed can provide suitable nesting locations and foraging perches for several of the state and federally listed raptors. Table 8-2 shows a listing of all Special Status Wildlife Species found within the watershed. Only the American peregrine falcon (*Falco peregrinus anatum)* is known to occur and has nested in the watershed. Other species that may utilize this habitat include: prairie falcon (*Falco mexicanus*), golden eagles (*Aquila chrysaetos*), and Cooper's hawks (*Accipiter cooperii*)

OAK WOODLANDS

Oak woodlands are recognized as a sensitive wildlife habitat due to the statewide phenomenon of a lack of oak regeneration and the high abundance of wildlife species associated with this habitat (Mayer and Laudenslayer, 1988). The lack of recruitment of young oaks to replace older oak stands occurs under grazing or agricultural development and when wildfire and floods are suppressed. Grazing or trampling of new oaks and the decrease in rodent populations associated with grazing are threats to oak regeneration. Animal damage to acorns and the burying of acorns by scrub jays, western gray squirrels, and California ground squirrels promotes the reproduction of oaks, as buried acorns are likely to germinate because they root better and are less likely to be eaten by other species.

RIPARIAN WOODLANDS

At the state level, riparian plant communities are considered sensitive habitat and have been identified by the California Department of Fish and Game as Habitat of Special Concern (Wetlands Resource Policy, California Fish and Game Commission, 1987). Riparian habitats are valuable because they support a high density and diversity of wildlife species and provide movement corridors and cover for a large number of mammal, reptile, and amphibian species, as well as for resident and migrating neo-tropical birds. Riparian woodlands are a diminishing resource, and in the State of California at least 89% of riparian areas existing 130 years ago have been lost.

These areas provide potential habitat for state or federally listed species, such as the yellow-billed cuckoo, willow flycatcher, foraging peregrine falcons, and greater western mastiff bat. Species of Special Concern known to occur in the riparian corridor of the Cow Creek Watershed include: Shasta salamander, osprey, and northwestern pond turtles.

WETLANDS

Vernal Pools

No surveys for vernal pools were undertaken for this assessment; however, there are several vernal pool locations documented in and adjacent to the Cow Creek Watershed (DFG comment, DWA, 2001). Vernal pools are habitats for several federally listed invertebrate Species of Special Concern and are of high wildlife value for waterfowl, shorebirds, mammals, predatory birds, reptiles, and amphibians. Species of Special Concern which are dependent on vernal pools include: tadpole shrimp (*Lepidurus packari*), conservancy fairy shrimp, (*Branchinecta conservatio*), vernal pool fairy shrimp (*Branchinecta lynchi*), and California linderiella (*Linderiella occidentalis).* These invertebrate species have evolved reproductive strategies consistent with seasonal evaporative surface water.

Fresh Water Marshes and Ponds

In general, wetlands and their associated riparian plant communities, including the plant communities surrounding the agricultural ditches, are considered sensitive habitats due to their high wildlife value, limited distribution, and decreasing acreage statewide. These sensitive habitats have been significantly reduced from their historical distributions. In addition, the ponds provide potential foraging habitat for bald eagles, peregrine falcons, herons, and many of the listed species of bats. The Cow Creek Watershed has significant pond development associated with agricultural uses. The marsh habitats enhance all other habitat areas located adjacent to the marshes. Wildlife species from adjacent areas are likely to use the open water and cover in route to surrounding areas.

WILDLIFE SPECIES OF SPECIAL CONCERN

Information on wildlife Species of Special Concern was obtained from the California Natural Diversity Database, which documents known occurrences of special-status species. Significant additional information was obtained from comments by technical advisory committee members that referenced personal observations of special species.

FEDERALLY LISTED SPECIES

Federally listed species are known to occur and occupy habitat in the Cow Creek Watershed, and are included on Table 8-2. Additionally, bald eagles are seen in the watershed but do not nest there. There is vernal pool habitat occurring in the lower Cow Creek Watershed and private property that has not been evaluated in regard to these species.

The population status (numbers of individuals and nest locations) of the California spotted owl (*Strix occidentalis occidentalis*) has been surveyed in the upper Cow Creek Watershed, especially on private timberlands and in the Latour State Forest. The occurrence of northern spotted owls (*Strix occidentalis caurina*) in the lower Cow Creek Watershed would be rare, as their habitat boundary is believed to end well above Hwy. 299 East. Additional information on northern spotted owls is available in the N.S.O. database (DFG/CDF). In addition, the Migratory Bird Treaty Act protects all migratory birds (with or without state or federal listings) and their nests, including the great blue heron and great egret rookery sites.

The status of the federally listed bald eagle and the de-listed American peregrine falcon (also known to occur in the Cow Creek Watershed) is less understood. No bald eagle nest sites have been documented in the watershed. However, sightings of bald eagles within the watershed and nest locations adjacent the watershed have been reported, especially near Lake McCumber and along Little Cow Creek. Surveys for American peregrine falcon nests have been conducted, and two sites within the watershed are currently identified. The peregrine falcon was de-listed as a federally endangered species in 1999. Habitat for other cliff nesting species, such as the prairie falcon, is available within the watershed but no documented sites exist. Eagles are also protected under the Federal Eagle Protection Act (DFG, DWA comments, 2001).

The red-legged frog is listed by the federal government as Threatened. This species inhabits quiet pools of streams and marshes west of the Sierra-Cascade crest, though uncommon in the Sierra-Cascade crest region.

STATE LISTED SPECIES

State-listed species are known to occur in the Cow Creek Watershed and are included on Table 8-2. Other Species of Special Concern may occur in the watershed, but their presence or absence has not been documented.

Only one species that is known to occur in the Cow Creek Watershed is fully protected by the state, the American peregrine falcon. While individual golden and bald eagles are commonly observed within the watershed, no sites have been documented. Cooper's hawks *(Accipiter cooperii*) and sharp-shinned hawks (*Accipiter striatus*) are reported to be present in the watershed (Pers. comm. R. Carey, 2001), but are not formally documented. Ringtail cats (*Bassariscus astutus*) are also likely present in the watershed.

The sharp-shinned hawk is a common migrant and winter resident throughout California. Listed by the state as a Species of Special Concern, it is found in most habitats except alpine, open prairie and bare desert. It prefers to roost in intermediate to high-canopy forests and nests in dense, even-aged and single-layered forest canopies (WHR, 1999). Foraging in openings at edges of woodlands, the sharp-shinned hawk eats mostly small birds, mammals, reptiles and amphibians. The ringtail cat is a widely distributed nocturnal animal and is a common to uncommon permanent resident of California. It is listed by the state as California Fully Protected. The ringtail occurs in a wide variety of habitats including riparian, brush, shrub and forests. It prefers to find cover in hollow trees and snags, down logs, and other cavities in talus slopes or rock outcrops. The ringtail is primarily carnivorous, eating mainly rodents (woodrats and mice) and rabbits; it is also known to take birds and eggs, reptiles, invertebrates, fruits and nuts (WHR, 1999).

OTHER SPECIES OF SPECIAL CONCERN

The California spotted owl is a sub-species of the spotted owl family that in California includes the northern spotted owl (Strix occidentalis caurina). The California spotted owl is identified as a California Species of Special Concern. As an uncommon but permanent resident, it can be found in dense, old-growth, and multi-layered forest habitats of the Cascade Range and Sierra Nevada. It feeds on a variety of small mammals including flying squirrels, woodrats, mice and voles. Information on California spotted owls is fragmented.

WILDLIFE POPULATIONS

The Cow Creek Watershed is comprised primarily of private lands with limited public land located on the eastern portion of the watershed. It supports a diverse variety of wildlife, predominantly because of the diversity of vegetation communities available. A complete detailed list of potential species by habitat type is available from the Wildlife Habitat Relationship Database (CDFG). Significant portions of the watershed have been developed for rural, agricultural, and timber purposes. Most of the watershed remains rural in nature. The lower part of the watershed, especially near State Highway 44, Millville, Palo Cedro, and Bella Vista, has seen increased levels of residential development. This development, whether in or adjacent to developed communities or within wildland areas, can impact wildlife populations.

TABLE 8-2
Special-Status Wildlife Species

Species	Scientific Name	Legal Status Federal/State/ CDFG	Distribution	Habitat	Quadrangle Codes
American Peregrine Falcon	Falco peregrinus americana	FE/SE	Summer on the Cascade and Klamath Ranges south through the Sierra Nevada to Madera, winters in the Central Valley	Breeds near wetlands, lakes, rivers on high cliffs, banks, dunes, mounds	DR, MM
Bald Eagle	Haliaeetus leucocephalus	FT/SE	Siskiyou, Modoc, Trinity, Shasta, Lassen, Plumas, Butte, Tehama, Lake and Mendocino Counties	Nests in large, old-growth, or dominate live tree with open branches (Ponderosa pine)	HG, VI, DR, BV
California Spotted Owl	Strix occidentalis californicus	SC	South of Hwy. 299 East	Found in dense, old-growth, and multi-layered forest habitats	MC
Long-Horned Elderberry Beetle	Desmocerus californicus dimorphus	FE	Unknown	Elderberry bushes in riparian areas	--
Northern Goshawk	Accipiter gentiles	SC	Modoc, Lassen, Mono, and Inyo counties	Mixed coniferous forest	MC, HP, JB
Northern Spotted Owl	Strix occidentalis caurian	FT/SC	In the Cascade Range and Sierra Nevada	High, multistory canopy, many trees with cavities, wood debris, and space under canopy	VI, HP
Northwestern Pond Turtle	Clemmys marmorata marmorata	FSC/CSC	From Oregon border and Siskiyou County, through Sacramento Valley	Permanent or nearly permanent water in wide variety of habitats	DR, OR, MM
Osprey	Pandion haliaetus	SC	Klamath and Cascade Ranges, and the northern tip of the Sacramento Valley	Ocean shore, bays, fresh-water lakes, and large streams	IW, VI
Pale Big-Eared Bat	Corynorhinus townsendii pallescens	SC	Throughout California	Wide variety, commonly in mesic sites	DR
Pine Marten	Martes americana	SC	Sierra Nevada, Klamath, Cascade mountains	Mixed evergreen forests	JB
California Red-legged Frog	Rana aurora draytonii	FT	Unknown	Vegetated shorelines in waters west of Sierra Crest	--
Ring-Tailed Cat	Bassariscus astutus	SE	Unknown	Wide variety of habitats, hollow trees, snags, etc.	--
Sharp-Shinned Hawk	Accipiter striatus	SC	Unknown	Dense forest, Forages in forest openings and meadows	--
Shasta Salamander	Hydromantes shastae	ST	Shasta County	Cool, wet ravines and valleys, dominant vegetation oak woodland or chaparral	MC, DR
Shasta Siceband Snail	Monadenia troglodytes	SC	Shasta and Siskiyou counties	Limestone terrain	DR
Sierra Nevada Red Fox	Vulpes vulpes necator	ST	Cascade Range east to the Sierra Nevada. Not documented in Cow Creek drainage	Dense vegetation & rocky areas for cover. Prefer forest interspersed with meadows or alpine fell-fields	VI
Vernal Pool Fairy Shrimp	Branchinecta lynchi	FT	Central Valley, central and south coast ranges from Tehama County to Santa Barbara	Small, clear-water sandstone-depression pools and grassed swale, earth slump, or basalt-flow depression	PC
Vernal Pool Tadpole Shrimp	Lepidurus packardi	FE	Vernal pools in the Sacramento Valley	Grass bottomed swales of unplowed grasslands, highly turbid habitat	PC

TABLE 8-2 Key:			
Federal FED = Federal FT = Federally Threatened FE = Federally Endangered FPD = Federally Proposed for Delisting D = Delisted C = Candidate SC = Species of Concern	**State = State of California** ST = State Threatened SE = State Endangered SOC = Species of Concern FP = Fully Protected	**USFS = U.S. Forest Service** Sens = Sensitive	**BLM = U.S. Bureau of Land Management** Sens = Sensitive
Quadrangle Codes MC = Montgomery Creek PC = Palo Cedro CG = Clough Gulch IW = Inwood OR = Oak Run WM = Whitmore JB = Jack's Backbone	MM = Miller Mtn. HG = Hagaman Gulch VI = Viola DR = Devils Rock BV = Bella Vista HP = Hatchet Mtn. Pass		

BLACK-TAILED DEER

Deer are a significant wildlife species in California and an integral component in the food chain. They serve as grazers of wildland plants and as prey for carnivores, including the mountain lion, coyote and golden eagle. Additionally, deer are California's most popular game mammal, attracting between 165,000 to 200,000 hunters annually, based on 1998 data (Loft, et al., 1998). Deer habitat, especially browse and forage species, are mainly comprised of early successional vegetation (grass, brush, and young trees). Deer are also an indicator species for a variety of other birds and mammals (song birds, blue grouse, mountain quail, mice/voles, coyotes) since they utilize similar habitats. As populations of deer fluctuate based on available habitat, other wildlife populations associated with them rise and fall.

There has been significant documentation over the past 50 years that deer thrive in an environment that is comprised of large amounts of early successional vegetation. In general, there is a period between 2 to 30 years following forest disturbances (fire, logging) when brush, shrubs and young trees are at their peak in terms of overall abundance and quality for forage. During this period, deer and their associated species thrive. As disturbances decrease, naturally or through human intervention, early successional habitat decreases, resulting in an overall reduction in deer feed, habitat, and populations.

Disturbances in the early and mid part of the 20^{th} century created significant amounts of early successional habitat. This, in turn, allowed for the increased deer populations seen in the 1950s and 1960s. Overall, populations of deer in California peaked during this period; and since 1960, population levels are significantly lower statewide (Loft, et al., 1998). DFG suggests these population decreases are a result of declining habitat quality. This is displayed in Figure 8-2. The increasing role of fire suppression and the reduction in logging has decreased the amount of early successional habitat available for deer populations. This reduction directly impacts deer through decreased food sources and increased competition for the limited available food reserves. The decreased food source ultimately affects the ability of the populations to thrive. This is included in Figure 8-3.

Residential development has increased over the last 20 years within the Cow Creek Watershed. With this development comes increased fire protection and associated suppression efforts by state and federal agencies. This fire suppression has reduced the overall early successional habitat in Cow Creek. This reduction of early successional habitat is across vegetation and corresponding WHR habitats, resulting in older vegetation communities. This lack of disturbance eliminates rejuvenation of brush and grass species, which are an important component of deer habitat.

The Cow Creek Watershed is part of the Cascade-North Sierra Nevada Deer Assessment Unit (DAU), one of 11 statewide units that assess deer habitat status, population trends, and issues surrounding deer management. This DAU comprises about 7,000 square miles from the Oregon border south to the Lake Almanor area and the Feather River drainage. Within this DAU, the DFG has estimated that deer populations have decreased from 100,000 in 1952 to 25,000 in 1996. Population estimates for DAU2, which include Cow Creek, are included in Figure 8-4. Loft, et al., cite the main habitat issues in the DAU as lack of habitat disturbances that create early successional communities, and localized overgrazing by livestock on summer range habitats. They report that decadent shrubfields dominate much of this range and may serve as climax vegetation communities in some areas. Within the Cow Creek Watershed, areas of dense and decadent brush reaching climax conditions can be seen in the upper watershed along Fern Road, between Oak Run and Whitmore, along Hwy. 299. In many areas conifer forests have dense stands of manzanita up to eight feet tall growing in the understory, effectively eliminating young vegetation.

DAU population estimates are made annually by DFG. Utilizing two 25-mile survey routes, DFG personnel survey deer populations using a nighttime spotlight method. Table 8-3 displays the results of DFG survey efforts, showing numbers of animals observed on each route. Based on the latest survey data, the Cow Creek deer herd has a population of 6,000-8,000 animals. This is down from 1990 estimates of 8,000-10,000 animals.

The decline in numbers of animals is thought to be primarily due to loss of early successional habitat in deer summer range. This summer range provides deer with needed forage for development of fat reserves, which help them survive the winter. In studies sponsored by DFG, it was determined that deer are beginning to metabolize (or use) their fat reserves in late summer and early fall, a time when they should be continuing to build up their fat reserves. As a result of this early use of fat reserves, deer lack adequate fat to flourish over winter. This lack of nourishment in the summer results in smaller animal size, reduced fawning, and increased mortality rates of both adults and fawns.

TABLE 8-3
Spotlight Survey Counts[1]
Mean Values, 1992-1999

	Mean Number of Animals by Year							
Transect	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Fountain Fire	24.0	21.0	15.3	17.7	19.7	15.7	11.0	20.0
Cow Creek	11.0	13.7	10.7	11.0	18.0	24.3	20.3	7.7
Mean	**35.0**	**34.7**	**26.0**	**28.7**	**37.7**	**40.0**	**31.3**	**27.7**

[1] - Taken from DFG, Region 1, and information on summer survey routes, for Cow Creek herd.

DFG has developed significant information on deer habitat, migration patterns and population estimates in the Cow Creek Watershed. Critical winter range and migration routes are shown in Figure 8-5. These areas were designated by DFG biologists based on their personal knowledge about the watershed. Critical winter range comprises 32,688 acres within the watershed and consists of habitat used during winter months. These areas provide important food resources and cover. These areas expand and contract based on habitat conditions, primarily early successional vegetation. Habitat loss and encroaching development are primary concerns. DFG estimates that 20% of deer utilizing this winter range are permanent residents. Many have taken advantage of adjacent residential areas where people provide food for them throughout the winter (Smith, 2000, pers. comm.). Historic prescribed burning efforts by local landowners provided substantial benefits to this habitat by maintaining young vegetation in conditions that provide optimal forage for deer and associated wildlife populations. Burning has not been conducted in the recent past.

As temperatures increase and spring vegetation emerges, deer move from winter range to summer range, following the new vegetation. Deer predominantly migrate from the winter range to the summer range along major ridgelines, which are displayed in Figure 8-5. Migration routes shown represent significant routes that have remained relatively unchanged over time.

BEAR

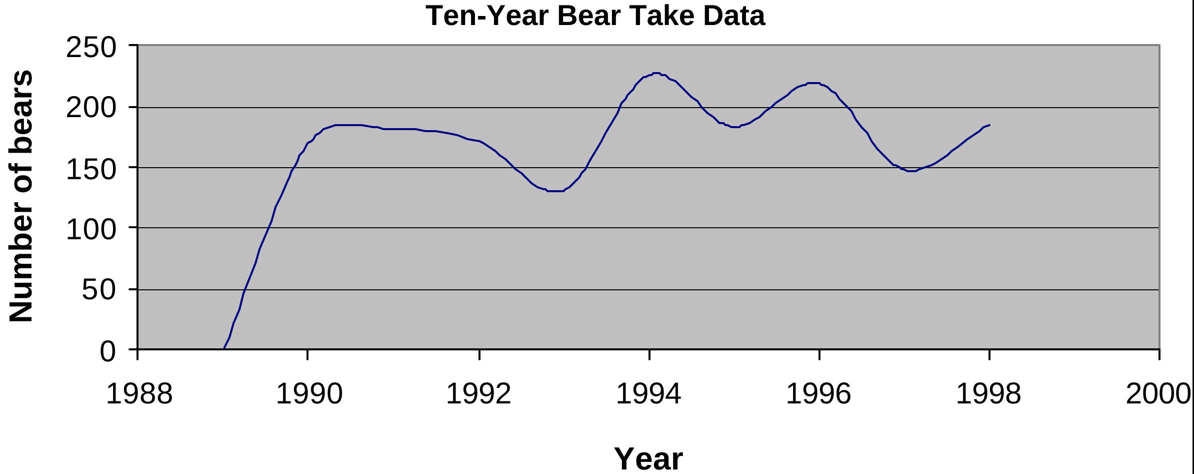
No specific data exist on bear populations in the Cow Creek Watershed. Black bear is a native species to California and they are known to be widely distributed in the Cow Creek watershed.

Historically, black bears and California grizzly bears occupied relatively distinct areas when the European explorers and settlers arrived. The black bear historically resided in forest communities and the grizzly resided in chaparral communities. When the grizzly was eliminated in the 1930s, the black bear expanded its range into chaparral habitat types of California. Suitable habitat for black bear can be characterized as forested areas with a mixture of vegetation types, providing both cover and a variety and abundance of food. If the vegetation mixture in one area is not sufficient enough to provide food for the bear all year, they will move relatively long distances to take advantage of seasonal abundance.

Black bears are members of the order Carnivora, though meat makes up a small portion of their diet. When emerging from their winter dens, bears forage on green grasses and forbs, as wells as insects and carrion. In the summer and fall months, they feed on berries and acorns to put on fat for hibernation. Some bears do take advantage of seasonal runs of anadromous fish during fall months; however, salmon do not constitute a major food in their diet (DFG, 2000). Occasionally bears do kill deer or eat carrion left over by other predators such as the mountain lion.

A ten-year study of black bear population within Shasta and Siskiyou counties indicates the bear population is increasing. According to the Bear Hunting Guide developed by DFG in February 2000, there are a total of 1,576,960 acres of black bear habitat in Shasta County. The following graph illustrates the ten-year bear take data for Shasta County. These data are independent of hunter effort.

FIGURE 8-6
Ten-Year Bear Take Data



MOUNTAIN LION

Mountain lions (cougars) are native to California and known to exist in the watershed. No specific population data are available for the Cow Creek Watershed. Lions are found in very diverse habitats throughout California, from deserts to humid coast range forests, and from sea level to 10,000-foot elevations. They spend most of their time on the ground, but are adept at climbing trees. Mountain lions prefer rocky canyons, escarpments, rim rocks or dense brush, usually avoiding heavily timbered areas. They prefer to den in an overhanging ledge, a crevice in a cliff, an enlarged badger burrow, a cavity under the roots of a tree, or a dense thicket.

Mountain lions are very powerful and normally prey upon larger animals, such as deer, bighorn sheep and elk. However, they often prey on smaller animals such as raccoon, coyote, squirrels, feral pigs, rabbits, and beavers. They are also known to feed on mice and other rodents, and insects such as grasshoppers if necessary. Cougars hunt on the ground and ambush their prey from behind. They are generally nocturnal and solitary hunters. The success of the hunt depends solely on the element of surprise. They are classified as a "stalking predator." A fatal bite below the base of the skull, resulting in a broken neck, is their preferred method of killing prey. The adult cougar may cover the carcass with dirt, leaves or snow, and may feed on one kill for several days. They are generally secretive and solitary, which makes it very likely for a person to live in the same area as a cougar without ever seeing one. Sometimes cougars are not nocturnal, because they need to be active at the time their prey is active. For instance, deer are active at dawn and dusk, so a mountain lion that feeds on deer will adjust its schedule to match the deer's.

An adult male's home range often spans over 100 square miles. Females have smaller ranges – between 20 to 60 square miles. In ideal habitat, such as the west side of the Sierra Nevada, as many as ten adult lions may occupy the same 100 square mile area. Cougars do not usually have fixed dens, except for mothers with cubs. Typically, they spend the day in thick cover if in a forest, perhaps in a cave or under an overhang, or in a rock fissure in more mountainous areas. A mountain lion's natural life span is about 12 years. Natural enemies include other large predators such as bears and other lions.

From 1907 to 1963, the mountain lion was classified as a Bountied Predator in California. During that 57-year period, more than 12,500 were taken – an average of 219 per year. During the bounty period, as many as 350 cougar were killed in one year. In 1963, it was reclassified as a non-game mammal and held that classification until 1969 when the mountain lion was listed as a game mammal. The cougar stayed a game mammal for only two years until 1972, when a package of laws prevented further hunting. During the two years it was hunted as a game mammal, only 59 animals were taken each year on over 4,300 tags that were purchased. In 1990, proposition 117 was passed that banned trophy hunting and human "management" of lion populations. Depredation permits issued and actual kills from 1972 until 1994 for Shasta County are included in Table 8-4.

TABLE 8-4
Shasta County Mountain Lion Depredation Permits Issued vs. Actual Kills 1972 - 1994

Year	Permits Issued	Kills
1972*	0	0
1973	0	0
1974	0	0
1975	0	0
1976	1	0

TABLE 8-4 (Continued)		
Year	**Permits Issued**	**Kills**
1977	2	0
1978	0	0
1979	2	0
1980	3	0
1981	7	1
1982	2	1
1983	1	1
1984	8	2
1985	3	1
1986	6	1
1987	8	2
1988	12	4
1989	8	4
1990	8	2
1991	18	7
1992	9	4
1993	8	0
1994	17	7
* No recreational hunting in 1972		

EXOTIC SPECIES

Several non-native introduced species occur within the Cow Creek Watershed: Brown headed cowbird (*Molthrus ater*), feral pig (*Sus scrofa*), Rocky Mountain Elk (*Cervus elaphus nelsoni*), wild turkey (*Meleagris gallopavo*), bullfrog (*Rana catebeiana*), ring-necked pheasant (*Phasianus colchicus*) and chuckar (*Alectoris chukar*) populations are known to occur. There have been no focused studies to monitor these populations over time or evaluate their interaction with other species within the Cow Creek Watershed.

BROWN-HEADED COWBIRD

The brown-headed cowbird is a non-native species that reproduces by parasitizing native passerine bird nests within its range. Brown-headed cowbirds parasitize other nests by exclusively laying their eggs in the nest of other birds, leaving their eggs to be raised by the host parents. In Central California, female brown-headed cowbirds laid about 30 eggs each season, with one to two eggs in each host bird nest (Zeiner, et al., 1990). Young brown-headed cowbird chicks then kick out the host bird chicks so the host parents exclusively raise the brown-headed cowbird chicks.

No field observations were made to determine the presence of the brown-headed cowbird in the watershed, and the presence and status is unknown. However, since these birds are relatively common and widespread it is assumed that populations are located in the Cow Creek Watershed.

FERAL PIGS

Wild pigs (*Sus scrofa*) are not native to North America. In California they are generally a cross between the European wild boar, introduced to the State in Monterey County during the mid-1920s, and the free-roaming feral pigs released by early settlers.

Wild pigs are common in forests, oak woodlands, and chaparral. The minimum requirements for good wild pig habitat are dense vegetation (chaparral and forest) and a water source. Suitable habitat consists of a mixture of dense brush and mature forest habitats for cover and reproduction within the watershed. Wild pigs also occur in riparian areas, mature conifer and hardwood forests, chaparral, and other brush types. Production of mast crops is an important factor influencing pig distribution. Adjacent agricultural lands also enhance the value of the pig's habitat. Wild pigs are omnivorous and their diet changes with the seasons. During the dry summer months, pigs eat green plants. During autumn, they consume acorns, walnuts, and fruit when these nutritious foods are available. During winter, when rains softens the soil, wild pigs eat roots, bulbs, insects, and worms that they locate by plowing or "rooting" the ground with their tough snouts. In the spring, as the soil dries, they gradually shift back to green plant parts. In some agricultural areas, barley and alfalfa are preferred foods. Small animals and carrion form a minor part of the pig's diet year-round.

Rooting by pigs in moist or irrigated soil is normally quite visible. Sometimes only a few small sites are rooted or the disturbed area may cover several hundred square feet or more. Rooted fields look like they have been rototilled. Rooting can harm pastures, crops, and native plants and may cause soil erosion. Pig rooting can alter the relative abundance of different plant species at the site and can change the functioning of natural ecosystems. In years of acorn shortage, wild pigs may compete with wild turkey, mule deer, squirrels, and black bears. Destruction by pigs of native vegetation and nests of ground-nesting birds may also be a serious problem.

Hunting is the primary method recommended by DFG for controlling wild pig populations and associated damage. Currently, hunters are allowed to kill and keep one pig per day year-round in most areas of the State. Population models predict that in normal years at least 70 percent of a wild pig population must be cropped annually to result in a stable population for the following year (Nee, 1992).

Wild pigs have been observed in the Whitmore area of the watershed. Although the current population of wild pigs in this area does not appear to be large (there have been no known studies assessing the wild pig population in Cow Creek), wild pig populations have the potential to create ecological and health problems. In studies conducted in Tehama County, wild pig densities were reported as five to eight pigs per km (Zeiner, et al., 1990). In the Tehama County study, home ranges of male wild pigs averaged about 52 km and females averaged about 13 km.

WILD TURKEY

Wild turkey can be found throughout much of the state, including Shasta County; however, there are no available turkey surveys in the Cow Creek Watershed. The information in this section is based on statewide data. Turkeys are well established in Cow Creek and numerous ranchers used to trap seed stock for planting outside of the watershed.

The California Fish and Game Commission first introduced Merriam's wild turkeys to California in June of 1908, with many more releases since that time. The historic range of this species is suspected to be Arizona, New Mexico, and Colorado. They have established populations in approximately 37 counties in California, and are generally found in deciduous riparian, oak, and conifer-oak woodlands.

They prefer large trees with some canopy, ideally with numerous grass/forb openings near water in hilly terrain. Densities range from 60 to 120 acres per bird in portions of their range, with a total estimated population of at least 154,000 birds in California. Nesting success for the turkey is 50 percent, with an average number of 10.5 eggs per clutch and hatching success around 87 percent. An average of 17,176 birds per year are taken in the annual harvest.

The DFG currently has an active program to expand and enhance wild turkey populations through translocation programs. The turkey is not native to California and this program has been receiving opposition. A suit has been filed by the California Native Plant Society against DFG, stating the potential impacts of these releases to sensitive flora and fauna. DFG is currently researching the wild turkey habitat relationship and food habits in California, to better address the possible impacts of this translocation program.

PHEASANT

Ring-necked pheasants are a small game birds known to exist in the watershed. They are generally found on agricultural lands, where grain crops exist near herbaceous and woody cover. This habitat exists in the Cow Creek Watershed, however no pheasant surveys have been done. Pheasant hunting does occur within the watershed. Current statewide hunting regulations permit the harvest of males only. Since pheasants are polygamous, hunting does not effect the reproduction of the species.

The ring-necked pheasant is not native to this continent. It was first introduced from China to the Willamette Valley of Oregon in 1881, and then introduced sometime in the 1880s in California. By 1925, the pheasant population established itself in California in sufficient numbers for a hunting season. The pheasant population has maintained itself since, with an estimated 732,214 birds throughout the state, and a density of 0.66 to 12 acres per bird. The nesting success of the pheasant is around 53 percent, with a clutch size averaging 12 and an 83 percent hatching rate (DFG, 2000).

CHUKAR

Chukars are predominantly found east of the Sierra Nevada and Cascade Range. They are generally found in arid, rocky annual grassland, and in brush and scrub habitats where water is available. This habitat exists in the Cow Creek watershed, and chukars have been sighted; however, no species-specific surveys have been conducted in the watershed. Chukars are a non-obtrusive species; there are no known impacts from their introduction.

The chukar is native to southern Asia and southeastern Europe. Since its introduction to California, it has been sighted from below sea level to an altitude of 12,000 feet, occupying 18 habitat types throughout the state. Densities of these birds range from 10 to 23 acres per bird (DFG, 2000). An estimate of 1,400,000 birds makes up the adult spring breeding population in California. According to DFG, the percentage of successful nests is 25 with an average clutch size of 15.5 eggs and a hatching rate of 80 percent.

Recreational hunting is the primary method recommended by the DFG for controlling the chukar populations. This control method utilizes licensed hunters who are allowed to take a specified number of chukars per year for given areas in the state. The estimated hunting mortality average is 60,210 birds per year throughout the state. There are no specific mortality or population statistics for chukar in the Cow Creek Watershed (DFG, 2000).

ELK

Rocky Mountain elk are not native to California. In 1913, about 50 elk were translocated by boxcar from Gardiner, Montana (Yellowstone National Park) by the Redding Elks Club. This herd was released at the Bully Hill Mine, which was found to be good elk habitat. Four populations of Rocky Mountain elk exist statewide, with a total population of approximately 1,000-1,500 (DFG, 2000). The herd that migrates through the Cow Creek Watershed is known as the Shasta Rocky Mountain elk herd. DFG estimates that there is minimum of 150-200 Rocky Mountain elk within the watershed, although there is no formal estimate of the number of elk that are specifically in the Cow Creek watershed. The herd is reported (Smith, 2000, pers. comm.) to have expanded and moved south across the watershed from Bella Vista into Shingletown. Increasing density of brush canopy and lack of browse plants in the original release area are reported to be responsible for the movement.

Elk gather in groups and cooperate for their mutual benefit. Herds are usually 25 or more animals, which protect the herd from predator attacks. They usually feed shortly after sunrise and before sunset; if disturbed by human activity or hunting, they will feed only at night. During the summer, elk tend to graze on grasses and forbs. In the fall when grasses tend to dry, they feed on saplings, berries, and mushrooms. During the winter, elk eat dried grass, trees, berry bushes, and large shrubs. They rely heavily on fat reserves to get them through the winter.

The public has had the opportunity to hunt Rocky Mountain elk. From 1969 through 1972, 500 elk license tags were issued in Shasta County. There was a resulting harvest of 50 elk, total, during that period (DFG, 2000). Since 1984, 1,015 license tags for Roosevelt and Rocky Mountain elk have been issued through public drawings: 110 of these tags were issued for the Shasta Rocky Mountain elk hunt, and 48 elk were taken as a result of this hunt (DFG, 2000). Currently, there is a program which allows five public hunting licenses to be issued for population control. Elk herds have demonstrated their ability to experience reductions in herd size without long-term adverse impacts on either local or regional population. Because Rocky Mountain elk are not believed to be native to California, current DFG policy has been to not relocate them within California.

BULLFROG

The bullfrog is native to eastern portions of North America, and was introduced into western states for mosquito control, mainly in the 1920s and 1930s. Records indicate bullfrog invasions were appearing in California as early as 1895. Bullfrogs are known to occur throughout the Cow Creek Watershed; however, no formal surveys have been conducted to estimate the frog population in the watershed or county.

Bullfrogs prefer warm, weedy, permanent ponds and lakes, and may be found in small ditches and along slow-moving streams. Adult bullfrogs unselectively prey upon native frogs, especially yellow-legged frog adults and tadpoles. Their diet also includes insects, young birds, mice, fish, and snakes.

A management practice that will aid the native frog population is the elimination of the bullfrog. Methods that have proven successful include long-term extermination efforts. This could result in the successful recruitment of a native frog population.

CONCLUSIONS

Wildlife populations in the Cow Creek Watershed have been modified by changes in vegetation management and diversity, development, introduction of non-native species and statewide policy decisions. Little watershed-specific information is available. No available reports, with the exception of deer data, are supported by infield monitoring.

- Exotic species can compete with native species.
- Rare, endangered, exotic and native species exist in the watershed.
- The Cow Creek deer herd is in decline due to reduction in early successional habitat.
- Turkeys are well established in the watershed.
- Wild pig is present in the watershed and may sustain lion populations during periods of deer decline (Dave Smith, pers. comm., 2000).
- No mountain lion population data are available for Cow Creek, but statewide data show mountain lion populations increased following hunting prohibitions, but may be stabilizing.
- Bear populations continue to increase statewide and in Cow Creek.
- Additional information is needed on special-status species habitat in the watershed.

The following data are not available:

- Watershed-specific population estimates for wildlife species.
- Watershed-specific inventory data for all species beside deer.
- Update of watershed-specific Specia l Species lists.

ACTION OPTIONS

Limited watershed-specific data are available for wildlife populations. Based on review of the watershed and available information, the following recommendations are presented:

1. Work with and encourage DFG to expand comprehensive monitoring programs for populations of selected wildlife within the watershed to monitor trends over time.
2. Encourage state agencies and landowners to identify and cooperate on worthwhile projects.
3. Prepare a riparian habitat assessment inventory.
4. Consider restoring riparian habitat in the watershed
5. Work with DFG to assess current levels of detrimental exotic fauna (brown-headed cowbirds and wild pigs) in the watershed, especially wild pigs. Population assessments can establish locations and trends of these animals.
6. Consider restoring and protecting oak woodlands in the lower watershed. Develop an oak regeneration program in the lower portion of the watershed. Evaluate need for zoning and land use protection for oak. Oak regeneration will enhance wildlife habitats.
7. Consider a fuels assessment and management plan for the watershed. CDF and the US Forest Service should tie this assessment to the CDF fuel types/models for consistency and ease of use.

The management plan should identify concentrations of residences, strategic locations for fire suppression efforts, and high priority areas for management of existing fuels.

8. Consider a prescribed fire program on private non-industrial lands. This cooperative effort should involve the CCWG, private landowners, CDF and DFG. Reintroduction of fire into the watershed will benefit wildlife by reestablishing early successional vegetation. Additional benefits will be to private lands and residences.

9. Protect and enhance summer and winter range deer habitat in the watershed by using fire as a tool for habitat enhancement, evaluating the effects of prescribed burning on the watershed deer populations, assessing changes in habitat usage and population trends of the Shasta deer herd following vegetation management practices implemented to increase forage and stream flow, and determining the impacts of predation from cougars and bears on the watershed's deer herd.

10. Encourage landowner participation in government cost-share programs that enhance/restore wildlife habitat.

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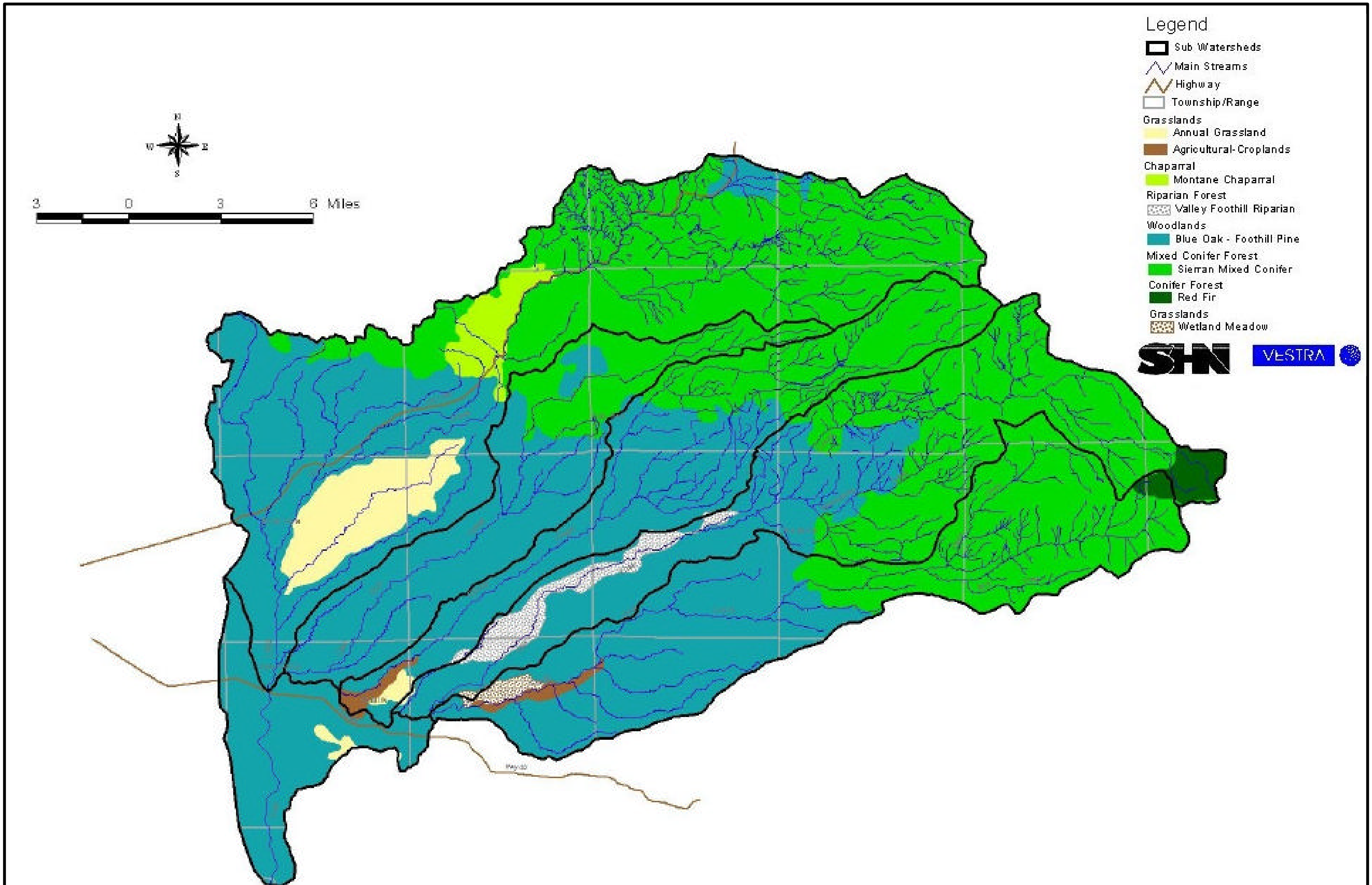
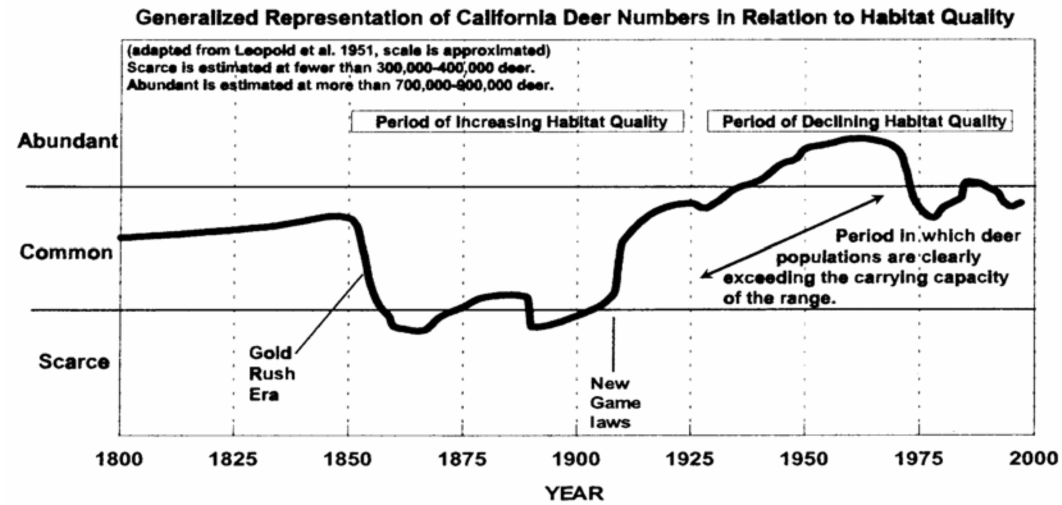


FIGURE 8-1
WILDLIFE HABITAT RELATIONSHIPS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

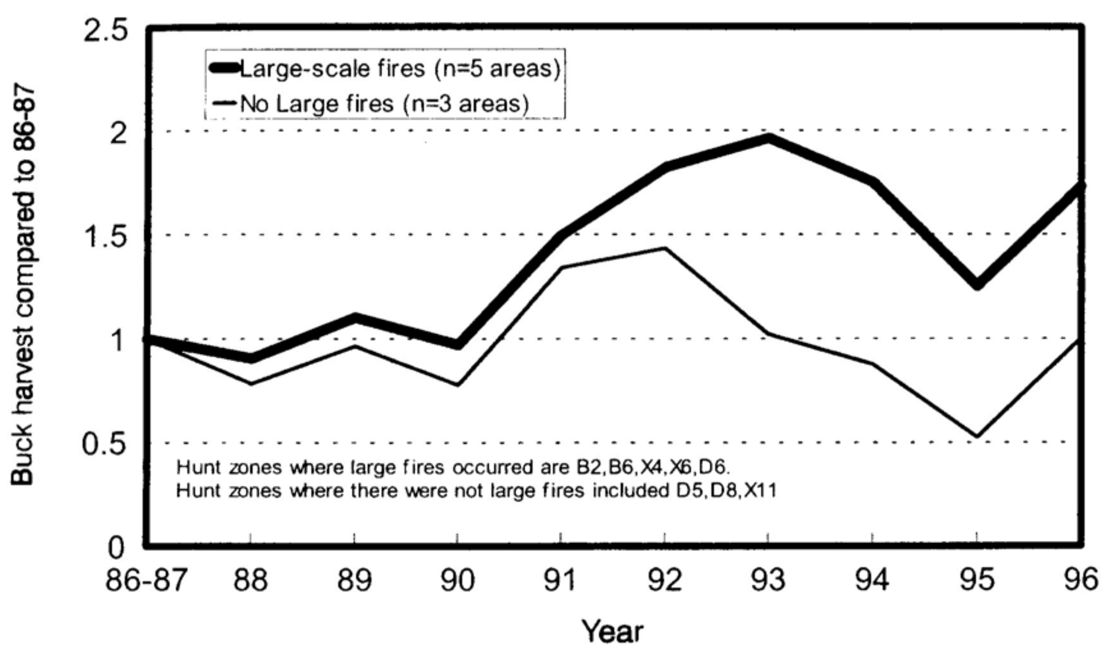
Reference: UC Santa Barbara GAP Analysis

FIGURE 8-2



Generalized deer population trends as they relate to key periods of increasing habitat quality due to disturbances (e.g., fire and logging) and decreasing habitat quality due to declining disturbance (fewer fires and more regulated logging). Opening of forests as a result of post World War II logging activities likely contributed to the final peak in deer numbers in the 1960s, but also signaled the start of the decline as those forests began to "close" again. (From DFG, 1998)

FIGURE 8-3



Buck deer harvest in years following 1987 fire year on forested deer ranges. Numbers reflect proportional change in deer harvest compared to 1987 values in five areas with, and three areas without, large fires. These zones comprise portions of the DAUs. Fires were each greater than 30,000 acres in size.

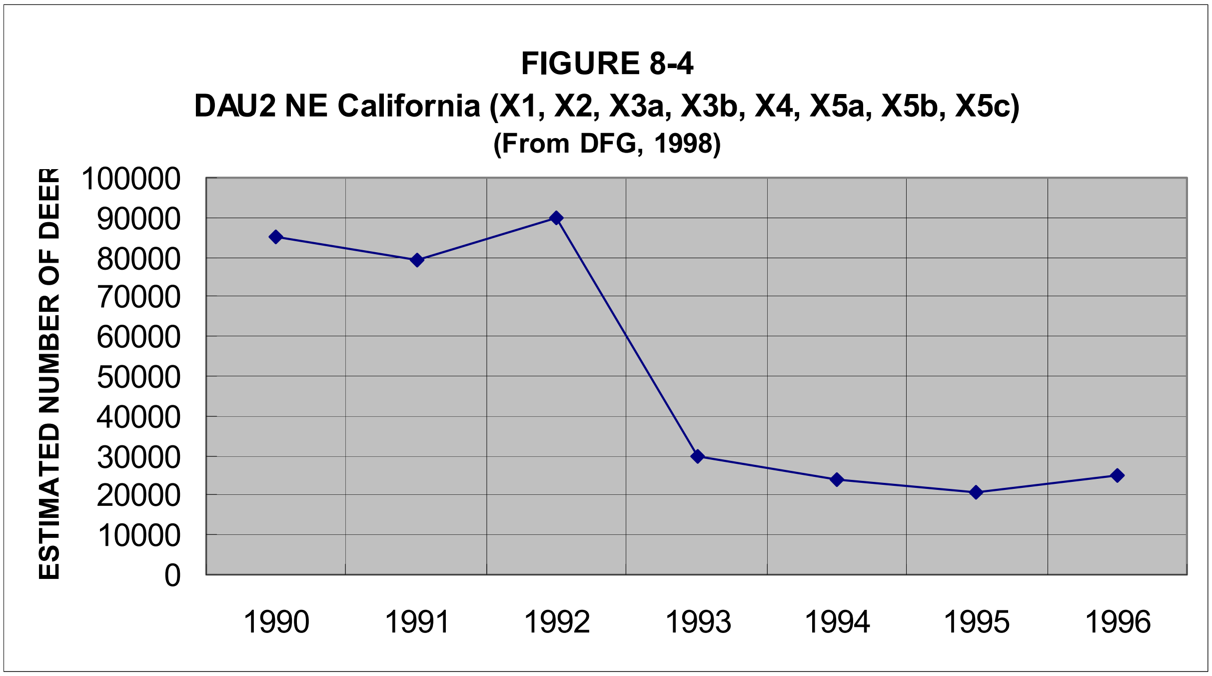


FIGURE 8-4
DAU2 NE California (X1, X2, X3a, X3b, X4, X5a, X5b, X5c)
(From DFG, 1998)
ESTIMATED NUMBER OF DEER
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1990
1991
1992
1993
1994
1995
1996

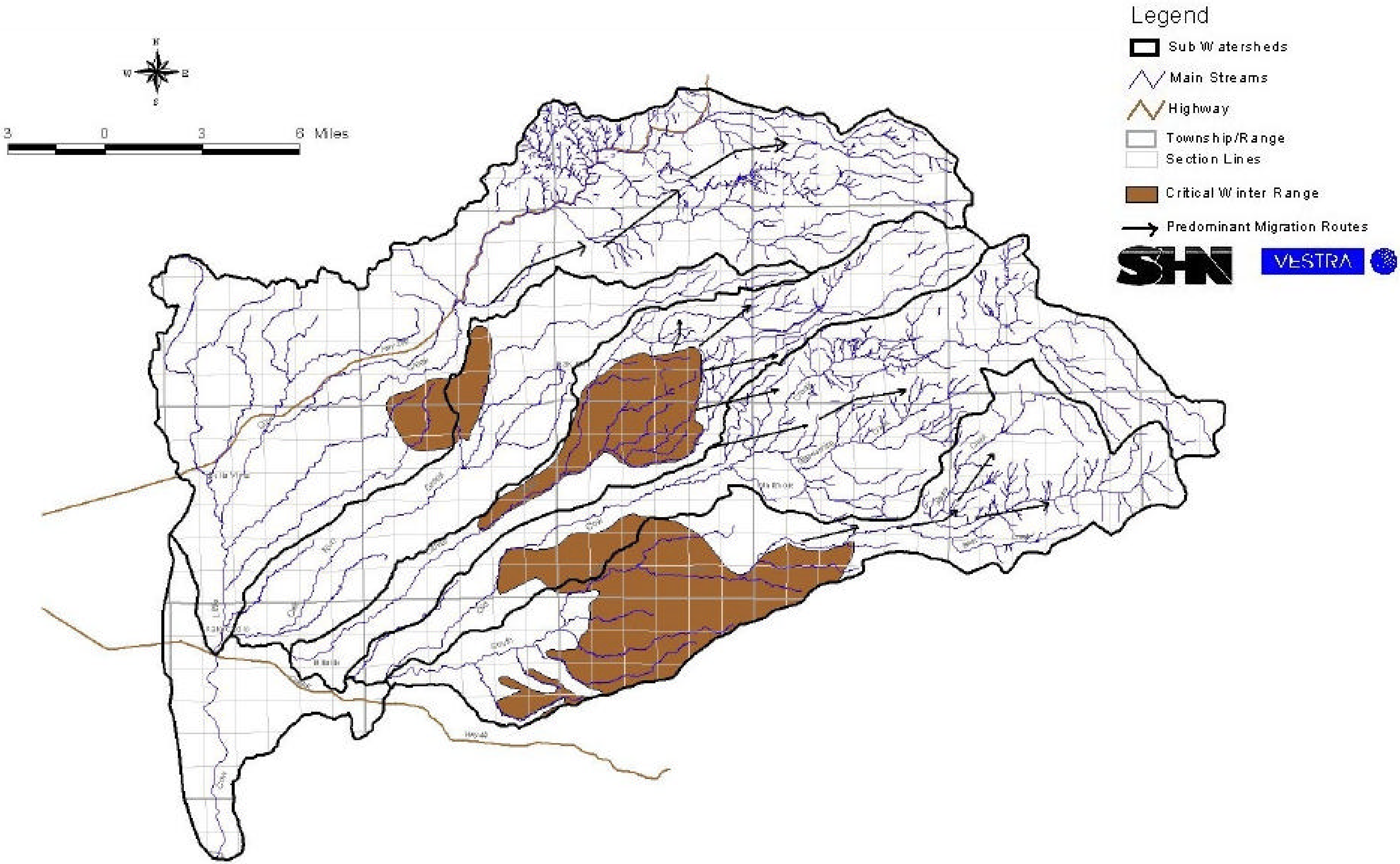


FIGURE 8-5
DEER RANGE AND MIGRATION PATTERNS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: DFG

Section 9
FISHERIES AND AQUATIC RESOURCES

Section 9
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Section 9
FISHERIES AND AQUATIC RESOURCES

REFERENCE CONDITIONS

No data on historic reference conditions for fisheries were found during the assessment process.

INTRODUCTION

Cow Creek is a large, uncontrolled tributary to the Sacramento River. Little Cow Creek, Oak Run Creek, Clover Creek, Old Cow Creek, and South Cow Creek flow in a southwesterly direction and form the mainstem of Cow Creek near Millville. These tributaries have been ranked as existing and potentially enhanceable habitat for chinook salmon and steelhead. Limited data are available on the fish resources in the Cow Creek Watershed.

Fall, late-fall, winter, and spring runs of chinook salmon (*Oncorhynchus tshawytscha*) occur in the Sacramento River. Historical spawning areas were generally in the upper reaches of the Sacramento, Pit and McCloud Rivers, in addition to the many tributaries along the mainstem of the river. Since the construction of Shasta Dam (fill year 1943), spawning has been limited to the Sacramento River below the dam and river tributaries, and the majority of the chinook spawning is fall-run (Moyle, 1976). Juvenile winter Chinook salmon may use Cow Creek as rearing habitat (non-natal rearing) even though they may have hatched elsewhere in the Sacramento River system (DFG, DWA comments, 2001). The winter-run chinook salmon is listed as endangered on both federal and California lists. Spring-run is listed as threatened under both federal and state lists.. Review of available information from DFG, USFWS, BLM, and other studies performed for various hydroelectric projects within the watershed, documents that fall-run and perhaps late-fall-run chinook salmon, as well as steelhead, use this watershed for spawning and rearing.

Fall-run chinook salmon are believed to occur in all tributaries of the watershed below natural barriers. The distribution of fall-run Chinook is generally restricted to the valley floor and lower foothill elevations of Cow Creek and its major tributaries; however, smaller portions of the population can be expected to ascend to the upper-most waterfall barriers in the system (typically to an upper limit of 1,000 feet of elevation). More detailed study and analysis is required to precisely describe the distribution of spawning activity in the creek system. Outside of the summer period, the low stream flow and high temperatures in the early fall may affect that portion of the adult population attempting early immigration to the spawning areas. Those same conditions in the late spring may affect that portion of the juvenile population attempting late out migration to the river. More detailed study and analysis is required to examine controllable factors during these periods. However, the stream system always has some flow during these periods due to the fact that the water rights adjudication and water master service requires that the upstream diversions allow sufficient water to reach the downstream diversions. (DFG, DWA comments, 2001).

The data relating late-fall-run chinook salmon are very limited. There are no estimates of the population of late fall-run in Cow Creek, although they have been documented there. According to DFG file data, the most recent survey for late-fall-run spawning was an aerial survey of Cow Creek conducted on February 26, 1965 (Healey, 1965). Fifty-four carcasses and 14 live fish were observed in the entire Cow Creek Watershed. Most of the live salmon were observed below the Hwy. 44 Bridge, while the carcasses were evenly distributed between Millville and the confluence with the Sacramento River. No carcasses or live salmon were observed in Old Cow or Sough Cow Creeks (DFG, DWA comments, 2001).

Summer flows are a limiting factor for both adult and juvenile spring-run Chinook in the foothill reaches of the stream. Little is known about spring-run Chinook populations in the Cow Creek Watershed. The best available information is that Cow Creek is not part of the present range and distribution of spring-run Chinook salmon in the Central Valley of California (Department of Fish and Game Report to the Commission: A Status Review of the Spring-run Chinook Salmon in the Sacramento River Drainage). There is some anecdotal information that South Cow Creek may have been part of the historic range and distribution of spring-run Chinook. (DFG, DWA comments, 2001).

Winter-run chinook salmon are not believed to be present in the Cow Creek Watershed. The best available information indicates that the Cow Creek system is neither part of the present nor past range and distribution of winter-run chinook salmon in the Central Valley of California (National Marine Fisheries Service Proposed Recovery Plan for Sacramento River Winter-run Chinook August 1997). However, recent studies have shown that Sacramento River tributaries may be used for non-natal rearing for this race of salmon (DFG, DWA comments, 2001).

Steelhead populations have not been estimated in Cow Creek. No specific studies have been conducted on Cow Creek to estimate the size of the steelhead spawning run, although DFG (1965) estimated that Cow Creek supported annual spawning runs of 500 steelhead (current estimates would be much lower). Adult steelhead have been observed in North Cow, Old Cow and South Cow creeks; however, it is unknown what percentage of the steelhead run utilizes the other tributaries. Most steelhead spawning in South Cow Creek probably occurs above South Cow Creek diversion. The best spawning habitat occurs in the 5-mile reach of stream extending from about 1.5 miles below South Cow Creek Diversion Dam to 3.5 miles above the diversion dam (Healy, 1974). Additional spawning habitat occurs upstream of this reach, but it is much less abundant. Sightings of adult steelhead have been made at the South Cow Creek Campground (approximately 8.5 miles upstream of the South Cow Creek Diversion Dam) and in Atkins Creek, located just upstream from the campground. (DFG, DWA comments, 2001).

Cow Creek has been identified by DFG and USFWS as a candidate for restoration of anadromous fisheries. A 1996 study by the RWQCB identified limiting elements in the watershed specific to anadromous fish resources as high temperature and low flow. In addition, the study identified high concentrations of fecal coliform in two of the five main tributaries.

The *Working Paper on Restoration Needs*, compiled by the Anadromous Fish Restoration Program Core Group in 1995, identified Cow Creek and its tributaries as in "relatively good condition" related to salmon and steelhead spawning habitat. The working group identified the primary limiting factors for chinook salmon and steelhead as low fall and summer flows affecting attraction, migration, spawning, and rearing, caused in part by irrigation diversions. Irrigation diversions also affect steelhead by delaying or blocking adult upstream migration and the entrainment of juvenile migrants. The report suggested that low flow conditions were a function of irrigation diversions.

The restoration report stated that, in general, agricultural diversions are unscreened, unladdered, and ditches unlined; also, that the irrigation season typically operates from April through October and negatively affects stream flows important for all-run attraction, migration, and spawning. The same report suggested that livestock grazing has reduced riparian vegetation and eroded stream banks in the various tributary streams and in the mainstem of Cow Creek, causing increased sedimentation and degradation of the quality of spawning gravel in Cow Creek. Increased demand for domestic water due to increased urbanization and development is reported to be affecting riparian habitat within the Cow Creek Watershed (Reynolds, et al., 1993), especially in the vicinity of Palo Cedro, Millville, Oak Run, and Bella Vista. The proposed restoration plan included recommended actions to provide additional flow, improve fish passages, reduce entrainment, and protect the riparian corridor.

The Central Valley Project Improvement Act Tributary Production Enhancement Report (CH2M HILL, 1998) states that the loss of habitat from livestock grazing practices and agricultural diversion of water…reduced or degraded salmon and steelhead spawning and rearing habitats. Hydropower facilities also have altered instream flows. Agricultural diversions are unscreened resulting in the loss of juvenile fish emigrating from the watershed. Population growth in the communities of Palo Cedro, Bella Vista, Oak Run and Millville is increasing the demand for water, and the associated development is impacting riparian areas within the lower watershed. . . . Water quality in Cow Creek has been significantly affected by siltation and erosion in the upper watershed. Excessive livestock grazing along Cow Creek and its principal tributaries has eroded stream banks. The resulting soil erosion and stream channel siltation have degraded salmon and steelhead spawning substrate in Cow Creek and its tributaries. . . . Elevated water temperatures in the summer, resulting from low stream flows and the lack of riparian cover due to livestock grazing, frequently reach levels that are detrimental or even lethal to salmon and steelhead.

The report identified six primary factors limiting anadromous fish production in Cow Creek:

1. Diversions decrease in-stream flows resulting in elevated spring, summer and fall water temperatures and reduced habitat availability;
2. Barriers limit upstream passage of adults;
3. Juveniles are entrained at irrigation and other unscreened diversions;
4. Livestock grazing results in sedimentation of substrate and the loss of riparian cover;
5. Urbanization and creek-side development results in habitat loss and degradation;
6. Gravel mining removes riparian vegetation and spawning gravel from the stream.

Cow Creek is one of the few streams in California that is not altered by a major storage dam. Fry (1961) attributed the decline in fall-run chinook salmon numbers in Cow Creek primarily to irrigation diversions. There are no minimum flow requirements for many diversions. A loss of juvenile migrating fish to water diversions and entrainment of juvenile salmon and steelhead is assumed to occur in Cow Creek and the tributaries. Only the PG&E diversions have fish screens that comply with DFG fish screen design criteria.

FISH POPULATION DESCRIPTIONS

There are three different groups of fish living in Cow Creek: Anadromous, Resident, and Exotic species. This section includes a brief discussion of background information on each of the general groups of fish.

Anadromous species with consistent runs up Cow Creek include fall-run chinook salmon and winter-run steelhead. Resident native species occurring in Cow Creek include: rainbow trout, hardhead, California roach, riffle sculpin, speckled dace, tule perch, Sacramento pikeminnow (formerly squawfish), and Sacramento sucker (Dettmen, 1977). Exotic species known to occur in Cow Creek are brown trout, brook trout, bluegill, carp, white catfish, small-mouth bass, large-mouth bass, and green sunfish. With the exception of the brook trout and brown trout, the majority of these species are found in the warmer waters in the mainstem and tributaries. DFG has planted hatchery-reared rainbow, brook and brown trout since 1930s. The brook trout plantings have generally been limited to the upper reaches and tributaries of the five main tributaries. Brown and rainbow trout have been planted throughout the watershed. Steelhead and chinook salmon have also been planted historically.

ANADROMOUS FISH

Anadromous fish emigrate to the ocean or estuary early in their life, typically grow to large size in the ocean or estuary, and return inland as adults to spawn in freshwater streams and rivers. Chinook salmon and steelhead are anadromous game fish using the Sacramento River and its tributaries. The habitat requirements of salmon and other anadromous fish in the freshwater environment vary by life stage, season, species, and race.

Four distinct races of chinook salmon spawn in the upper Sacramento River and its tributaries - they are named for the season during which the majority of the run enters fresh water as adults. The timing of the immigration run is not the only feature that makes each race distinct. Each chinook salmon race spawns in different portions of the watershed. Fall-run chinook salmon usually spawn within a few weeks of their arrival to spawning grounds in the low-gradient sections of the river in the fall. Late-fall-run chinook salmon immigrate at the same time as fall-run chinook salmon, but hold in the river and delay their spawning until winter. Late-fall-run chinook salmon spawn in mid-elevation regions of the watershed. Winter-run chinook salmon enter the river during the winter and wait until early the following summer, in the headwaters of a volcanic watershed, to spawn. Spring-run chinook salmon immigrate in the spring and spend the summer in deep, cool pools of the headwaters, and spawn in the upper elevations early in the fall. Given this diversity in life history, timing of immigration, spawning, and hence, incubation, emergence, rearing, and emigration, chinook salmon may be found in the Sacramento River at any time of year. (Please see Figure 9-1.)

Life history characteristics for Sacramento chinook salmon races are included in Figure 9-1, taken from Vogel and Marine, 1991. Salmon life history is closely associated with hydrology and water quality. Timing of immigration of adults, spawning, and emigration of juveniles and smolts are also affected by local events that include: photoperiod or water temperature (environmental trigger, or a water quality factor), rearing conditions (rapid growth accelerates emigration), or seasonal storms.

Impacts to spawning success include:

- Adequate-sized territory;
- Sufficient size and quality of gravel;
- Appropriate water depth;
- Appropriate water temperature;
- Appropriate water velocity.

Chinook salmon spawning typically occurs in swift, relatively shallow riffles or along edges of fast runs where there is an abundance of loose gravel. Chinook salmon require clean, loose gravel. The territory required for pre-spawning activity is between 200 and 650 square feet, but this varies widely according to population density. The minimum spawning area for a chinook salmon female is between 75 and 100 square feet. This may vary with the size of the female. The female digs a spawning redd in the gravels and deposits her eggs in several egg pockets. The eggs are fertilized by the male and buried in the gravel by the female. The adults die within a few days after spawning. An average female chinook salmon produces 3,000 to 6,000 eggs, depending on the size and race of fish. Chinook salmon select spawning areas within a narrow range of water velocity and stream depth (CH2M HILL, 1998).

Water velocity is more important than depth for determining the suitability of a spawning site. The water velocity determines the amount of water that will pass over the incubating embryos. Sufficient water must percolate through the gravel to supply oxygen and remove metabolic wastes from the developing embryos or alevins. In general, optimal water velocity for chinook salmon spawning is 1.5

feet per second (fps). Chinook salmon typically spawn at depths ranging from one to five feet. Rare instances are reported in the literature where spawning occurs in water as deep as 20 feet. Successful spawning requires cool, well-oxygenated water. Migrating adults prefer water temperatures less than 60 degrees F; however, acceptable temperatures for upstream migration range from 57 degrees F to 67 degrees F. The preferred stream temperature for chinook salmon spawning is generally 52 degrees F, with a range of 42 to 56 degrees. Stream temperatures beyond this range result in reduced viability of incubating embryos or increased mortality of developing fry (Reynolds, et al., 1993). The embryo life stage is more sensitive to water temperature stress than any other life stage. Half the embryos die at temperatures colder than 37.4 degrees F (Beacham and Murray, 1990). Lowest embryo mortality was within the range of 53 degrees F to 57.5 degrees F during incubation (Boles, 1988). Beacham and Murray (1990) found that half the embryos die at stream temperature in excess of 57 degrees F, with total mortality occurring at 62 degrees F. Embryos usually hatch within 40 to 60 days. When embryos become alevins, their tolerance for both colder and warmer stream temperatures increases (Frank Fisher, pers. comm., 2001). Only ten percent of the alevins die at temperatures as low as 35.6 degrees F (Beacham and Murray, 1990). Alevins usually remain in the gravel for an additional four to six weeks, until the yolk sac is completely absorbed; then they emerge from the gravel as fry. The rate of embryo and alevin development is faster at higher temperatures, but oxygen requirements also increase with increasing stream temperatures, while dissolved oxygen concentrations decrease with increasing temperature at the same time. Fingerling chinook salmon have a preferred range of 53.6 degrees F to 57.2 degrees F, with maximum growth occurring at 55 degrees F (Boles, 1988). The upper lethal temperature for chronic exposure to chinook salmon in the Sacramento River is 78.5 degrees F, although higher temperatures can be tolerated for brief periods (Boles, 1988).

Generally, chinook salmon require 79 days of 50 degrees F as the total time from spawning through emergence. Chinook salmon generally reach full maturity at three to four years of age; however, some two-year-old males ("jacks" or "grilse") become sexually mature. Clark (1929, cited in Hanson, et al., 1940) concluded that 50 percent of the Sacramento-San Joaquin chinook mature at four years, and the age of maturity in decreasing order of abundance was four years, five years, three years, six years, and two years. Ocean harvest has probably changed the age structure of chinook salmon. Commercial fisheries continually remove larger and older individuals, leaving mostly three-year-old fish to return to spawn. It is inferred that run resiliency may be adversely affected in at least the spring-run and late-fall-run chinook salmon (Moyle, et al., 1994). All Pacific salmon die after spawning.

The abundance of chinook salmon has been declining. Prior to 1915, the peak chinook salmon runs in the Sacramento River may have been as large as 800,000 to one million spawners, with an average run size of 600,000 (Reynolds, et al., 1990). During the period of 1976 through 1985, the average annual run of all races of chinook salmon in the upper Sacramento River and its tributaries has been 233,888 (Reynolds, et al., 1990).

Fall-Run Chinook Salmon

Adult fall-run chinook salmon migrate upstream into fresh water from July through December, and spawn from early October through late December (Reynolds, et al., 1993). Migration activity increases with seasonal rainstorms. Fall-run chinook salmon spawn in the low gradient portions of most Central Valley streams. Peak spawning occurs in October and November. Embryo incubation occurs from October through March, and juvenile rearing and smolt emigration occurs from January through June (Mills and Fisher, 1994). Timing of emigration varies with water year; juveniles emigrate past the Red Bluff Diversion Dam during winter in normal precipitation years, but delay until spring in dry years (Johnson, et al., 1992). Unlike the other chinook salmon races, the majority of young, fall-run chinook salmon emigrate to the ocean during the first few months following fry emergence from the spawning gravels (i.e., they smolt on the run).

Fall-run chinook salmon migrate upstream into Cow Creek during the fall (late September through December) after the first autumn rains have increased stream flow. It appears that the upstream limit of fall-run chinook salmon migration into Cow Creek is limited by physical barricades of most tributaries and flow volumes. When lower than usual flows are present, the fall-run is limited generally to the mainstem and portions of South Cow Creek and Little Cow Creek (Healy, pers. comm., 2001). After hatching in December through March, the fry rear for only a few months and emigrate to the ocean primarily during April through June.

Data for the Sacramento River from 1950 show peak population value of 403,000 fish in 1953, which was considered the highest escapement during the 1939 to 1969 period (Reynolds, et al., 1993). Sacramento River fall-run chinook salmon abundance ranged from 92,442 to 256,817 from 1967 to 1991 with a 25-year average of 176,092. Other data show annual estimate of fall-run chinook salmon spawning escapement in minor Sacramento River tributaries (1953-1991) peak return was in 1957 with over 90,000 returning individuals. CH2M HILL estimated the average annual production of fall-run in the Cow Creek system at 2,316 (CH2M HILL, 1998). The target minimum production goal presented in the same report was 4,632. The data were taken from Mills and Fisher and are presented in Table 9-1 and Figure 9-2.

TABLE 9-1
Estimates of Abundance for Naturally Spawning Stocks of Fall-Run Chinook Salmon in Cow Creek

Year	Grilse	Adults	Total
1967	94	426	520
1968	694	6,846	7,540
1969	668	4,902	5,570
1970	N.E.	N.E.	N.E.
1971	N.E.	N.E.	N.E.
1972	N.E.	N.E.	N.E.
1973	N.E.	N.E.	N.E.
1974	N.E.	N.E.	N.E.
1975	N.E.	N.E.	N.E.
1976	107	619	726
1977	N.E.	N.E.	N.E.
1978	N.E.	N.E.	N.E.
1979	N.E.	N.E.	N.E.
1980	N.E.	N.E.	N.E.
1981	N.E.	N.E.	N.E.
1982	N.E.	N.E.	N.E.
1983	N.E.	N.E.	N.E.
1984	97	153	250
1985	57	243	300
1986	34	266	300
1987	181	320	500
1988	28	172	200
1989	51	199	250
1990	8	67	75
1991	31	219	250
Average	171	1,203	1,373

N.E. – No Estimate. Taken from Central Valley anadromous sport fish annual run-size harvest, and population estimates, 1967 through 1991. (Mills, DFG, 1994)

In 1965, the Department of Fish and Game estimated the average fall chinook salmon run to be 1,460 fish (SWRB, 1965). Potential utilization by female salmon has been estimated at about 9,000 fish. Fall-run chinook salmon population estimates are presented by year in Figure 9-3 (Latour, 1995). Population estimates were completed from 1953 to 1969. Starting in 1985, helicopter flights were conducted to document presence or absence of fish in various basins. Spawning redds were counted and these data are presented in Figure 9-4. The volume of water can explain much of the variability in the channel systems. In drought years, it is late in the season before the salmon can get in the channel system and spawn; the resulting numbers are thus much lower.

Late-Fall-Run Chinook Salmon

Late-fall-run chinook salmon are a state Species of Special Concern and a federal "candidate" species. Late-fall-run chinook salmon are a recent addition to chinook salmon stock inventory in the Central Valley as it has only been since the construction of the Red Bluff Diversion Dam, the fish ladders and the trap, that counting and separation of this chinook salmon race has been possible. Therefore, the history information is limited because of relative lack of time and effort.

Late-fall-run chinook salmon were probably more widely distributed historically, but have been restricted by anthropogenic habitat alteration, mostly dams. Moyle believes that the late-fall-run chinook salmon historically spawned in the middle elevation reaches (or sufficiently high in the watershed to receive adequate cold water) of the little Sacramento, McCloud, and Pit Rivers, and Battle Creek (Moyle, 1995). Presently, late-fall-run chinook salmon are found mainly in the Sacramento River, and most spawning and rearing of juveniles takes place in the reach between Red Bluff and Redding (Keswick Dam). According to Vogel and Marine (1991), however, approximately 15-30 percent of the late-fall-run can spawn downstream of Red Bluff when water quality is good. Late-fall-run chinook salmon have apparently spawned in Battle, Cottonwood, Clear, and Mill Creeks and the Yuba and Feather Rivers, but these are a small fraction of the total spawners (R. Painter cited in Moyle, et al., 1982, p. 104). CH2M HILL documents that late-fall-run is present in the Cow Creek drainage. This is the only reference that includes the late-fall-run in the Cow Creek populations (CH2M HILL, 1995).

Steelhead

Steelhead trout *(Oncorhynchus mykiss)* are anadromous rainbow trout that emigrate to sea and return to inland waters as adults to spawn. California steelhead rarely exceed six years of age (Shapovalov, 1967). Unlike salmon, not all steelhead die after spawning - in the upper Sacramento River, 83 percent are first-time spawners, 14 percent spawn for a second time, 2 percent are three-time spawners, and 1 percent spawning spawn for a fourth time (Hallock, 1989). Survival following spawning is higher among females than among males.

Steelhead are generally classified into two non-interbreeding races – winter steelhead and summer steelhead – depending on the time of year they enter fresh water on their upstream migration. Only winter steelhead occur in the Sacramento River system. Summer steelhead have been introduced into the basin, however, as have strains of winter steelhead from the Eel and Mad Rivers and even Oregon (Rogue River) and Washington (Washougal River) river basins. Consequently, the genetic composition of the native steelhead has been significantly modified. Because of the modified genetic composition and the influence of modified and unnatural flow and temperature regimes throughout the basin, the current Central Valley steelhead strains can be found as adults in fresh water in every month of the year.

Steelhead populations have not been as well documented as salmon populations. It is difficult to appraise the current status of steelhead runs in Cow Creek due to a lack of records of historical distribution or abundance. It is assumed that the winter-run is the most common form and the other forms have been reduced to remnant populations.

Steelhead are a part of a complicated species complex of rainbow trout that is still taxonomically unsettled. All steelhead populations in California are *Oncorhynchus mykiss* irideus (Behnke, 1992). The winter-run steelhead are ocean maturing steelhead which are largely dependent on hatchery supplementation (USFS, DWA comments, 2001). They are larger because they stay in the ocean until they are three or four years old before returning to freshwater to spawn. Consequently, they can be as large as 20 pounds. Winter-run steelhead probably migrate upstream into Cow Creek during the late fall and winter, primarily when flows increase from increasing storms. There are no steelhead counts on Cow Creek to establish timing of migration. Based on fish counts elsewhere in the Sacramento River tributaries between 1953 and 1964, the peak of steelhead migration is likely in November and February.

Steelhead prefer to spawn in clean, loose gravel, and swift, shallow water. The size of a steelhead redd spawning area ranges from 22.5 to 121 square feet and average 56 square feet. The female steelhead digs six to seven egg pockets in each redd. The male steelhead fertilizes the eggs as they are deposited. A female steelhead from the American River produces an average of 3,500 eggs with a range of 1,500 to 4,500 eggs (Reynolds, et al., 1993). Steelhead tend to prefer shallower stream depths and smaller gravel but the same water velocities for spawning as the chinook salmon. Steelhead will spawn in streams as shallow as 0.75 foot in gravel from 0.25 to 3.0 inches in median dimension and in 1.5 fps stream velocity (Reynolds, et al., 1993). Steelhead are less tolerant of fine sediment in the gravel than chinook salmon, probably because the eggs are smaller and the oxygen requirements for developing embryos are higher (Reynolds, et al., 1993).

All freshwater life stages of steelhead, except rearing, require lower stream temperatures than salmon. The preferred stream temperatures for steelhead migrating and holding in the Sacramento River are between 50 degrees F and 58 degrees F. Preferred temperatures for spawning are generally lower, from 39F to 55 degrees F, and the optimal incubation and hatching temperature is 50 degrees F (Reynolds, et al., 1993). The rate of steelhead embryo development is stream temperature dependent, and consistency of stream temperature is also important. Hatching occurs in 31 days at 50 degrees F and in 24 days at 55 degrees F. The embryo is very sensitive, or tender, during the first half of the incubation period. A sudden change in stream temperature generally results in high mortality. Fry usually emerge from the gravel about four to six weeks after hatching, but factors (e.g., redd depth, gravel size, siltation, and temperature) can accelerate or retard this time (Shapovalov and Taft, 1954). The optimal temperature range for fry and juvenile rearing is from 45 degrees F to 60 degrees F and <57 degrees F for smoltification (McEwan and Jackson, 1996).

Newly hatched steelhead alevins remain in the gravel until the yolk sac is completely absorbed, a period of four to six weeks. Alevin emergence from the gravel is followed by a period of active feeding and accelerated growth. The emergent fry's diet consists primarily of aquatic invertebrate drift. As they grow, fry move from shallow quiet margins of streams to deeper, faster water (Reynolds, et al., 1993).

Juvenile steelhead usually remain in freshwater for at least one year before emigrating to the ocean. Unless there are adequate water temperatures, high rearing mortality will occur. The steelhead in the Sacramento River typically emigrate during spring and early summer months. Emigration is more closely associated with size than age. Emigrants are generally six to eight inches, but may vary in age from less than one to two years (Reynolds, et al., 1993).

Specific population data for steelhead populations for Cow Creek are unavailable.

NATIVE RESIDENT FISHES

Resident fish spend all their lives in freshwater, generally in the same area or habitat unit of a stream. Resident fish species that inhabit Cow Creek are Sacramento pikeminnow, Sacramento sucker, hardhead, California roach, tule perch, and sculpin (Dettman, 1977; Alley, 1978).

Rainbow Trout

Rainbow trout *(Oncorhynchus mykiss)* are abundant and widely distributed. They are frequently the only fish found in cool, well-shaded headwaters. However, they are typically most abundant and reach larger size when in association with other species, usually sculpin, speckled dace, sucker, or California roach (Moyle, 1982). Resident rainbow trout are widely distributed in Cow Creek, ranging from all of the headwater tributaries to the main stem where warm water temperature probably sets the downstream limit of distribution.

Sacramento Pikeminnow (formerly Squawfish)

Sacramento pikeminnow *(Ptychocheilus grandis)* is an aggressive predator. Adults are consistently found in large deep pools of larger streams, where gradients are moderate, temperatures warm, and cover abundant. Juvenile pikeminnow are found in a much wider variety of habitats, including shallow pools of intermittent streams and riffles and runs of permanent streams. Both juveniles and adults are most abundant in waters where summer temperatures exceed 68 degrees F for extended periods of time (Moyle, et al., 1982). There is a spawning migration in the spring within the Cow Creek tributary system. The Sacramento pikeminnow populations are likely a combination of year-round residents and migratory populations. Adult Sacramento pikeminnow are known to migrate up from the Sacramento River in the spring to spawn. Pikeminnow densities in the Sacramento River may be affected by cold water releases from Shasta Dam. While preferring warmer water they may tend to congregate near the mouths of creeks. (USFWS comments on DWA, 2001).

Hardhead

Hardhead *(Mylopharodon conocephalus)* are identified as a Species of Special Concern (Moyle, et al., 1995). Hardhead have the most restricted microhabitat utilization of all the widely distributed Sacramento-San Joaquin fishes. They are found only in the sections of large, warm, streams that contain deep, rock-bottomed pools. The juveniles are found in the side pools and shallow areas of these same sections of streams. This strong habitat preference of the hardhead gives them a very spotty distribution pattern that is further interrupted by the construction of dams in areas of optimal habitat (Moyle, et al., 1982). They are closely associated with Sacramento pikeminnow and Sacramento sucker in the mid-elevation (100-1,000m) portions of Sierra streams. This location has been called the pikeminnow-sucker-hardhead zone (Moyle, 1976).

California Roach

California roach *(Hesperoleucus symmetricus)* are characteristic of small, warm, intermittent streams (Moyle, 1982). They can frequently be found in high densities in isolated pools in such streams, where water temperatures are high and oxygen levels are low. However, the roach is not confined to this habitat. They are frequently abundant in small trout streams of moderate gradient, as well as in larger streams in association with other native cyprinids. In the latter situation, roach are frequently found in the shallow edges of the pools and riffles. Roach were often abundant in areas that had been altered by man, either through reduced stream flows or through the creation of pools by dredging or small dams.

Speckled Dace

Speckled dace *(Rhinichthys osculus)* are most abundant in small, warm streams, especially in riffle areas with coarse bottoms. Their consistent lack of association with shade and bank cover indicates their ability to find cover under rocks and in flowing water. Their wide distribution indicates their ability to use a wide range of habitats. It may be that their absence from many areas results largely from interactions with other species, especially sculpins and California roach (Moyle, et al., 1982).

Sacramento Sucker

Sacramento sucker *(Catiostomus occidentalis)* are so widely distributed that they show no strong associations with any particular set of environmental variables. They are largely absent from cold, swift, high gradient waters in which large pools are infrequent. The adults and juveniles show some segregation in habitats, with the juveniles being abundant in many small, shallow streams from which adults are absent. These streams serve as nursery areas for juvenile suckers that move up into them to spawn in the spring. The adults are abundant whenever deep pools or runs provide cover (Moyle, et al., 1982).

Riffle Sculpin

Riffle sculpin *(Coitus gulosus)* are widely distributed in the Central Valley. They typically occupy the cool upper reaches of streams.

EXOTIC FISHES

Exotic fish species that now inhabit Cow Creek have been identified as Eastern brook trout, green sunfish, small-mouth bass, large-mouth bass, and bullheads (Dettman, 1977; Alley, 1978).

Brown Trout

Brown trout *(Salmo trutta)* were imported to the United States from Loch Levin, Scotland in 1883, and from Germany in 1895. Brown trout were introduced into Cow Creek in 1931 (Healy, 2001, pers. comm.) and are now a self-sustaining population that is the dominant species in some reaches (Latour SYP, 1995).

Carp

Carp (*Cyprinus carpio)* were introduced to California in 1872. They are occasionally found in the lower reaches of Cow Creek.

Green Sunfish

Green sunfish *(Lepomis cyanellus)* were introduced into California in 1891 and have shown considerable ability to disperse upstream into undisturbed or semi-natural habitats, but are unable to establish populations of any size in such areas (Moyle, et al., 1982).

Small-mouth Bass

Small-mouth bass *(Micropterus dolomiew)* were introduced into California in 1874. They frequent the pikeminnow-sucker-hardhead zone (100-1,000m in elevation). Small-mouth bass have been observed in the mainstem of Cow Creek and may be established in the flatter reaches of the main tributaries. These bass are voracious predators and may be a significant threat to juvenile salmon and steelhead.

Large-mouth Bass

Large-mouth bass *(Micropterrus salmoides)* were introduced into California in 1874. They are a warm-water gamefish. Interviews with local residents state that this bass has been introduced to the warmer waters of the main stem of Cow Creek and that the population has been expanding.

Bullheads

Bullheads *(Ictalunis* sp.) are a warm-water gamefish that are likely found in the lower reaches of Cow Creek.

SENSITIVE AND SPECIAL-STATUS SPECIES

Known sensitive and special-status species that inhabit Cow Creek or may be transient visitors are included on Table 9-2. A query of the CNNDB for Cow Creed identified no other special-status fish species for the watershed (CNNDB, 2000).

TABLE 9-2
Sensitive and Special-Status Species Known to Inhabit or Transiently Visit Cow Creek

FISHES	State	List Date	Federal	List Date
Winter-run chinook salmon[1] *(Oncorhynchus tshawytscha)*	SE	9-22-80	FE	2-3-94
Spring-run chinook salmon *(Oncorhynchus tshawytscha)*	ST	2-5-99	FT[2]	11-15-99
Steelhead-Central Valley ESU[3] *(Oncorhynchus mykiss)*			FT	5-18-98
Fall-run chinook salmon *(Oncorhynchus tshawytscha)*	SSC		C	
Late-fall-run chinook salmon *(Oncorhynchus tshawytscha)*	SSC		C	

NOTES:
[1] Federal: Sacramento River winter run chinook salmon.
[2] Federal: Central Valley spring-run ESU. Includes populations spawning in the Sacramento River and its tributaries.
[3] The Sacramento and San Joaquin Rivers and their tributaries.
ESU=Evolutionarily Significant Unit.

FISH PLANTING HISTORY AND CURRENT ACTIVITIES

California Department of Fish and Game has planted fish in the Cow Creek Watershed since 1930. Records indicate that the Mt. Shasta and Burney Creek hatcheries performed the plantings within the watershed until the 1950s when the Crystal Lake Hatchery (CLH) began operation. Crystal Lake conducted the entire planting program until the 1960s when Darrah Springs Hatchery (DSH) began planting in Oak Run and Clover Creeks.

From 1930-1940, the hatcheries planted primarily fingerlings and sub-catchable trout and salmon; mostly Loch Levin brown trout and rainbow trout, with a few plants of Eastern brook trout and chinook salmon. In the 1940s and 1950s, DFG only planted rainbow trout, except Old Cow Creek, where they planted brown trout annually from 1945 to 1950 - these were mostly catchable sized trout. Planting records for the 1960s indicate rainbow trout were planted in all five creeks of the watershed, with a two plantings of Eastern brook trout in the early 1960s in North Cow and Old Cow Creeks. Exact planting location in individual creeks are unknown or estimated.

Planting has also occurred in Buckhorn Lake since 1930 and Kilarc Reservoir since 1950. Planting events occur more than twice a year for the lakes in the watershed, usually around Memorial and Labor Day, revolving around sport fishing. Varying species have been planted in Buckhorn Lake over the years, including Loch Levin, rainbow, brown, and eastern brook trout. Catchable rainbow trout is the only species planted in the Kilarc Reservoir.

The following sections summarize the historic planting that has occurred in the Cow Creek Watershed since 1930. Many of the records were obtained from personal communication with Crystal Lake Hatchery personnel. Historic planting locations are included in Figure 9-5. Historic planting numbers are included on Figure 9-6.

HISTORICAL PLANTING

Planting 1930 to 1940

Between 1930 through 1940, either Mt. Shasta or Burney Creek Hatcheries planted every creek in the watershed yearly. Planting records indicate that a total of 1,582,135 fish were planted throughout the entire watershed. The majority of the fish planted were rainbow trout and Loch Levin, with a small planting of Eastern brook trout in North Cow, Old Cow and South Cow Creeks. Chinook salmon were only planted in Old Cow Creek in 1932 and 1933. During this reference period, large numbers of fingerlings and sub-catchable species were planted more than twice a year at varying location on the creeks. The exact planting locations are not specified on all planting records. However, there is mention of planting at Frisbie's Ranch on North Cow Creek, ten miles west of Oak Run on Oak Run Creek, the first crossing on Clover Creek at Whitmore Road, near Kilarc on Old Cow Creek, and above and below Whitmore on South Cow Creek. Records are included in Tables 9-3 and 9-4.

TABLE 9-3
Historical Fish Planting Records (1930-1970)

	Number of Fish Planted			
Stream/Lake	**1930-40**	**1941-50**	**1951-60**	**1961-70**
North Cow Creek	265,000	No Record	29,126	35,651
Oak Run Creek	145,000	19,000	3,244	5,550
Clover Creek	243,000	14,000	4,396	11,747
Old Cow Creek	592,000	90,000	8,900	14,689
South Cow Creek	337,135	225,000	7,385	3,155
Total	**1,582,135**	**348,000**	**53,051**	**70,792**

TABLE 9-4 Species Planted in Watershed (1930-1970)				
	Number of Fish Planted			
Species	**1930-40**	**1941-50**	**1951-60**	**1961-70**
Rainbow/Loch Levin Brown Trout[1]	1,225,135	339,000	53,051	58,809
Brown Trout	0	90,000	0	600
Eastern Brook	45,000	0	0	11,383
Eagle Lake	0	0	0	0
Chinook	312,000	0	0	0
Total	**1,582,135**	**429,000**	**53,051**	**70,792**

[1] Before 1942, there is no record of the exact number of rainbow trout or Loch Leven brown trout planted since DFG did not record trout species separately. After 1941, rainbow trout were listed separately.

Planting 1941 to 1950

Planting records show that during 1941 through 1950, planting occurred on four of the five major creeks. No records were found for North Cow Creek, however personnel at the Crystal Lake Hatchery indicated hatchery records show 15,000 to 20,000 rainbow trout fingerlings were planted yearly in North Cow between 1944 and 1946. Oak Run, Clover and South Cow Creeks have records indicating approximately 5,000 catchable rainbow trout were planted yearly at unspecified planting locations by Mt. Shasta Hatchery. Burney Creek Hatchery planted 10,000 brown trout annually from 1941 to 1950 in Old Cow Creek. The total number of fish planted within the watershed during this period was 429,000.

Planting 1951 to 1960

Between 1951 and 1960, Crystal Lake Hatchery planted a total of 53,051 catchable rainbow trout in the Cow Creek Watershed. The majority of the planting occurred on North Cow Creek, with 29,126 fish, at six planting locations along Highway 299 between Sugar Creek and Ingot. The other creeks were planted with between 3,000 and 9,000 rainbow trout yearly at unspecified locations. Starting in 1951 planting began in Kilarc Reservoir, varying numbers of catchable rainbow trout were planted two or more times per year for sport fishing in the area.

Planting 1961 to 1970

Planting records for 1961 through 1970 indicate 70,792 catchable trout were planted in the Cow Creek Watershed by Crystal Lake and Darrah Springs hatcheries. During this time period, 58,809 rainbow trout were distributed throughout the five creeks, 11,383 Eastern brook trout were planted in North Cow and Old Cow Creeks between 1963 and 1966 by CLH, and 600 brown trout were planted in Old Cow Creek in 1969 by DSH.

CURRENT ACTIVITIES

Planting records from 1970 to present indicate catchable rainbow and Eagle Lake trout have been planted in North Cow, Clover, Old Cow and South Cow Creeks. According to hatchery records, Oak Run Creek has not been planted since 1971. During the drought of 1977, Oak Run Creek dried up and residents of the area state that the trout population has not recovered since. Residents report that small-mouth bass now inhabit the creek. The remaining planting allotments for the creeks in the watershed belong to Darrah Springs Hatchery, except North Cow Creek, which continues to be planted by Crystal Lake Hatchery. There were also plantings of steelhead by Coleman National Fish Hatchery under the direction of US Fish and Wildlife Service in the 1980s and 1990s. Approximate planting locations indicated by hatchery personnel at Crystal Lake and Darrah Springs hatcheries are as follows:

- North Cow Creek - six locations along Highway 299 from Sugar (Cedar) Creek to Ingot
- Clover Creek- at the Forest Service Station at the culvert
- Old Cow Creek- off of Ponderosa Way at the Powerhouse and Kilarc Reservoir
- South Cow Creek- both sides of the Ponderosa Way Bridge, at the South Cow Campground

The following section summarizes the current planting that has occurred in the Cow Creek Watershed since 1970. Tables 9-5 and 9-6 illustrate the planting numbers for each creek in the watershed and the planting numbers for each species during decade planting periods.

Planting 1971 to 1980

Planting records show that during 1971 through 1980, planting occurred on four of the five major creeks in the watershed. No records were found for Old Cow Creek. Oak Run Creek records indicate one planting occurrence in 1971. Official planting records for North Cow Creek could not be located; however, Crystal Lake Hatchery personnel indicated 41,234 catchable rainbow trout were planted in North Cow Creek during this time. Darrah Springs Hatchery was responsible for planting Clover and South Cow Creeks with 14,263 and 36,000 catchable rainbow trout, respectively. The total number of fish planted within the watershed during this time was 92,202. A total of 111,918 catchable rainbow trout were also planted in Buckhorn Lake and Kilarc Reservoir during this planting period. In 1974, a transplant of large-mouth bass was placed in Buckhorn from Big Jack Lake in Lassen County. This transfer was expected to reduce the golden shiner population in Buckhorn. Shiners reproduced rapidly in the lake and were competing with planted rainbow trout for food. This transfer was to increase the survival rate of the planted rainbow trout.

Planting 1981 to 1990

Planting records for 1981 through 1990 indicate 92,591 catchable rainbow and Eagle Lake trout were planted in the Cow Creek Watershed by Crystal Lake (CLH), Darrah Springs (DSH) and Coleman National Fish hatcheries. The planting occurred in North Cow, Clover, Old Cow and South Cow Creeks. In 1984, Darrah Springs Hatchery planted 204,280 fingerling chinook salmon in Old Cow Creek. The Coleman National Fish Hatchery also planted in the Cow Creek Watershed during this period. They planted juvenile fall-run chinook in the main stem of Cow Creek and steelhead in South Cow Creek. Both plantings occurred in 1985.

Planting 1991 to Present

From 1991 to present North Cow, Clover, Old Cow and South Cow Creeks have been planted with a total of 49,492 catchable Rainbow trout. Darrah Springs Hatchery also planted Eagle Lake trout in Clover Creek in the early 1990s. The Coleman National Fish Hatchery planted steelhead in North Cow, Old Cow, and South Cow Creeks, as well as the main stem of Cow Creek. Buckhorn Lake and Kilarc Reservoir are also planted twice a year with catchable trout for sport fishing purposes.

TABLE 9-5 Current Fish Planting Records (1971-2000)			
	Number of Fish Planted		
Stream/Lake	**1971-80**	**1981-90**	**1991-2000**
North Cow Creek	41,234	23,287	99,019
Oak Run Creek	705	No Record	No Record
Clover Creek	14,263	8,991	2,381
Old Cow Creek	No Record	228,593	27,120
Cow Creek (mainstem)		204,660	205,231
South Cow Creek	36,000	140,412	471,587
Total	**92,202**	**605,943**	**814,218**

TABLE 9-6 Species Planted in Watershed (1971-2000)			
	Number of Fish Planted		
Species	**1971-80**	**1981-90**	**1991-2000**
Rainbow 1	92,202	88,521	48,940
Brown trout/Loch Levin	0	410	0
Eastern brook	0	0	0
Eagle Lake	0	3,660	552
Chinook	0	408,940	0
Steelhead	0	104,412	755,846
NOTE: Includes rainbow, and Loch Levin for these years.			

PLANTING SUMMARY

During early plantings within the Cow Creek Watershed, DFG planted varied species of trout in all five sub-basins. The watershed was planted with large quantities of fingerlings and sub-catchable trout in the 1930s. Since the 1940s, the number of fish planted has dropped significantly, and catchable rainbow trout are the primary fish planted. The following graph shows the raw numbers of fish that have been planted since 1930. The number of fish planted in the watershed has increased 1980s and 1990s due the additional steelhead plantings by US Fish and Wildlife Service.

OBSERVATIONS AND SURVEYS

Surveys that have occurred within the Cow Creek Watershed have been performed by different entities for different purposes. All of the surveys have been performed for varying time periods, using many different methods. Several of the surveys have been one-time electrofishing passes to perform an inventory of fish populations in areas of proposed hydroelectric development. This section references survey events and reported observations of fish within the Cow Creek Watershed. A numbered list of events is included on Figure 9-7 and observation numbers summarize each event.

TABLE 9-7 Survey and Observations	
1	In a one-time sampling event on May 15, 1974, DFG set a standard selective monofilament gill net in the South Cow Creek powerhouse forebay to obtain samples of the fish species inhabiting this water. The net was set for 17 hours.
2	Steelhead were observed in South Cow Creek up to Ponderosa Way crossing at South Cow Creek campground. No numbers or dates given.
3	Spring run chinook sighted below the PG&E Mill Creek Diversion Dam on South Cow Creek by PG&E maintenance personnel. No numbers or dates given.
4	A local game warden spotted steelhead upstream from the PG&E Mill Creek Diversion Dam on South Cow Creek. 1974
5	Steelhead observed at Ditty Wells Falls on North Cow Creek.
6	A face mask survey of Little Cow Creek (North Cow Creek) was conducted on June 16, 1981, by U.S. Bureau of Land Management personnel. A total of ten dead and two live chinook salmon were observed in about a one-mile reach of stream below the falls. No spawning had occurred. High water temperature was apparently the cause of the mortalities.
7	In a report from California Regional Water Quality Board, Central Valley Region, dated October 18, 1984, a fish survey was conducted on North Cow Creek to determine the impact of acid mine drainage on fish population. The survey was done using an electroshocker at three stations, upstream and downstream from the Afterthought Mine.
8	On July 23, 1997, sections of Old Cow Creek from Upper Whitmore Falls to Lower Whitmore Falls were snorkel surveyed by two divers for the occurrence of adult chinook salmon. One adult female was observed at the Upper Falls. One additional adult female was observed between upper and lower falls. Both salmon were assumed to be either winter or spring -run salmon strays. These pools were snorkeled in September 1991, and again during the summer of 1992, and no adult salmon were observed. In the memorandum dated August 1, 1997, it was stated Upper Whitmore Falls are a barrier to upstream migration during normal water flows and the habitat above the falls lacks adequate holding pools and spawning gravels. Below the falls, holding and spawning habitat is also limiting and water temperatures are lethal. (Colleen Harvey, 1997)
9	Fall-run chinook salmon spawn from the base of Wagoner Canyon (PG&E Cow Creek Powerhouse) downstream to the confluence with the Sacramento River. The majority of spawning in South Cow occurs downstream of Millville.
10	Late-fall-run chinook salmon remain on the valley floor. The furthest upstream late-fall-run have been observed is near Old Cow's confluence with South Cow Creek.
11	Spawning areas include: the main stem from Palo Cedro to Deschutes Road, North Cow Creek from Bella Vista to Palo Cedro, and South Cow Creek from Powerline Crossing to Palo Cedro. (EIP Associates, June 1997) On October 20, 1981, Oscar Larson & Associates assessed the distribution and abundance of fisheries resources in an area of Clover Creek that would be impacted by a proposed hydroelectric facility. Using electrofishing and snorkeling methods, 200 resident rainbow trout were identified in the lower section (where the Mega Hydro Powerhouse now stands) and 700 rainbow trout were identified in the upper section (where the Mega Hydro Diversion now stands). The rainbow trout varied in size from one to thirteen inches in both survey areas. No brown trout or other species were observed.
14	In an investigation of fish-salvage problems in relation to Shasta Dam, authored by the US Department of the Interior, an estimate of about 9,000 female salmon potentially utilize the 66.5 miles of Cow Creek streambed. It was reported that a small fall-run of salmon enters the stream and spawns in the lower reaches, but upper sections are not used extensively because of irrigation and power developments.
15	In 1973, DFG conducted a survey of Hunt Creek, a tributary to Old Cow Creek (RM 23), found "numerous rainbow trout" and "some brown trout".
16	In the mid-1970s electrofishing survey conducted upstream of the existing intake of the Kilarc hydroelectric project on Old Cow Creek (RM 21) found "trout populations large for the stream size" (DFG, 1985). Species identified included rainbow trout, brown trout, and riffle sculpin.
17	Electrofishing was conducted in March of 1985, on a 400-foot stretch of stream where instream flow data were collected (RM 15). During the survey, 26 rainbow trout and 15 unidentified sculpins were collected. No brown trout were identified in this survey.

18	In March of 1984, an IFIM hydraulic and habitat simulation model was performed for Old Cow Creek on the Olsen Property near Whitmore for the proposed hydroelectric project. Using flow data for this stretch of stream, a habitat relationship was formed and an estimated population for rainbow and brown trout was found. Weighted Usable Area Curves were developed for individual life stages. Fry, juvenile and adult life stages reached maximum within flow ranges of 20-25 cfs, 30-40 cfs, and 36-40 cfs, respectively. Spawning peaked between 100 and 120 cfs.
19	In a report of estimated rainbow trout, populations decline due to the Olsen Hydroelectric Facility on Old Cow Creek. 75.3 kg (165.7 lbs) of rainbow trout biomass was estimated within the 4.8 km of stream.
20	During 1985, a fisheries habitat study was performed on South Cow Creek, between South Cow Campground and the Morelli Ranch. Habitat discharge relationships were developed for various life stages of rainbow trout, brown trout, steelhead trout and chinook salmon. Electrofishing survey was also performed; rainbow trout, brown trout and chinook salmon were captured in both upper and lower sections of the reach. The survey results were used to generate population estimates for each species and each life stage. No distinction was made between resident rainbow trout and migratory steelhead. It is probable the chinook encountered in this survey resulted from hatchery planting. No adult steelheads were identified during survey, however, a few redds were located in upper reaches of Atkins Creek.
21	Surveys were conducted on Little Cow Creek in September 1985 for the McMillian Power Project. Two sites were selected for electrofishing surveys upstream and downstream from the project site. Only rainbow trout were collected at these sites and it is assumed that this is a self-sustained population, due to the lack of recent DFG plantings. It is reported that steelhead trout migrate up North Cow Creek to Ditty Well Falls.
Aquatic Invertebrate	
12	On April 23, 1981, bottom invertebrates were collected from Little Cow Creek at four sites: Site #1 upstream from Afterthought mine, Site #2 below the first mine, Site #3 between the two mines and Site #4 below the second mine. A total of 304 invertebrate species were collected during this sampling event at all four sites.
13	In October 1988, biological samples were collected and analyzed for evaluation of the sediment discharge to North Cow Creek caused by the bridge construction activity at Buzzard Roost Road bridge. Three net samples were taken at each riffle. The results indicate a 55 percent reduction of aquatic insects on the riffle located 100 yards below the point of discharge.

COW CREEK GENERAL

In an investigation of fish-salvage problems in relation to Shasta Dam, authored by the US Department of the Interior in 1994, an estimate of 9,000 female salmon potentially utilize or could utilize the 66.5 miles of Cow Creek streambed. It was reported that a small fall-run of salmon enters the stream and spawns in the lower reaches, but upper sections are not used extensively because of irrigation and power developments. Table 9-8 includes data from this report.

The remaining observations or surveys identify the areas salmon spawn within the Watershed. In a memorandum from DFG, (dated 1994) fall-run chinook salmon spawn from the base of Wagoner Canyon (PG&E Cow Creek Powerhouse) downstream to the confluence with the Sacramento River. The majority of spawning in South Cow occurs downstream of Millville. Fall-run and late-fall-run chinook typically remain in the "valley floor" sections of the watershed to spawn and do not ascend into steep boulder-cascade habitat of Wagoner Canyon (DFG, 1994). Table 9-9 is taken from this memorandum, and shows fall-run chinook spawning escapements. The fall-run chinook salmon spawning areas have also been determined, based on DFG aerial redd surveys and are shown on Table 9-10.

TABLE 9-8 1994 Survey Data in Cow Creek Watershed					
Stream Section	**Length in miles**	**Average width in feet**	**Estimated % of streambed suitable for spawning**	**Potential Utilization (female Salmon)**	**Limiting factors**
Mouth to Clover Creek	9.5	60	4.04	3,040	Water temp high
S. Cow Creek (Clover Creek to Wagoner Canyon)	13	30	2.17	1,117	Hydroelectric development. Stream intermittent.
Old Cow Creek (mouth to Co. road cross)	8	35	2.2	813	Intermittent flow, irrigation diversions.
Oak Run (mouth to Co. road crossing)	12	32	5.94	3,011	Intermittent flow, irrigation diversions
Little Cow Creek (mouth to Seaman Gulch)	15	25	1.4	693	Bedrock bottom, irrigation diversions.
Total	**66.5**			**9.149**	

CH2M HILL, 1998 estimated the average annual production of fall-run in the Cow Creek system at 2,316. The target minimum production goal presented in the same report was 4,632. The data were taken from Mills and Mills and Fisher and were presented previously in Table 9-1 and Figure 9-2. In 1965, the Department of Fish and Game estimated the average fall chinook salmon run to be 1,460 fish (SWRB, 1965).

SOUTH COW CREEK

Three observations on South Cow identified steelhead up to Ponderosa Way crossing and upstream from the PG&E Mill Creek Diversion Dam (identified as 2 and 4 on the observations map). Spring-run chinook are reported below the PG&E Mill Creek Diversion Dam, without numbers or dates (#3).

Two surveys have been performed on South Cow Creek, one in 1974 and the other in 1985. In the one-time sampling event on May 15, 1974, DFG set a standard selective monofilament gill net in the South Cow Creek powerhouse forebay to obtain samples of the fish species inhabiting this water. The net was set for 17 hours; the results of the sampling event are summarized in Table 9-11. This survey location is identified as #1 on the observations map.

TABLE 9-9 Fall-Run Chinook Spawning Escapements	
Year	**Cow Creek Population Estimates**
1953	300
1954	4500
1955	1300
1956	3200
1957	700
1958	3300
1959	680
1960	650
1962	1500
1964	1000
1965	1000
1966	7600
1967	520
1968	7540
1969	5570
1976	726
1984	250
No population estimates made 1985-1993 1-1989 3 surveys; 4.3 miles; 95 live; 95 redds, 138 carcasses 2- 1990 no survey	
3- 1991 2 surveys; 6.6 miles; 63 live; 126 redds; 12 carcasses 4- 1992 1 survey; 6.6 miles; 4 live; 116 redds; 12 carcasses 5- 1993 2 surveys; 4.3 miles; 21 lives; 74 redds; 37 carcasses	

Source: Inland fisheries Division, DFG, Red Bluff.

TABLE 9-10 Fall-Run Chinook Salmon Spawning Areas in Cow Creek				
Section	**Landmarks**		**Legal Description**	
	Downstream	**Upstream**	**Downstream**	**Upstream**
Main stem	Deschutes Road	Palo Cedro	Tuscan Butte: T31N R3W S5	Millville: 31N R3W S8
North Fork	Palo Cedro	Bella Vista	Millville: T31N R3W S8	Millville: T32N R3W S9
Oak Run	No records of spawning (marginal habitat and low flows)			
Clover Creek	No records of spawning (marginal habitat and low flows)			
Old Cow	No records of spawning (marginal habitat and low flows)			
South Cow	Palo Cedro	Powerline Crossing	Millville: T31N R3W S8	Millville: T31N R3W S13

Source: DFG, IFD, Red Bluff, based on DFG aerial redd survey

TABLE 9-11 DFG 1974 Survey Results		
Species	**Number Caught**	**Size Range (inches)**
Sacramento Sucker	10	8.3 -11.5
Rainbow trout	5	2.5 - 9.5
Brown trout	2	7.5 - 9.0
Green sunfish	3	3.5 - 6.5
Steelhead	1	19.5

Sources: Letter to Millard Coots from Terry Healey, May 30, 1974

During 1985, a fisheries habitat study was performed on South Cow Creek, between South Cow Campground and the Morelli Ranch. Habitat discharge relationships were developed for various life stages of rainbow trout, brown trout, steelhead trout and chinook salmon (graphs are included in the appendix). Electrofishing survey was also performed; rainbow trout, brown trout and chinook salmon were captured in both upper and lower sections of the reach. The survey results were used to generate population estimates for each species and each life stage. No distinction was made between resident rainbow trout and migratory steelhead. It is probable the chinook encountered in this survey resulted from hatchery planting. No adult steelheads were identified during the survey; however, a few redds were located in upper reaches of Atkins Creek. Table 9-12 records the population estimates generated from this study. This area is identified as #20 on the observations map.

TABLE 9-12 Population Estimates Payne 1986 Calculated with Moran-Zippen Method			
Species	**Size**	**Location**	**Fish/mile**
Rainbow trout	All sizes	Upper reach	10263
Rainbow trout	All sizes	Lower reach	6168
Rainbow trout	Above 90 mm	Upper reach	2553
Rainbow trout	Above 90 mm	Lower reach	2048
Brown trout	All sizes	Upper reach	768
Brown trout	All sizes	Lower reach	617
Brown trout	Above 90 mm	Upper reach	174
Brown trout	Above 90 mm	Lower reach	198
Chinook salmon	All sizes	Upper reach	793
Chinook salmon	All sizes	Lower reach	469

Source: Letter to DFG from Thomas Payne & Associates, 1986.

Cow Creek drainage is estimated to have annual runs of 950 fall-run chinook salmon and 500 steelhead (SWRCB, 1965). Prior to the installation of the fish ladder at the PG&E Diversion Dam, PG&E personnel observed adult steelhead upstream of the diversion dam. They also reported “king” salmon (spring-run) below the dam. Low water flows in the fall prevented access to the upper portion of the creek beyond the diversion dam. Limiting factors for anadromous fish populations are high summer water temperature, irrigation use, and hydroelectric water diversions. During the summer, water temperatures have been shown to reach 73 degrees F.

The stream above the diversion has good spawning grounds and plenty of water to sustain anadromous fish and is characterized by dense riparian vegetation. The stream between the diversion and Wagoner Canyon is characterized by pool and riffle areas. Wagoner Canyon contains numerous logs and boulders. There are no riffle or slow pool areas. The lower portion of South Cow Creek between Wagoner canyon and Old Cow Creek is reported to be a particular area of good spawning habitat. The majority of anadromous fish use in the Cow Creek Watershed appears to be in South Cow Creek.

The following fish species have been documented in South Cow Creek:

- Pacific lamprey
- Chinook salmon
- Rainbow and steelhead trout
- Brown trout
- California roach
- Sacramento sucker
- Riffle sculpin
- Green sunfish

The DFG has planted rainbow trout of numerous strains at the South Cow Creek Campground at the Ponderosa Way Bridge since 1941.

The barriers existing in South Cow Creek have been removed. A natural barrier in Wagoner Canyon was blasted to allow for fish passage during high flows. The gradient in this canyon is still steep, but fish can pass. The PG&E Diversion Dam created a barrier prior to the installation of the fish ladder. This ladder was added in the late 70s, and allows for the passage of anadromous fish.

LITTLE COW CREEK

There have been two recorded observations and two electrofishing surveys performed on Little Cow Creek. In observations, steelhead were observed at Ditty Wells Falls (#5 on Map). A snorkel survey was also conducted on Little Cow Creek (North Cow Creek) at the falls, on June 16, 1981 by U.S. Bureau of Land Management and DFG personnel. A total of ten dead and two live chinook salmon were observed in about a one-mile reach of stream below the falls. No spawning had occurred. DFG believes these were stray spring-run salmon (Healy, 2001, pers. comm.). The formal BLM report lists the salmon as winter-run; however, T. Healy, the DFG representative on the dive, recalls that the eggs were not sufficiently developed to be winter-run. DFG does not believe that the fish ever spawned due to high temperature, which was reported to have been >70 degrees F. High water temperature was apparently the cause of the mortalities (#6).

In a report from California Regional Water Quality Board, Central Valley Region, dated October 18, 1984, a fish survey was conducted on Little Cow Creek to determine the impact of acid mine drainage on fish population. The survey was done using an electrofisher at three stations, upstream and downstream from the Afterthought Mine. Table 9-13 summarizes the results of this survey; #7 identifies the survey location on the observations map.

Surveys were also conducted on Little Cow Creek in September 1985, for the McMillan Power Project. Two sites were selected for electrofishing surveys upstream and downstream from the project site. Only rainbow trout were collected at these sites and it is assumed that this is a self-sustained population, due to the lack of recent DFG plantings. It was also reported that steelhead trout migrate up North Cow Creek to Ditty Wells Falls. Table 9-14 summarizes the electrofishing survey results and #22 on the observations map identifies the survey location.

TABLE 9-13 1984 Electroshock Survey – Little Cow Creek (Afterthought Mine)					
Location	**Flow (cfs)**	**Water Temp (F)**	**Species**	**Number**	**Size (inches)**
70-150 yards upstream from AMD source	10.4	67	Rainbow trout	1	7.5
			Sacramento sucker	3	4-9
			California roach	3	1.5-2.5
100-150 yards downstream from AMD source			Rainbow trout	9	2.5-4
			Sacramento sucker	1	2
			California roach	25	2-3
Ingot-1.1 miles downstream from AMD	10.2	73	Rainbow trout	1	2
			California roach	30	1-3.5

Source: Memorandum from RWQCB, October 18, 1984

TABLE 9-14 Electrofishing Survey – Little Cow Creek	
Total Length (mm)	**Number of Rainbow Trout**
40-49	2
50-59	13
60-69	16
70-79	3
80-89	3
90-99	9
100-109	7
110-119	7
120-129	9
130-139	6
140-149	1
150-159	3
160-169	2
170-179	3
180-189	2
190-199	
200+	1
Total	**87**

Source: Envirosphere Company, 1985.

Two separate aquatic insect surveys have been performed in the watershed, one on Little Cow Creek and the other on North Cow Creek. On April 23, 1981, bottom invertebrates were collected from Little Cow Creek at four sites: Site #1 upstream from Afterthought mine, Site #2 below the first mine, Site #3 between the two mines and Site #4 below the second mine. A total of 304 invertebrate species were collected during this sampling event at all four sites. Results are presented on Table 9-15.

TABLE 9-15 Bottom Invertebrate Survey				
Order	**Site**			
	#1	**#2**	**#3**	**#4**
Placoptera	10	3	4	2
Ephemeroptera	76	26	4	3
Tricoptera	52	11	19	9
Coleoptera	30	10	9	6
Diptera	12	9	6	2
Odonota	0	0	1	0
Total	**180**	**59**	**43**	**22**

Source: Letter to Dennis Heiman CRWQCB June 15, 1981

In October 1988, biological samples were collected and analyzed for evaluation of the sediment discharge to Little Cow Creek caused by the bridge construction activity at Buzzard Roost Road Bridge. Three net samples were taken at each riffle. The results indicate a 55 percent reduction of aquatic insects on the riffle located 100 yards below the point of discharge. Results are included as Table 9-16.

TABLE 9-16 Aquatic Invertebrates Collected Above and Below Sediment Discharge From Buzzards Roost Road Bridge							
Station	**Totals**	**Sample 1**		**Sample 2**		**Sample 3**	
		Number of Organism	**Number of Order**	**Number of Organism**	**Number of Order**	**Number of Organism**	**Number of Order**
Control (upstream)	967	210	16	551	19	206	15
100 feet downstream	438	88	13	284	15	66	9

OLD COW CREEK

Several surveys have been performed on Old Cow Creek surrounding activities of the hydroelectric plants, Kilarc and Olsen. In the 1970s, two separate surveys were conducted on Old Cow Creek; one on Hunt Creek and the other at the existing intake of Kilarc. In 1973, DFG conducted a survey of Hunt Creek, a tributary to Old Cow Creek (RM 23), finding “numerous rainbow trout” and “some brown trout” (#16). In the mid-1970s, an electrofishing survey conducted upstream of the existing intake of the Kilarc hydroelectric project on Old Cow Creek (RM 21) found “trout populations large for the stream size” (DFG, 1985). Species identified included rainbow trout, brown trout, and riffle sculpin (#17).

In March 1984, an IFIM hydraulic and habitat simulation model was preformed for Old Cow Creek on the Olsen Property near Whitmore for the proposed hydroelectric project. Using flow data for this stretch of stream, a habitat relationship was formed and an estimated population for rainbow and brown trout was found. Weighted Usable Area Curves were developed for individual life stages. Fry, juvenile, and adult life stages reached maximum within flows ranges of 20-25 cfs, 30-40 cfs, and 36-40 cfs, respectively. Spawning peaked between 100 and 120 cfs. The Curves and table are included in the appendix and study location is identified on observations map as #19. In a separate report, estimating rainbow trout populations decline due to the Olsen Hydroelectric Facility on Old Cow Creek, 75.3 kg (165.7 lbs) of rainbow trout biomass was estimated within the 4.8 km of stream at the time of the study.

On July 23, 1997, sections of Old Cow Creek from Upper Whitmore Falls to Lower Whitmore Falls were snorkel-surveyed by two divers for the occurrence of adult chinook salmon, survey area identified as #8 on the observations map. One adult female was observed at the Upper Falls. One additional adult female was observed between upper and lower falls. Both salmon were assumed to be winter-run salmon strays. These pools were snorkeled in September 1991, and again during the summer of 1992, and no adult salmon were observed. In the memorandum dated August 1, 1997, it was stated Upper Whitmore Falls is a barrier to upstream migration during normal water flows and the habitat above the falls lack adequate holding pools and spawning gravels. Below the falls, holding and spawning habitat is also limiting and water temperatures are lethal (Colleen Harvey, 1997). Egg size references in Harvey's memorandum question the salmon as winter-run as the eggs sizes described are insufficiently developed to be winter-run for the spring data. Healy believes these are likely stray spring-run chinook.

Currently there is a survey being performed at the Olsen Power Project on Old Cow Creek. Electrofishing with the survey method with one pass, performed January 31, 2001, and another planned for June 2001. Results from this survey are not known at this time (DFG personnel, 2001, pers. comm.).

CLOVER CREEK

According to survey records, one survey was performed on Clover Creek. On October 20, 1981, Oscar Larson & Associates assessed the distribution and abundance of fisheries resources in an area of Clover Creek that would be impacted by a proposed hydroelectric facility. Using electrofishing and snorkeling methods, 200 resident rainbow trout were identified in the lower section (where the Mega Hydro Powerhouse now stands), and 700 rainbow trout were identified in the upper section (where the Mega Hydro Diversion now stands). The rainbow trout varied in size from one to thirteen inches in both survey areas. No brown trout or other species were observed.

OAK RUN CREEK

No survey or observation records have been located for Oak Run Creek.

POTENTIAL ADVERSE CONDITIONS

Fisheries are impacted by many different conditions and activities. Adequate habitat is required for fish populations to exist. Habitat requirements vary by species; however, anadromous species have very significant habitat requirements. To date the studies on Cow Creek have been limited to evaluation of anadromous species habitat. Specific adverse conditions to anadromous fish include:

- Water Quality
- Entrapment
- Elevated Temperature
- Physical Barriers
- Degradation of spawning areas
- Low Water Flows
- Predation

WATER QUALITY

Water quality can be affected by natural geologic formations; however, in general, human activities have the greatest impact on water quality. Water quality in the Cow Creek Watershed is generally good. Only the two miles of Little Cow Creek below the Afterthought Mine have been identified as impacted by pollution.

Water quality, especially dissolved oxygen, can be reduced by the introduction of organic pollutants, such as sewage or gray water. The majority of the residences in the Cow Creek Watershed are served by leach field type septic disposal systems. These types of systems can be sources of nitrate contamination and bacteria contamination to surface and ground water. Hannaford et al., in the *Preliminary Assessment* completed for the watershed found elevated levels of bacteria in sites along Cow Creek. The sources of the increased bacteria concentrations were not identified. A study conducted by the RWQCB in 1996 identified overall good water quality with elevated temperatures and bacteria levels as concerns in the lower reaches of Cow Creek.

ENTRAPMENT

Inadequate fish screens, due to design or inadequate maintenance, or lack of screen altogether, can trap spawning adults or emigrating juveniles. Few diversions in the Cow Creek Watershed are screened and the few screens that have been constructed do not meet the current DFG requirements. Juvenile and smolt mortality is a major factor affecting chinook salmon and steelhead abundance in the entire Sacramento-San Joaquin drainage system and all runs of chinook salmon have been documented to have increased mortality due to entrapment. Once outside of the Cow Creek drainage, anadromous salmonid juveniles are susceptible to entrapment into unscreened or inadequately screened water diversions along the Sacramento River.

Pump intakes are also a major source of juvenile mortality. As early as 1959, DFG had identified fish loss from irrigation diversions as a primary cause of juvenile mortality in the Sacramento River system. DFG and others have estimated that the majority of the out-migration of young fall-run salmon occurs from January to March, but may extend into May and June. It is the later migrants that are at the greatest risk and may be impacted by diversion activities.

Unlike salmon, not all adult steelhead die after spawning. Many adults return to the ocean after spawning. The peak return interval is April to June, a period of peak agricultural diversion activities. The young steelhead may remain in the tributaries for as many as two years before emigrating to the ocean. Generally, emigration occurs in the spring, peaking between March and April (Vogel and Marine, 1991).

TEMPERATURE

Increase in temperature can be a function of reduced flows, introduction of warm return water, reduction in cooler water sources (springs) or reduction in riparian canopy. Water diversions, especially during the spring and fall irrigation season, reduce stream flow and have been identified as likely reasons for increased temperature. Numerous long-term residents interviewed for this assessment stated that since the intrusion of the brush, berry and non-native grass, many local springs that used to re-supply the tributaries to Cow Creek have ceased to flow. In addition, domestic uses of springs have increased with increased development, thereby reducing the flow to the natural system. The riparian canopy has undergone significant changes in physical composition and species composition in the last 80 years. The effect of the changes on stream temperature has not been measured.

In the upper reaches of the watershed, timberland owners have monitored stream temperature, especially in the area of the Fountain Fire, and have seen no appreciable difference in pre and post-fire or pre and post-logging activities. In general, upland watercourse temperatures are below an average of 55 degrees F throughout the year with a high of 55-60 degrees F recorded in July and August. This would imply that the primary reason for increased temperature is located lower in the watershed.

Temperatures in excess of 77 degrees F (25 Degrees C) are lethal to even adult salmonoids. Hannaford et al. found that the main stem of Cow Creek exceeds optimum temperatures for chinook salmon approximately six months out of the year, May until October, and that the maximum lethal temperature was exceeded daily for most of the period. The temperatures within lower reaches of both Old Cow Creek and South Cow creek were higher than those in the main stem (Hannaford, 2000). The most critical periods for anadromous fish are spring and early fall. Especially in the fall, the adult salmon wait in the river for the first rains to increase water levels and reduce temperatures to allow spawning. In many years, adults start up the tributaries with the first rains only to be trapped in the warm water when additional rains fail to arrive. Consistent October rains, necessary to increase flow and reduce temperature, appear to be critical to the success of annual fall-run chinook spawning in Cow Creek. Late spring rain may also be important to provide low temperature water and flows for juvenile emigration.

The impact of stream temperatures on salmonid populations in Cow Creek is not documented in detail. Biologists disagree on the impacts of temperature on differing runs of chinook salmon. An issue of contention was the definition of summer flows. DFG defines “summer flow period” as the first day of summer (June 22) to the first day of fall (September 22).

The previous discussion dealt more with the “irrigation” season, which commonly occurs from May 15 to October 15. DFG felt very strongly that the watershed assessment “document needed to be completely clear on how the water needs of the salmon and agriculture relate to each other in each reach of stream during different periods of the year.”

The following is DFG analysis of the “summer water” limiting factor by species, time period and reach of stream:

Fall-run Chinook

Summer flows are not a limiting factor for any portion of the population of this species. The adults of this species enter the stream in the fall after the first series of rains have conditioned the watershed sufficiently to allow flows to increase and water temperatures cool (timing depends on water year type). The juveniles of this species migrate downstream in the spring as more pronounced dry conditions in spring cause flows to decline and water temperatures to increase (timing depends on water year type). The distribution of fall-run chinook is generally restricted to the valley floor and lower foothill elevations of Cow Creek and its major tributaries; however, smaller portions of the population can be expected to ascend to the upper-most waterfall barriers in the system (typically to an upper limit of 1,000 feet of elevation). More detailed study and analysis is required to precisely describe the distribution of spawning activity in the creek system. Outside of the summer period, the low stream flow and high temperatures in the early fall may effect that portion of the adult population attempting early immigration to the spawning areas. Those same conditions in the late spring may affect that portion of the juvenile population attempting late out migration to the river. More detailed study and analysis is required to examine controllable factors during theses periods. However, the stream system always has some flow during these periods due to the fact that the water rights adjudication and water master service requires that the upstream diversions allow sufficient water to reach the downstream diversions.

An important restoration action, that we believe there is sufficient information to recommend for the protection and restoration of all species of anadromous fish, is the installation of fish screens and fish ladders on significantly sized diversions. More information and analysis is needed for developing a systems approach to prioritize screen and ladder installations according to size and location. Installation and operation of fish screens allows juvenile fish to avoid mortality in irrigation systems, and fish ladders allow upstream passage of adults. Both are consistent with the State legislature's decisions to install such structures.

Late Fall-run Chinook

Summer flows are not a limiting factor for adults but can be a limiting factor for early life stages produced by spring spawning adults (after March 20). Water temperatures would be a greater limiting factor to this portion of the population even under natural conditions. There are no estimates of the population of late fall-run in Cow Creek, although they have been documented there. According to CDFG file data, the most recent survey for late-fall-run spawning was an aerial survey of Cow Creek conducted on February 26, 1965 (Healey, 1965). Fifty-four carcasses and 14 live fish were observed in the entire Cow Creek Watershed. Most of the live salmon were observed below the Hwy. 44 bridge, while the carcasses were evenly distributed between Millville and the confluence with the Sacramento River. No carcasses or live salmon were observed in Old Cow or South Cow Creeks.

Spring-run Chinook

Summer flows are a limiting factor for both adult and juvenile spring-run chinook only in the foothill reaches of the stream. Little is known about spring-run chinook populations in the Cow Creek Watershed. The best available information is that Cow Creek is not part of the present range and distribution of spring-run chinook salmon in the Central Valley of California (Department of Fish and Game Report to the Commission: A Status Review of the Spring-run Chinook Salmon in the Sacramento River Drainage). There is some anecdotal information that South Fork Cow Creek may have been part of the historic range and distribution of spring-run chinook.

Winter-run Chinook

The best available information indicates that the Cow Creek system is neither part of the present nor past range and distribution of winter-run chinook salmon in the Central Valley of California (National Marine Fisheries Service Proposed Recovery Plan for Sacramento River Winter-run Chinook August 1997). However, recent studies have shown that Sacramento River tributaries may be used for non-natal rearing for this race of salmon.

Steelhead

Summer flows are not a limiting factor for spawning adults but can be a limiting factor for juvenile steelhead that re distributed in the uppermost foothill reaches of the stream where resident rainbow trout occur. The anadromous and resident rainbow trout can form a single interbreeding population in streams like Cow Creek (Department of Fish and Game Steelhead Management Plan 1996). Summer flows should not be limiting factors in the valley floor reach. The juvenile population does not rear in the valley during the summer due to high water temperature and the out migration of juveniles occurs outside the summer period. It is believed by the Department that Cow Creek offers an excellent opportunity for restoration of native and wild steelhead populations in the upper Sacramento River (Department of Fish and Game Steelhead Management Plan 1996).

No specific studies have been conducted on Cow Creek to estimate the size of the steelhead spawning run, although DFG (1965) estimated that Cow Creek supported annual spawning runs of 500 steelhead (current estimates would be much lower). Adult steelhead have been observed in North Cow, Old Cow and South Cow creeks; however, it is unknown what percentage of the steelhead run utilizes the other tributaries. Most steelhead spawning in South Cow Creek probably occurs above South Cow Creek diversion. The best spawning habitat occurs in the 5-mile reach of stream extending from about 1.5 miles below South Cow Creek Diversion Dam to 3.5 miles above the diversion dam (Healey, 1974). Additional spawning habitat occurs upstream of this reach, but it is much less abundant. Sightings of adult steelhead have been made at the South Cow Creek Campground (approximately 8.5 miles upstream of the South Cow Creek Diversion Dam) and in Atkins Creek, located upstream from the campground.

Summer flows are essential for resident fish, amphibians and stream-dependent wildlife. Cow Creek flows are uninterrupted during the summer providing flows for resident fish and irrigation. Summer flow is not eliminated because the water rights adjudication and water master service requires each diverter to bypass water to support the needs of all the downstream diversions. Because there are diversions along the entire stream system, there is bypassed water and agricultural return present throughout the system. There are self-sustaining populations of resident fish in the warm water sections of the stream on the valley floor and cold-water resident fish in the higher elevation reaches (see Inland Fishes of California by Peter Moyle, 1976, pp 24).

Impacts of cold-water releases from Shasta Dam on other species are not documented. Pikeminnow densities may be affected by cold water releases (USFS comment on DWA, 2001).

PHYSICAL BARRIERS

Physical barriers to fish passage are located on each of the five main tributaries of the Cow Creek system. These barriers are both naturally occurring and man-made. The natural barriers are a function of the geology of the watershed and consist of falls located on Little Cow Creek, Old Cow Creek and Clover Creek. Diversion dams are located on South Cow Creek, Old Cow Creek and Little Cow Creek. These diversion dams are a significant deterrent to the passage of adult salmonids in the fall. The severity of the man-made barriers is a function of diversion type, height, diverted flow and timing. With the exception of the PG&E facilities, no diversions are laddered.

Dams can change water temperature regimes, alter flow regimes, interrupt bedload transport, starve downstream reaches of spawning gravel, and reduce input of woody debris. Red Bluff Diversion Dam and other contributing factors are associated with the decline of the Cow Creek spawning run (Calfed Ecosystem Management Plan).

The *Preliminary Assessment of Cow Creek Tributaries* prepared by Hannaford et al 2000 included the following diagram relating to the stream gradient of the Cow Creek tributaries. Stream gradient itself may be a detriment to anadromous fish passage, as the fish tire prior to reaching a small falls or steep gradient and are unable to supply sufficient energy to mount the falls. This is much more prevalent in salmon than in steelhead. In general, steelhead are much better adapted to use steeper gradient streams than the chinook, as they remain stronger longer and do not tire as easily.

The barriers are discussed in detail in the sections on Geomorphology and Hydrology. They are summarized in Figure 9-9 and in Table 9-17.

TABLE 9-17 Barrier Summary (Large Diversions)		
Tributary	**Milepost**	**Barrier**
Main Stem		No barriers referenced
South Cow Creek	17.6	PG&E Diversion (Ladder added 1978)
		Wagoner Canyon – some natural rock barriers
		Wagoner Canyon to Hooten Gulch. Dry during low flow due to diversion
	13	Wagoner Diversion Dam – T32N R1W S 33
Old Cow Creek	3.5	15foot Whitmore Falls below bridge three separate levels (may be passable to chinook at ideal flows
		Impassable barrier below Kilarc Power Plant (reported)
Clover Creek		120-150-foot falls
Oak Run Creek		No formal survey. Report of 10-15 foot bedrock falls below Oak Run.
Little Cow Creek		Ditty Wells Falls 15-foot bedrock falls
		Cook and Butcher Diversion (Below the Falls)

Using the physical barriers, and estimated diversion locations, the available physical spawning area available for anadromous fish is shown on Figure 9-10. Note the available area may be limited significantly by flow and temperature.

SPAWNING AREAS AND SEDIMENT

Substrate composition is a critical factor in spawning suitability. It is vitally important that spawning gravels percolate to deliver fresh oxygen to the eggs and developing embryos. Fine sediment reduces oxygen flow; therefore, adequate substrate crust has low proportions of sand and fine sediment. Anadromous fish prefer substrates generally composed of gravels from 0.75 inches to as large as six inches if sufficient smaller materials exist. Gravels are unsatisfactory when they are cemented with clays or other fines, or when fine sediment deposition smothers embryos.

Available literature identifies sediment as a primary detriment to anadromous habitat in the Cow Creek system. "Water quality in Cow Creek has been significantly affected by siltation and erosion in the upper watershed. Stream banks have been eroded by excessive livestock grazing along Cow Creek and its principal tributaries. The resulting soil erosion and stream channel siltation have degraded salmon and steelhead spawning substrate in Cow Creek and its tributaries" (CH2M HILL, 1998). This contention was based on a 1992 reconnaissance survey.

Sediment is also generated from construction activities, development and related projects (utility installation, road reconstruction). NPDES storm water construction permits are required for major activities and all construction actives greater that five acres in size are required to prepare a Storm Water Pollution Prevention Plan to be followed during construction.

Results of DFG evaluations of spawning gravel suitability are included in Table 9-18. This study was conducted in the 1940s, and additional work is required.

TABLE 9-18 Spawning Gravel Suitability	
Tributary	**Amount of Gravel**
Little Cow Creek - mouth to Seaman Gulch, 15.0 miles	1.40% bed suitable for spawning
Oak Run Creek - mouth to County Road, 12.0 miles	5.94% bed suitable for spawning
Clover Creek - mouth to Dry Clover, 8.0 miles	2.2% bed suitable for spawning
Old Cow Creek - mouth to County Road, 9.0 miles	1.6% bed suitable for spawning
South Cow Creek - Clover to Wagoner Canyon, 13 miles	2.17% bed suitable for spawning
Main Cow Creek - mouth to Clover Creek, 9.5 miles	4.04% bed suitable for spawning
South Cow Creek - through Wagoner Canyon	0-25% of section suitable for spawning
South Cow Creek - South Cow Campground down 8 miles	32,000 ft^2 of suitable spawning habitat
South Cow Creek - South Cow Campground to Morelli Ranch	(From IFD-4) Graph of weighted suitable area/1000 ft cfs for steelhead and chinook spawning (speculation)
Confluence of Old Cow Creek to 2.1 miles upstream (S.16)	13,900 ft^2 excellent quality
Oak Run Creek	
Clover Creek	
Old Cow Creek	WUA vs vfs done for Rt and BN since barrier – no anadromous
Stream mile 5.7 to confluence (NW1/25 35)	

LOSS OF RIPARIAN HABITAT

Loss of riparian vegetation can increase stream temperatures and eliminate cover and food for fish. Terrestrial insects that fall into streams from riparian vegetation provide an important food source for juvenile anadromous salmonids (Reiser and Bjornn, 1979).

Livestock grazing is often blamed on the degradation of riparian habitat. In certain low gradient and stream systems, over grazing may adversely affect the riparian vegetative community. The literature suggests that Cow Creek riparian areas have been degraded by livestock grazing activities (DFG, 1992). Significant changes in the physical and species composition of the riparian areas may be related to the establishment of non-native weed species such as Tree of Heaven and Himalayan berry, and exclusion of fire. In the lower reaches of the main stem, Arundo has begun to displace cottonwood and willow seedling.

No detailed riparian inventory or damage assessment has been conducted in the watershed.

PREDATION

Excessive predation is an area of management attention. Excessive predation by Sacramento pikeminnow has been blamed for the decline of salmon. However, Brown and Moyle (1981) found that this predation has little impact on numbers of returning adults. Large-mouth bass, striped bass, small-mouth bass, spotted bass, green sunfish, white crappie, black crappie, and channel catfish are all exotic pisciverous (carnivorous) fish which have been introduced into the Sacramento System. Their relative abundance may be directly related to the level of predation on juvenile salmonids. Recently, bass have been found in the main stem of Cow Creek and may significantly impact returning salmonid populations (Healy, pers. comm., 2001). No site-specific studies have been conducted to determine the effect of predation on emigrating salmonids in the Cow Creek system.

HATCHERY PRACTICES

Hatcheries were initiated as a method to mitigate for spawning habitat loss or alteration due to large human-related projects, such as dams and hydroelectric facilities. Initial hatchery efforts were well intentioned, but not always successful. The science of hatchery management has evolved significantly in the last 40 years. Early efforts have been criticized as lacking sufficient genetic diversity and conveying diseases into world populations. Hatchery mitigation is still a key component of management of fish populations. The artificial increases in abundance of fish from hatchery plantings and resultant increases in angling pressure have been criticized as being responsible for the decline of wild populations of native fishes; however, hatchery efforts are responsible for significant portions of current populations. Hatcheries are also responsible for the artificial propagation of resident fish.

Both state and federal hatchery practices in California have hybridized spring-run with fall-run chinook salmon. Numerous non-native species, such as brown and brook trout were introduced from hatchery stock. Both of these introduced species have successfully colonized many areas of California. The USFWS planted steelhead in the upper reaches of the Cow Creek System. No new artificial propagation of anadromous fish is planned for Cow Creek.

CONCLUSIONS

The native populations of fisheries are augmented by planted stock. Lower reaches support populations of warm-water fish, as elevated summer temperatures limit habitat for cold-water species.

Cow Creek tributaries also provide habitat for fall-run chinook salmon, late-fall-run and steelhead. Anecdotal evidence suggests that spring–run may have used Wagoner Canyon. Although data for Cow Creek are limited, anadromous fish populations appear to be resident and the watershed supports at least some critical habitat in this area. Physical barriers limit access to the upper watershed. Other key factors limiting possible improvement of current populations are

- Adequate stream flow to provide for the passage of adult fish
- Lack of ladders for passage over irrigation diversion during low flow conditions
- Lack of screens to protect emigrating juveniles
- Elevated temperature in the mid to lower reaches of the tributaries which limits adult passage and may hinder late juvenile migration.

Significant portions of the flows of all tributaries are diverted for irrigation and power use. Few diversions are screened. Pumps in Old Cow and the main stem divert significant additional flows; pump intakes are also not screened.

Few data are available on resident and anadromous fish populations in the Cow Creek Watershed. Data available are discontinuous, physically and in time. In general, in stream population studies are associated with permitted developments, such as hydropower plants, or periodic DFG surveys. Additional data are needed to monitor success of any actions and to develop baseline population data.

Additional data is required on the bank stability and impact of sediment on habitat in Cow Creek. Limited data is available for spawning gravel quality and stream habitat analysis.

ACTION OPTIONS

1. Establish baseline data and a continuing comprehensive monitoring program for anadromous fish populations, enabling biologists to verify stressors and trends.

2. Rank by impact and develop a program to financially assist landowners to install screens and ladders on existing diversions.

3. Rank by impact and develop programs for screening pump intakes in Old Cow and the main stem of Cow Creek.

4. Investigate measures to increase flows in Cow Creek and tributaries, such as:

   - Investigating opportunities to increase irrigation efficiency.
   - Managing vegetation to improve water supply and timing of supply.
   - Purchasing water or water rights from willing sellers.
   - Removing or laddering diversions.
   - Providing alternate water sources during important periods.
   - Implementing a conjunctive use program.

5. Evaluate whether increasing flow will reduce temperature within the watershed.

6. Lobby for incentives for restoration activities such as tax credits.

7. Evaluate effects of predation of bass and other species in juvenile salmon in certain reaches.

8. Conduct annual population evaluation of identified reaches to set baseline and evaluate success of restoration programs.

9. Obtain landowner easements and cooperation along key habitat corridors.

10. Evaluate impacts of diversions and screen on fishery.

11. Evaluate quality and quantity of spawning gravel in Cow Creek.

12. Instream habitat typing survey.

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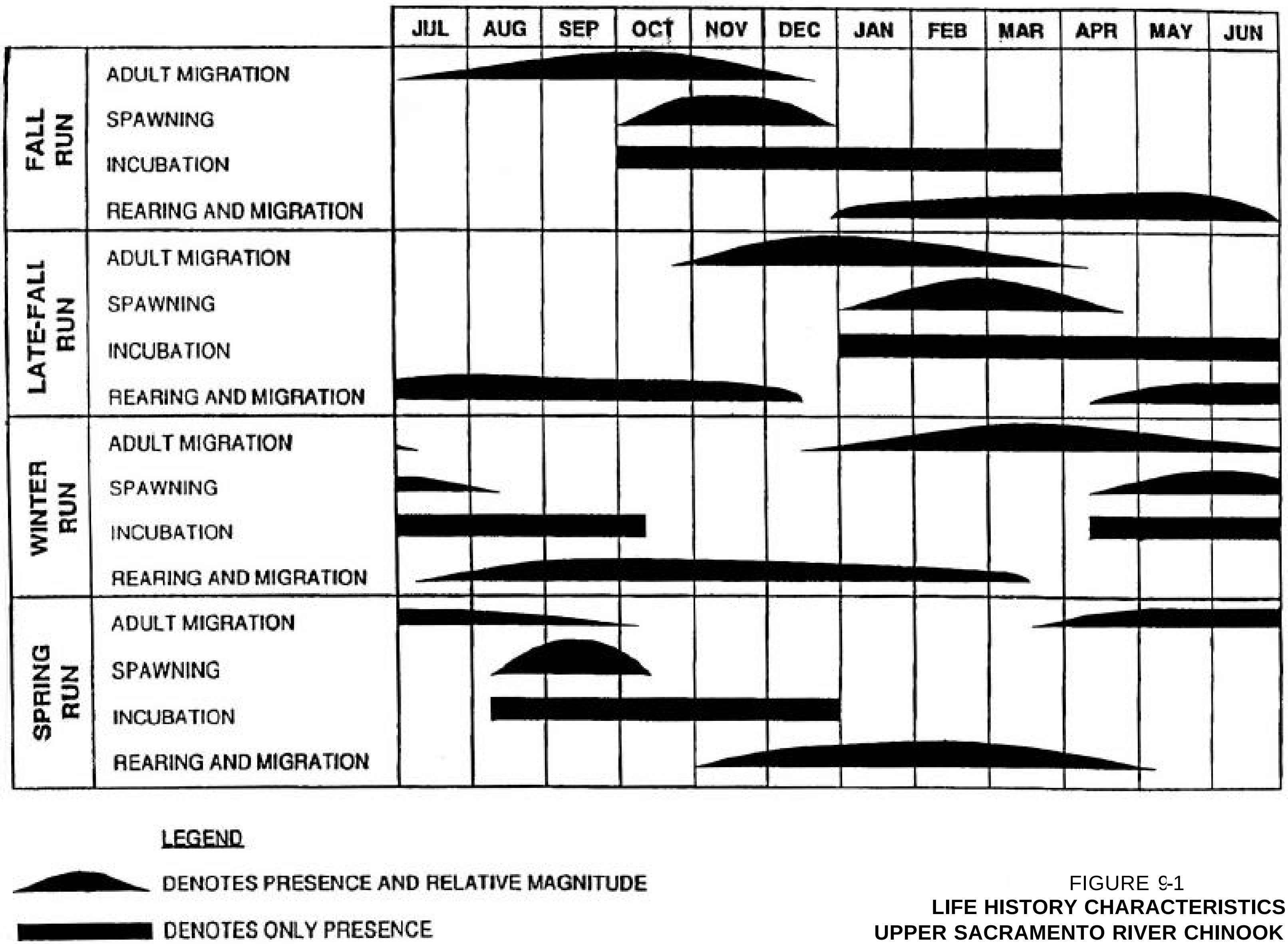
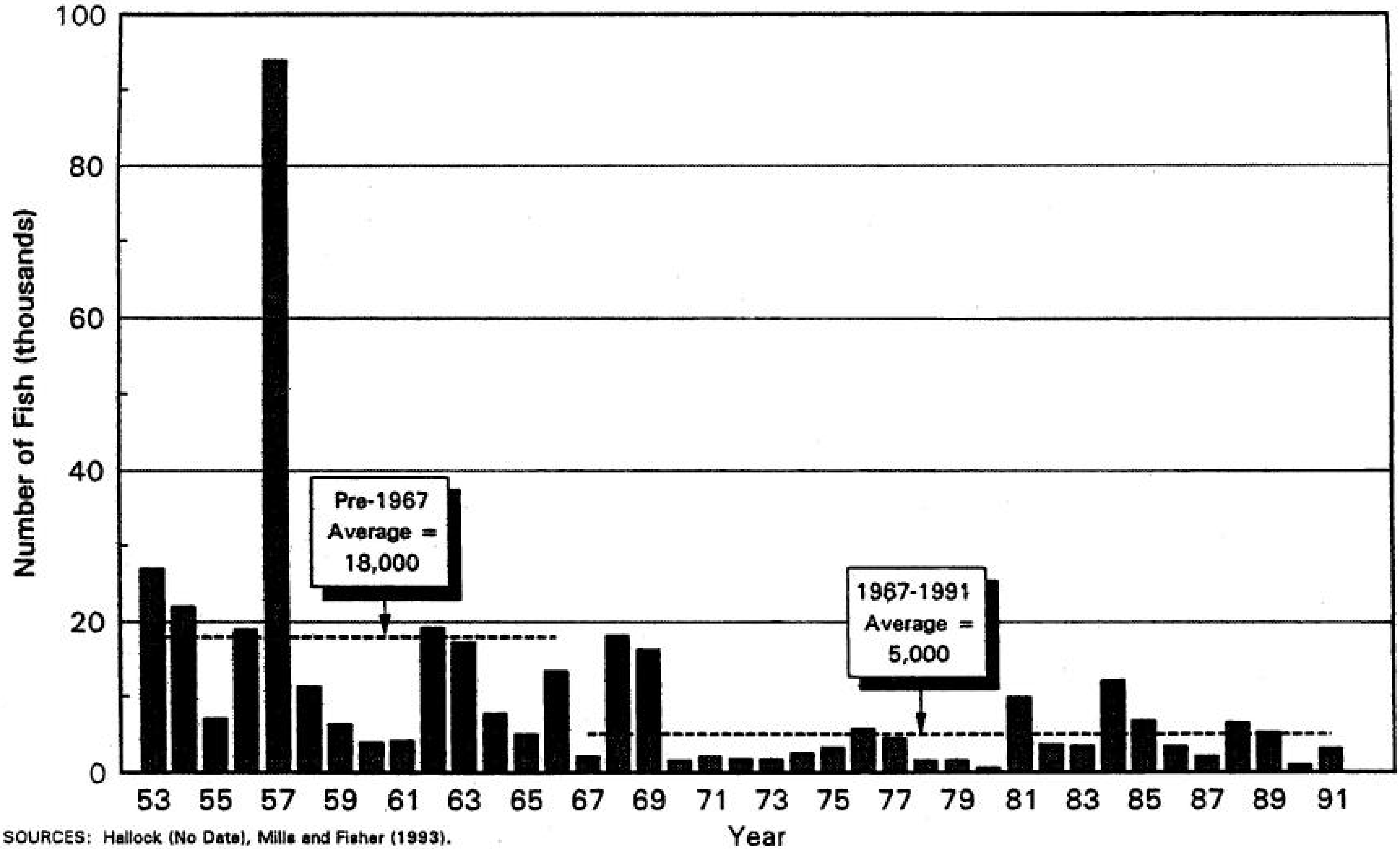
UPPER SACRAMENTO RIVER MAIN STEM DATA NOT SPECIFIC TO COW CREEK



NOTE: FIGURE FROM VOGEL AND MARINE (1991)

FIGURE 9-1
LIFE HISTORY CHARACTERISTICS OF
UPPER SACRAMENTO RIVER CHINOOK SALMON
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA



SOURCES: Hallock (No Date), Mills and Fisher (1993).

NOTE: Annual estimates are not strictly comparable because of inconsistent monitoring of tributary salmon runs.

FIGURE 9-2
ANNUAL ESTIMATES OF FALL-RUN CHINOOK SALMON SPAWNING ESCAPEMENT IN MINOR SACRAMENTO RIVER TRIBUTARIES (1953-1991)
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

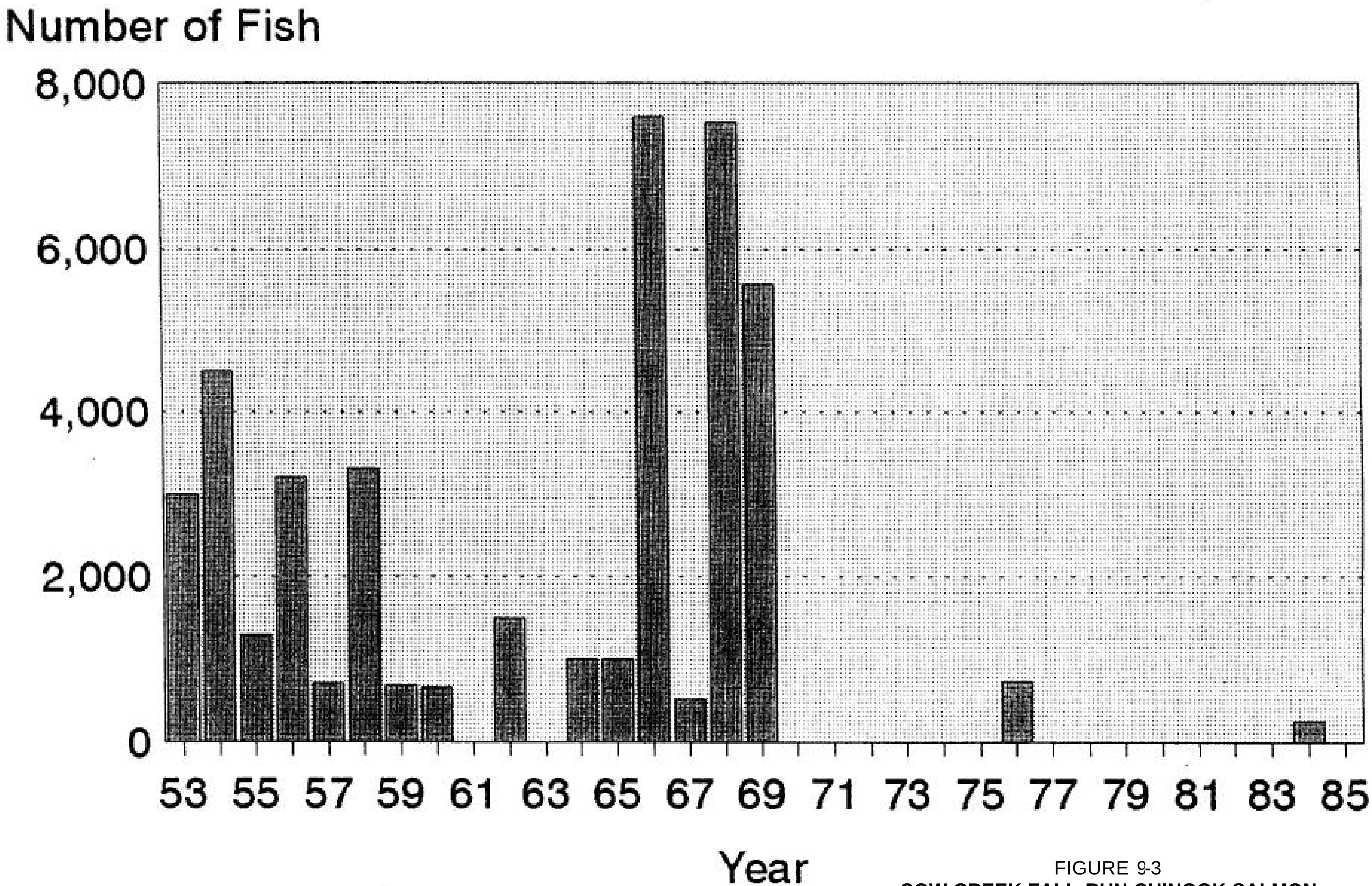


FIGURE 9-3
COW CREEK FALL-RUN CHINOOK SALMON ESTIMATES
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

SOURCE: LATOUR, 1998

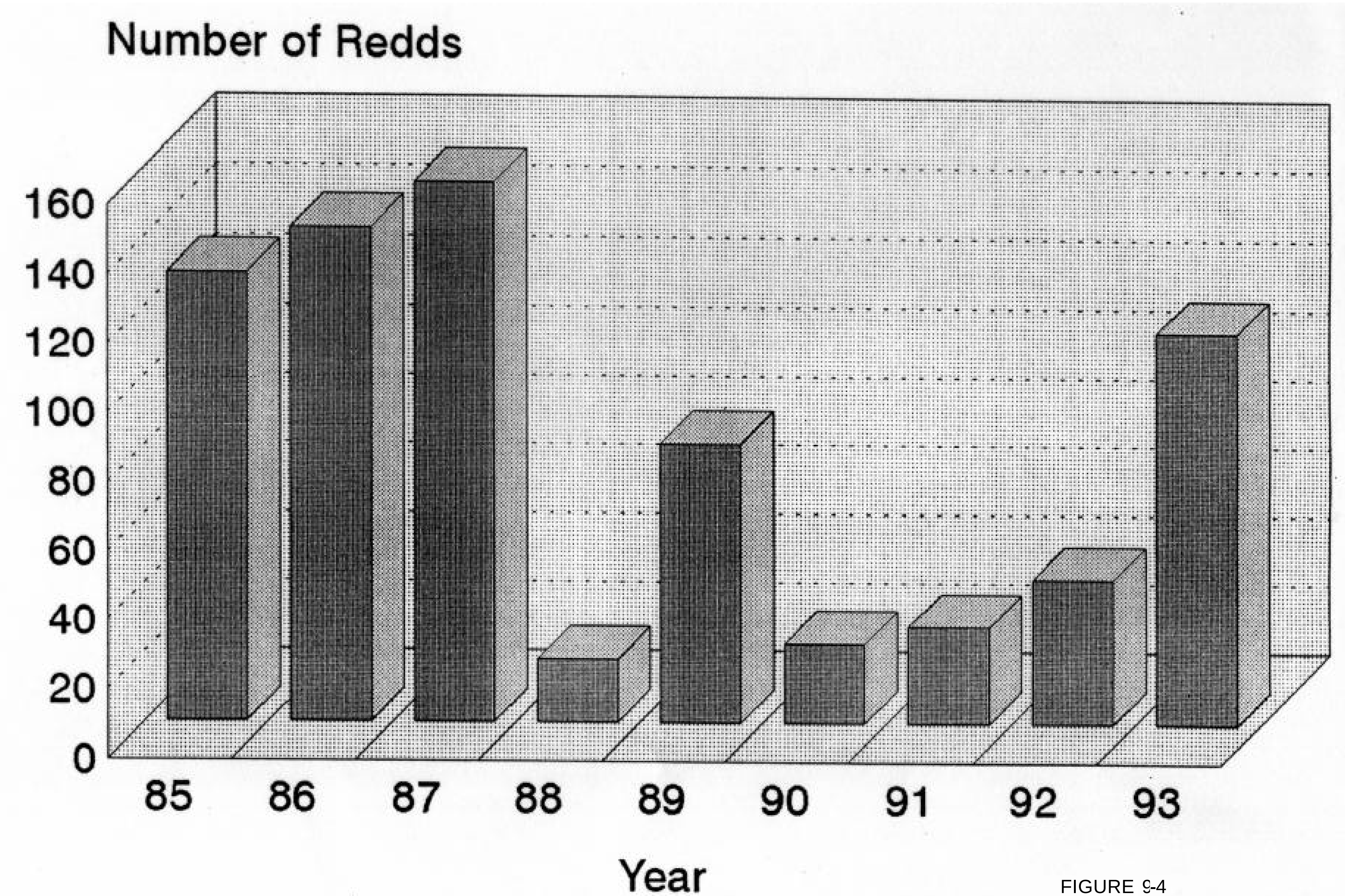
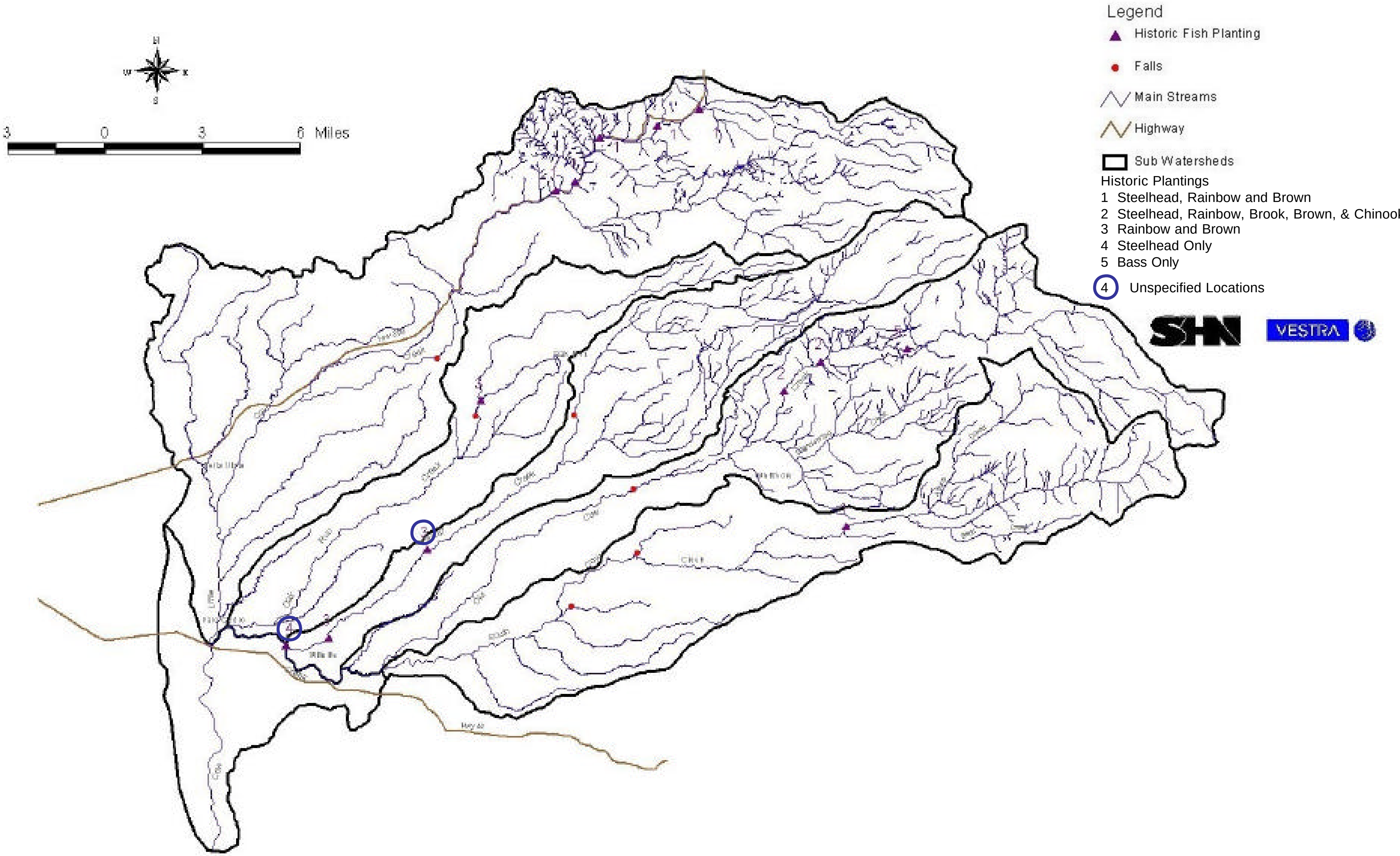


FIGURE 9-4
COW CREEK FALL-RUN CHINOOK SALMON REDD COUNTS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

SOURCE: LATOUR, 1998



Reference: DFG

FIGURE 9-5

HISTORICAL PLANTING LOCATIONS

COW CREEK WATERSHED ASSESSMENT

SHASTA COUNTY, CALIFORNIA

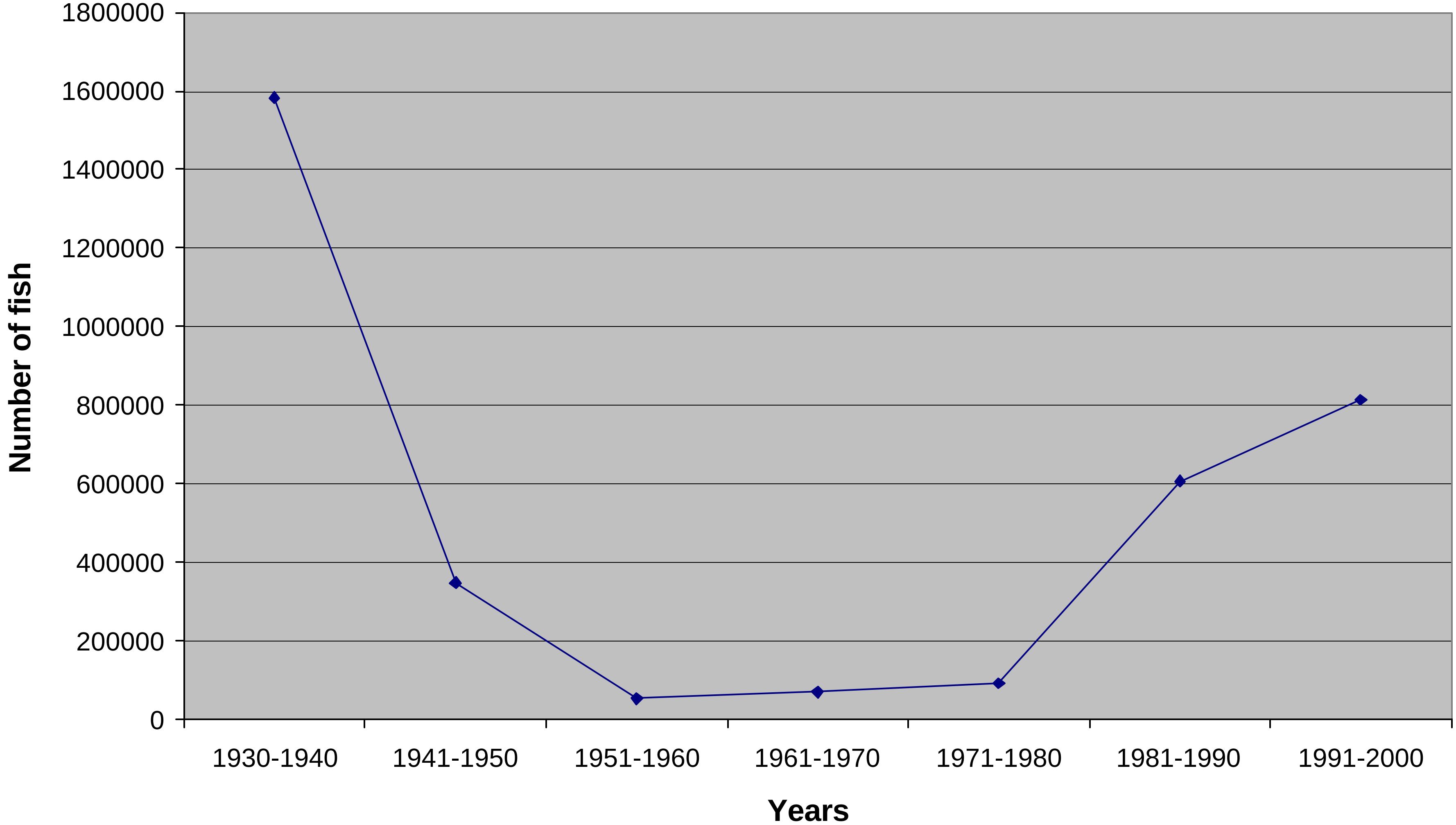
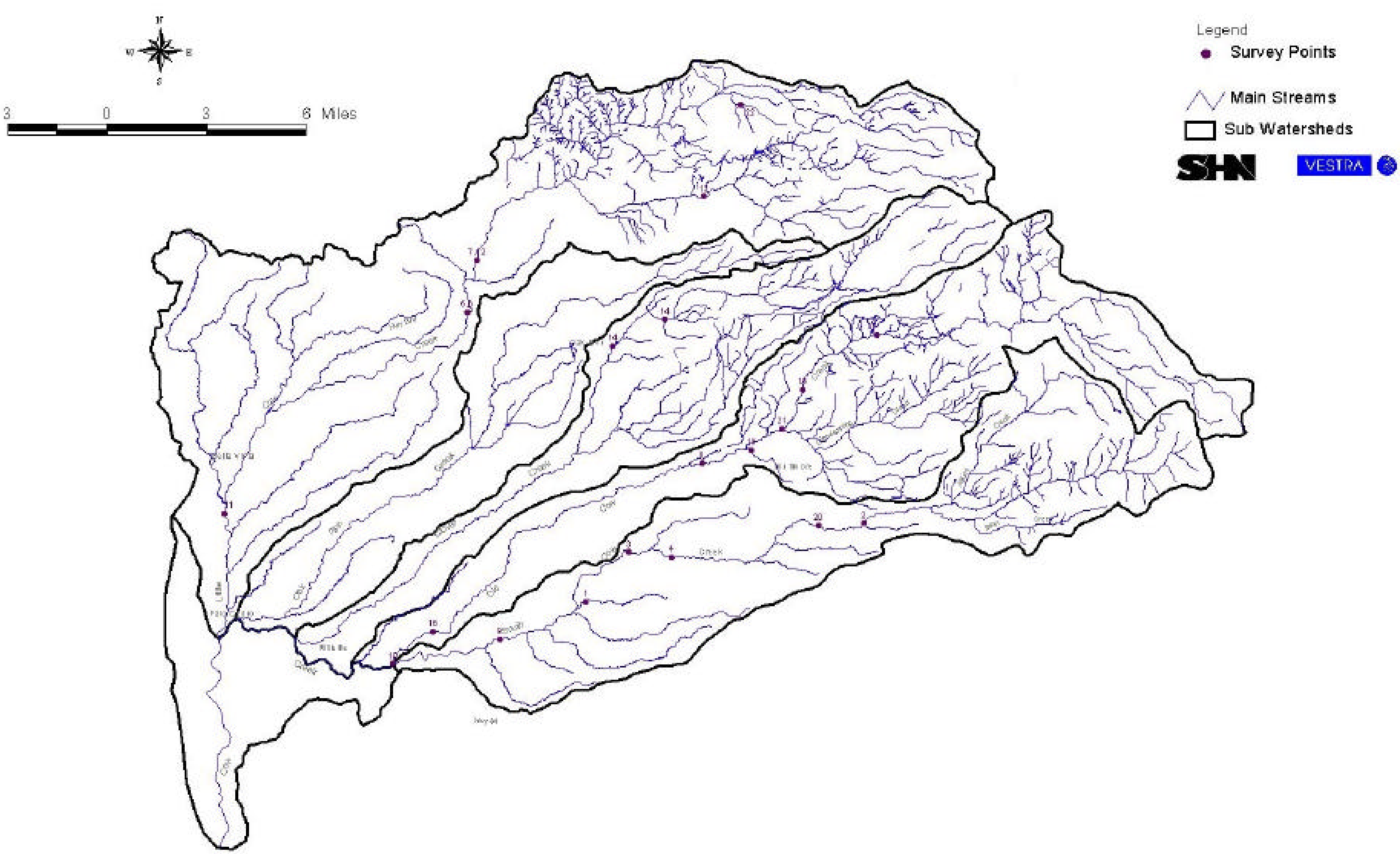
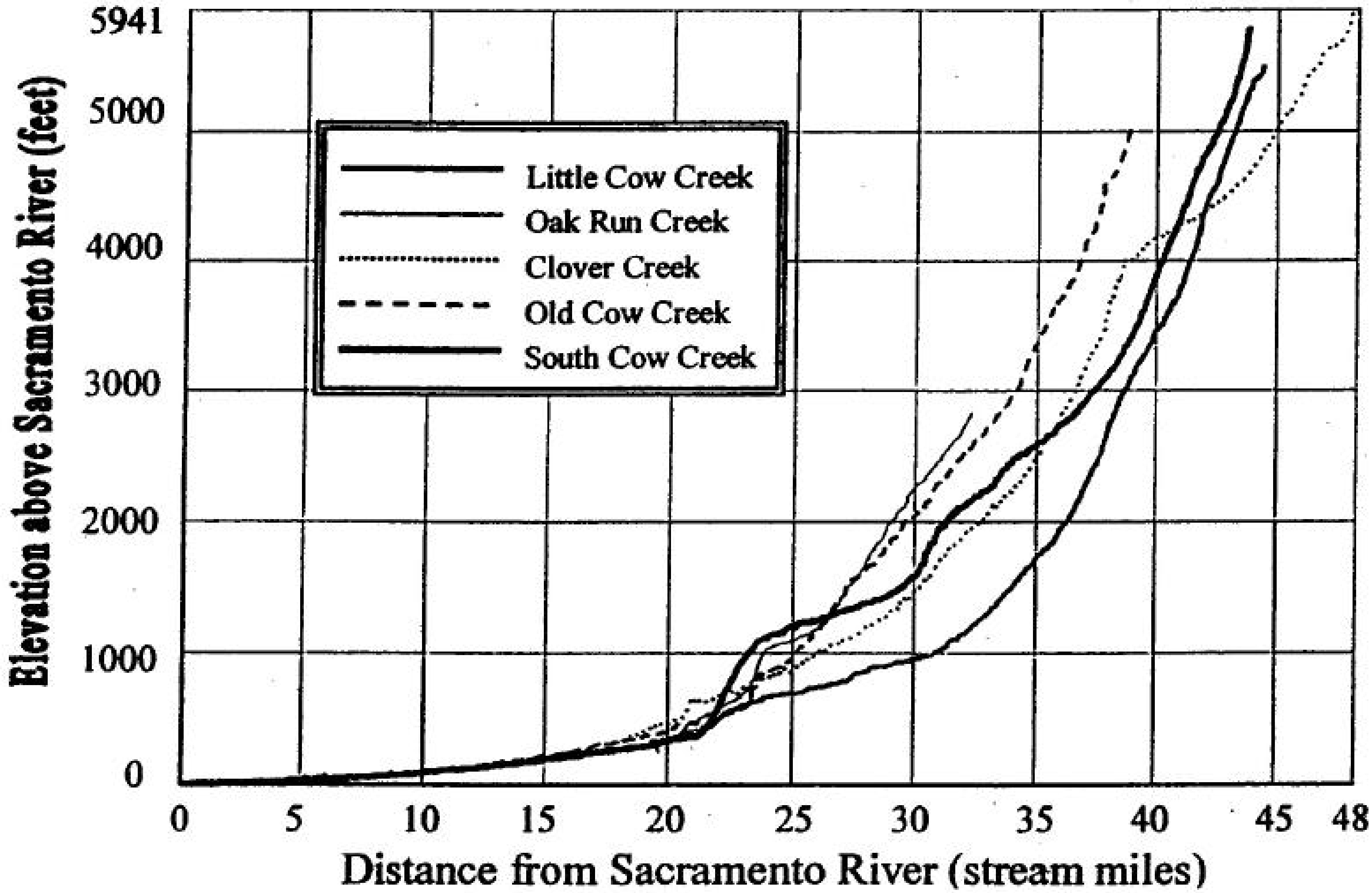


FIGURE 9-6
HISTORIC FISH PLANTING NUMBERS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA



Reference: DFG

FIGURE 9-7
OBSERVATION & SURVEY LOCATIONS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA



Elevation units can be adjusted to sea level by adding 372 feet. Prominent shifts in gradient occurring at 20-25 miles limit chinook salmon to the lower elevation reaches (i.e., below 1,000 ft. above sea level).

FIGURE 9-8
STREAM GRADIENT PROFILE
FOR COW CREEK TRIBUTARIES
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

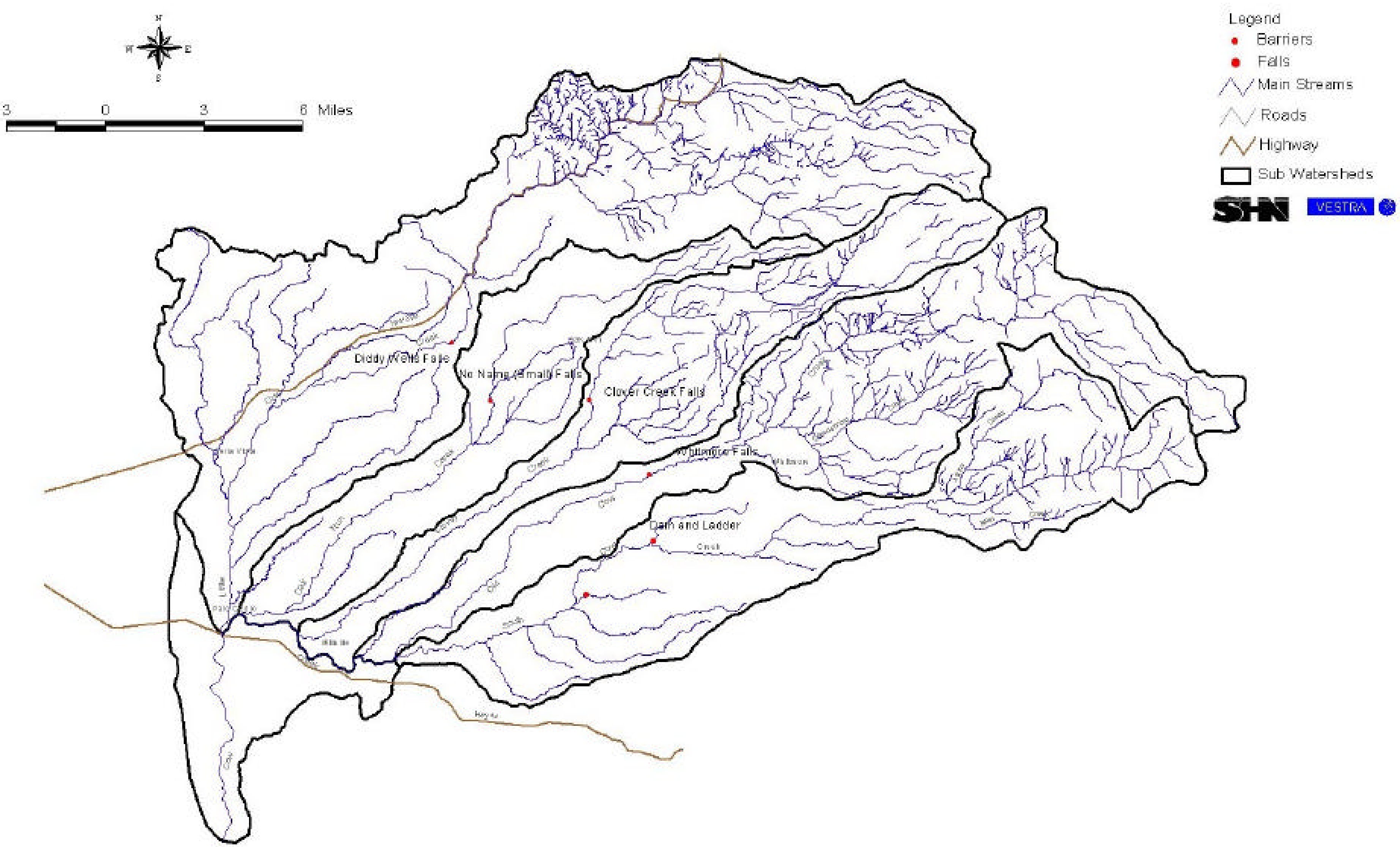


FIGURE 9-9
BARRIER LOCATIONS
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

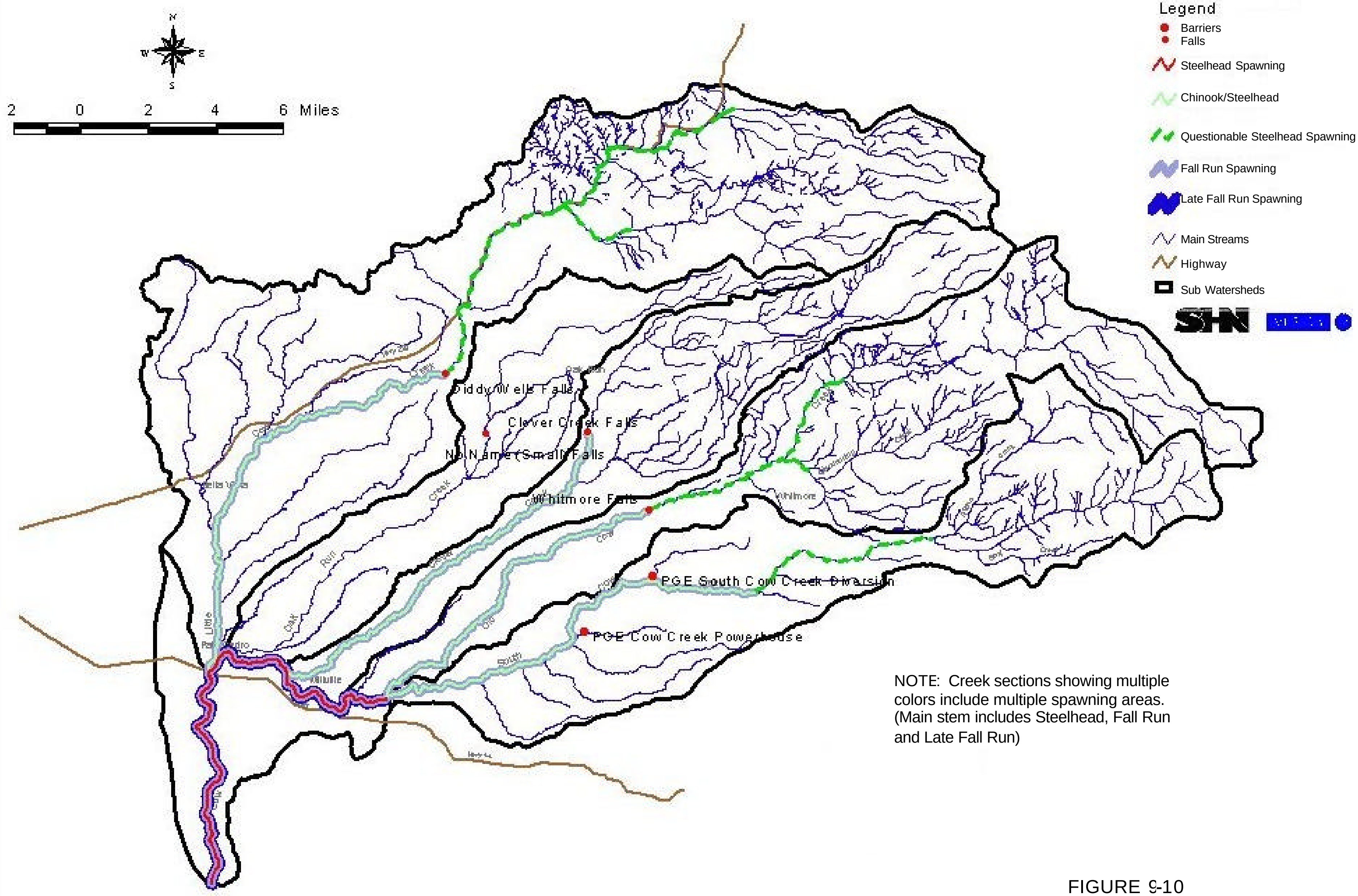


FIGURE 9-10
AVAILABLE ANADROMOUS FISH HABITAT
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: DFG

Section 10
FIRE AND FUELS

Section 10
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Section 10
FIRE AND FUELS MANAGEMENT

OVERVIEW

Fire shapes the structure and regulates the functions of ecosystems. In California, fire has dominated the landscape for as long as there has been vegetation to burn. Even without people, the state's volatile combination of climate, terrain, and vegetation produces one of the most combustible natural fire environments on earth (CDF, 1995). Each year these factors combine into conditions that raise the question not of *whether it will burn, but when it will burn* (Wilson, R.A., 1994).

Selective logging of large conifers, and fire suppression efforts over the last 100 years have, increased the fire hazard in many of California's ecosystems. These land management practices have resulted in extensive forest areas dominated by dense stands of small trees that are predominantly shade-tolerant and fire-sensitive species. The result is a significant increase in the volume and continuity of live and dead woody fuels near the forest floor, which provide a ladder for connecting surface fuels with the forest canopy (McKelvey, et al., 1996). The increased competition for available water and sunlight in these dense stands often weakens or kills trees, increasing fire severity.

Simultaneously, fire exclusion practices have allowed brush and chaparral to invade foothill woodland communities. The risk of catastrophic fire has increased dramatically. At the same time, encroaching developments and increasing property values have moved human populations into ever-increasing risk of loss. Fire suppression activities have shifted the fire regime away from numerous smaller fires, toward fewer, larger fires under more severe weather conditions. Fire suppression activities and historic forest management practices have combined to increased fuel loading in conifer forests, and to develop stands that are younger, denser and at a higher risk to loss by fire (CDF, 1995).

The nature of the climate in the Cow Creek Watershed (hot dry summers with convective summer storms) makes the upper watershed especially prone to fire. The steep slopes of the watershed are vegetated with a combination of fuels consisting of grass commingled with dense areas of chaparral and brush, and medium to heavy conifers. The combination of these vegetation types and the "ladder" structure of the vegetation significantly increase the likelihood of catastrophic wildfire.

FIRE HISTORY

As agencies and the general public have sought to "protect" the forest from fire, a consequence has been the increased levels of fuel loads, setting the stage for larger and more devastating wildfires. Cow Creek has experienced this over recorded history, where more, smaller fires have changed to fewer larger fires. In order to get the watershed vegetation back to a more "natural" fire regime, landowners, timber companies and agencies have conducted several prescribed burns within the watershed. These began in the early 1950s and continued recently under the California Vegetation Management Program (CVMP). Acreage is burned to dispose of logging and thinning slash, prepare areas for timber or range regeneration, reduce hazardous brush accumulations, improve wildlife habitat and livestock forage, or to improve water yields. Additionally, burning programs occur on federal lands administered by the Forest Service and BLM.

WILDFIRE

Years of aggressive fire suppression have dramatically changed the character of the Cow Creek Watershed. These changes were discussed previously in the Reference Conditions portion of Section 8, Botanical Resources. Pre-European forests were generally open, park-like pine and fir forests that were subject to frequent low-intensity fires. Fire was a common influence on the structure and function of California's ecosystems in prehistoric times with as much as 5.5 to 13 million acres burning annually on average (CDF, 1999).

Prior to 20th century suppression efforts, lightning and Native Americans ignited forests. Native Americans played a major role and had an important impact on the ecosystem by repeatedly burning the vegetation. They did this to modify plant and animal communities for human benefit. In California, native peoples had at least 70 different reasons for burning vegetation (Kay, C.E., 1994). Pre-settlement fire return intervals were generally less than 20 years throughout a broad zone extending from the foothills though the mixed conifer forests (McKelvey, et al., 1996). Nearly a century of wildfire control and prevention has created forests that are smaller, younger, and denser, have high fuel loads and are prone to larger, and in some cases, catastrophic fire conditions.

Several large wildfires have occurred in the Cow Creek Watershed in the last seventy years that records have been maintained. CDF fire history records indicate a total of 42 wildfires within the Cow Creek Watershed. Of these fires, nine have been in excess of 3000 acres in size. The most recent large fire that occurred in the Cow Creek Watershed was the Jones Fire that burned 26,020 acres in the northwestern portion of the watershed in October of 1999. The largest fire of record is the Fountain Fire that burned a total of 65,300 acres, of which only 9 percent or 9,300 acres was located in the Cow Creek Watershed. The Fountain Fire occurred in August 1992.

TABLE 10-1
Wildfire History in Cow Creek Watershed

Fire Name	Acreage	Year	Cause
Buzzard	3,316	1924	Human
Cow Creek	3,481	1939	Human
Blue Mtn.	5,366	1958	Escape
Whitmore	7,286	1978	Lightning
Blue Mtn.	3,146	1983	Lightning
Blue Mtn. West	4,000	1985	Unknown
Fern	7,559	1988	Powerline
Fountain	60,300[1]	1992	Arson
Jones	26,020	1999	Human
Total Acres	**120,474**		

[1] Only 9,300 acres in Cow Creek Watershed

Fire size and intensity have increased steadily. Historic fire acreage is included in Table 10-2. Since 1975 the total acreage lost to wildfires has increased by a factor of four. Over 25 percent of the Cow Creek watershed has burned under catastrophic circumstances since 1975.

Figure 10-1 displays recorded fire history in the Cow Creek Watershed. CDF began keeping records of wildfires in the 1920's. A brief history of fire in the Cow Creek watershed is presented below. A more detailed discussion of historic fire is included in Section 2. Historic fires are included in Figure 10-1.

TABLE 10-2 Fire Summary Acreage			
Date	**Fire Type**		**% Watershed Burned**
	VMP acres	**Wildfire acres**	
1850 - 1900	None Noted	None noted	n/a
1900 - 1950		10,209	4
1951 - 1975	4,079	11,119	6
1976 - present	23,934	45,365	25
TOTAL	**28,013**	**66,693**	**35%**

PRESCRIBED FIRE

Based on observed increases in fuels and reduction in livestock feed a controlled burning program was initiated by Cow Creek Ranchers in the 1940-50s. Large control burns in Whitmore began in the 1950s. The first formal control burn in the Blue Mountain area consisted of 10,000 acres between Bear Creek, South Cow Creek, Morelli Ranch on the east, and Hufford and Wagoner Ranches on the west. A total of four burns occurred, with the last one taking place in the 1970s. The last fire took place in 1996 and included approximately 200 acres. These early vegetation management burning programs were successful not only in reducing the invasion of brush species and non-native weeds, but increasing water and spring yield.

Ranchers in the watershed that were interviewed have conducted control burns on their ranches consisting of a few hundred acres to thousands of acres since the 1940-50s. Most of the Ranchers have abandoned this practice due to the difficulty in obtaining permits and problems adhering to the air quality regulations. In addition, complaints from neighboring houses, which have moved into recent subdivisions, have resulted in undesired conflicts.

The need for prescribed fire should be balanced and assessed along with the potential increase in erosion and potential increases in water availability as a result of burning (DFG, DWA comments, 2001.)

ENVIRONMENTAL CONSEQUENCES OF CATASTROPHIC FIRE

Catastrophic (uncontrolled wildfire) fire is detrimental to both watershed function and quality and can negatively impact all aspects of the watershed. In a catastrophic wildfire, typically all vegetation is removed or damaged, including seeds and important soil microorganisms.

SOIL

The frequency and severity of wildfire affects the magnitude of accelerated erosion. Wildfire increases the potential for accelerated erosion primarily through its effects on vegetation and soil. During an intense wildfire, all vegetation may be destroyed, and the organic material in the soil may be burned away or may decompose into water-repellent substances that prevent water from percolating into the soil. As a result, even normal rainfall may result in unusual erosion from burned areas. The potential for fire to increase erosion increases with fire severity, soil erodibility, steepness of slope, and intensity or amount of precipitation. However, low intensity fires, such as prescribed burn, will burn at temperatures seldom exceeding 200 degrees F, with flame height generally less than three feet and causing little or no soil damage. The effects of heat on soil quality are included on Table 10-3.

TABLE 10-3
Effects of Heat on Soil Quality

Severity Rating	Temp. (°C)	Physical Effects	Nutrient Effects
Low	< 220	Negligible effects on particle-size distribution; plasticity; elasticity. No significant loss of organic matter.	Soluble K, Ca and Mg increase; Ammonium nitrogen and available phosphorous increase.
Medium	220 – 460	Organic matter oxidized; completely gone at 460°; organic compounds driven down form hydrophobic layers; more sand-sized particles formed.	Nutrients mineralized; Nitrogen vaporized.
High	Over 460	Permanent changes in clay structure, soil texture; porosity; plasticity; elasticity.	Soluble P, Ca and Mg decrease dramatically.

WATER

Water supplies are also affected by fire. The loss of ground cover, such as needles and small branches, and the chemical transformation of burned soils make watersheds more susceptible to erosion from rainstorms. Many times after large wildfires, flooding occurs due to increased runoff and erosion from burned areas. Flooding and increased sediment can effect the chemical composition of surface water in a watershed. In certain instances, where severe burns have occurred, elevated levels of manganese and phosphates have been detected in surface water up to two years after fires. Erosion continues to occur at an accelerated rate on steep hillsides that have been severely burned, even after there are signs of vegetation recovery. Landslides can occur following removal of vegetation due to burning, reduction in evapotranspiration, and decomposition of dead root systems.

AIR

Air quality is of particular concern in California and within the Cow Creek Watershed. Residents generally seek out rural lifestyles because of the high quality of life, low population densities, and closeness to “nature”. Poor air quality is generally associated with urban environments and smoke is generally an unwanted intrusion. Suppression of wildfires provides a short-term benefit to air quality by reducing the amount of vegetation consumed, thereby reducing smoke emissions. However, by delaying a natural event to a later date, poor air quality is simply pushed to a future time. When fire occurs, it is often during a time of year that traps smoke and particulate matter within the valley, intensifying the time and duration of effects. Additionally, large wildfires result in the burning of larger fuels than would be unlikely to burn under a natural fire regime. By fostering larger unregulated fires, the watershed has seen larger acreages of fire and longer durations of smoke that greatly impact air quality. Estimating the impacts from air pollutants is difficult in general, and is more complex in a wildland setting. Wildfire smoke, and in some cases that from prescribed fire, can affect visibility, human health and pollution rights. Overall, air quality impacts of smoke are important, especially given the fact that the Sacramento Valley Air Basin is in a non-attainment status. Wildland fires are categorized as an "area source" by many pollution agencies, since they tend to release pollutants over large areas (CDF, 1999).

WILDLIFE

The major impact of wildfire on wildlife centers on its influence on vegetation structure and composition. The loss of down and dead woody material, during wild and prescribed burns, removes essential structural habitat components for a variety of wildlife and reduces species diversity. Loss of brush fields and forestlands restrict the ability of wildlife to forage for food and find shelter. Fire has the potential to accentuate impacts to fish and wildlife associated with other landscape fragmentation and development (timber harvesting, road building, forest management practices). For fish, the primary concerns relative to fire are increases in water temperature, sediment loading, stream cover, and the long-term loss of woody debris from stream channels. The most severe effects on fish habitat from wildfire occur when riparian vegetation (streamside forest) is lost. This vegetation plays an important role by providing shade, and providing a food source. Streamside vegetation also decreases the rate of erosion along stream banks.

Changes in species composition from intense wildfire favor early successional habitat and its assorted wildlife populations. Significant increase in browsing species population (such as deer) is common following severe fire. Physical movement of animals is also enhanced after wildfire. Low intensity fires do not generally result in significant changes to vegetation composition and resulting wildlife species, but may have similar benefit by increasing the diversity of vegetative mosaics providing better food and cover border areas.

RANGELAND

Rangelands in Cow Creek play an important role in the state's overall production of range livestock. Typical rangelands consist of annual grasslands mixed with foothill pine and blue oaks. Wildland fire impacts rangelands by destroying present forage on the land during the fire as well as reducing the capacity of the same lands to produce forage for the next two years (CDF, 1999). Increases in capacity generally occur in the years following intense wildfire. This results in livestock owners having to purchase replacement feed or grazing lands for at least the balance of the grazing season and sometimes into the next. Over time, recurrent fire can actually improve and maintain healthy rangelands.

RECREATION

While concentrated recreation within the watershed is limited, due to the high percentage of private lands, the watershed does provide for considerable dispersed recreation (hunting, fishing, hiking, sight-seeing). Wildfire impacts recreation values through loss of use, reduced wildlife habitat and change in species mix of vegetation. Areas burned that attract visitors for hunting and fishing will diminish in value after wildfire, as visitors are not attracted to burned forests. Wildlife that loose habitat and forage will disperse to other locations, resulting in lower hunter numbers for several years. Additionally, wildfires that significantly change the vegetation composition (forest to brush) result in visitors by-passing these areas.

While direct economic loss from land use can be measured, it is more difficult to estimate the loss of recreation. Recreation use numbers tend to display visitors in terms of user days, and are generally geared toward a specific attraction (campground, park, forest). In the Cow Creek Watershed, the loss in recreation value can be similar to these other locations, but the economic loss more subtle. This may equate to reduction in tourist traffic at local stores, restaurants and gas stations that is masked by other overriding economic factors, such as the increase in gasoline costs.

TIMBERLANDS

Timberland losses can be significant during wildfire. The most noticeable direct effect is the loss of timber and its economic value. Catastrophic stand replacing fires tend to remove much usable wood fiber from the landscape due to the intense fire conditions. Any remaining timber is generally of low quality, low value, scattered over the fire area, and has a reduced economic value. Reforestation efforts are expensive and time consuming, generally in excess of $500 per acre. The resulting forests require periods of intensive management with no economic return for up to 60 years. Indirect effects of fire include loss in soil productivity, changed forest successional characteristics, reduced forest health and increased risk of insect and disease infestations.

HUMAN RESOURCES

Wildfire poses a significant risk to human health and property. Population growth has climbed steadily in the areas outlying population centers. Both recent Cow Creek Watershed Fires, the Jones Fire and Fountain Fire resulted in significant destruction of homes and property. These losses are both economic and social, as many non-renewable historic buildings are destroyed, as well as the memories of hundreds of families.

FUEL LOADING AND CONDITIONS

Fire behavior is a function of fuels, weather, and topography. Of these three components, referred to as the fire triangle, only fuel conditions can be influenced by human activity.

FUELS

No formal fuel inventory has been conducted in the Cow Creek Watershed. The only fuel loading and inventory available is through CDF Landsat imagery included on Figure 10-2. Notably the areas of historic fire are shown as light brush areas. The area of the Jones Fire is not included due to the date of the photography. The CDF fuel-loading mapping is based on vegetation and is used to feed specific fuel models. Varieties of fuel models are available to evaluate fuel loading and inventory.

Recent work conducted by the Western Shasta RCD in cooperation with BLM, CDF and BOR for the Clear Creek watershed used the 13 fuel models developed by Anderson in 1982. In short, the models use combinations of topography and fuels to predict fire behavior, which are then used to develop fire protection strategies such as location of firebreaks and high-risk areas.

Significant differences in fire behavior exist between understory or ground or surface fires and crown fires. Crown fires often generate their own weather and wind, while surface fires are more responsive to topography and the weather of the day.

Fuel parameters important to fire behavior that affect intensity, speed of spread, and behavior include, loading, size and shape, compactness, horizontal continuity, vertical continuity and species.

WEATHER

The weather in the Cow Creek Watershed is variable by season, but during the fire risk period of summer, the dominant wind condition is usually from the southwest to northwest and often driven by thunderstorms. Generally, the fires that have occurred in the watershed have progressed from southwest to northeast. The exception to this is the Jones Fire, which traveled generally southeast driven by ever changing wind conditions.

TOPOGRAPHY

Topography is a key element to the direction, intensity and rate of spread of fire. Aspect, steepness of slope, elevation and shape all contribute to how a fire behaves once ignited. Surface fires are very dependent on topography and generally move more quickly upslope than down slope and may slow significantly over the ridges. For this reason CDF commonly uses ridges for fuel breaks and protection areas.

FIRE PROTECTION

Prevention, detection, pre-suppession, suppression, and fuels management are the five programs in fire protection on high fire risk lands throughout the area by various resource and fire agencies. Prevention includes contracts, law enforcement, building inspection, patrols, and public education. Detection activities are carried out through use of fire lookouts and aerial surveillance. Pre-suppression involves arranging for fire forces, training, equipment, and structural improvements before they are needed. Suppression includes fire-fighting activities with hand crews, engines, and aircraft. Fuels management helps reduce fires by removing or rearranging logging slash, brush, or other accumulation of burnable material.

PRESCRIBED FIRE

Prescribed fire is the controlled application of fire to the land to accomplish specific land management goals. These goals can vary from annual burning around residences to clear grass and weeds, to agricultural field burning for preparation of crop planting, burning of brush piles, and landscape burning of forests to remove brush and accumulations of forest fuel. Forestlands can benefit from prescribed fire by attempting to regulate or moderate the frequency and intensity of wildfires. By returning to regular burning, forests can achieve a measure of protection from catastrophic loss by reducing the amounts and concentrations of brush and other forest fuels.

Historical land-use changes in the upper watershed make a return to the prehistoric fire regime infeasible. Not only are structures, infrastructure, and managed forests at risk of fire damage too expensive to permit burning at the pre-settlement rate, but regulatory constraints and the social costs of fire and its effects (e.g., low air quality) also prohibit burning at pre-European scales (SAF, 1997). Although fire will remain an essential element of these wildland ecosystems, it must be controlled and used in conjunction with other techniques to reduce fuel loads to levels consistent with maintaining healthy forests (McKelvey, et al., 1996).

Prior to introduction of any fire regime, fuels treatment will be required. Less fuel treatments will be required in the mid-chaparral grasslands than in the coniferous forests of the upper watershed or in developed valley areas.

Mechanical fuel management can reduce fire hazard. Recent studies of the behavior of fires immediately following harvesting found that prescribed burning, harvesting or biomass fuel reduction followed by prescribed burning, and sanitation-salvage or group-selection harvests with slash and landscape fuels treatments, produced fuel structures that minimized average fire intensities, heat per unit area, rate of spread, area burned, and scorch heights. In contrast, sanitation-salvage harvests without slash treatment or with lopping and scattering of slash result initially in more extreme fire behavior than in untreated areas. The latter treatments probably result in less severe fires relative to untreated stands, however, after sufficient time has passed to allow the slash to decompose (SAF, 1997).

Prescribed fire can also be an effective tool for managing fuels. Prescribed fire includes ignited fires (fires intentionally set to burn a planned area at a planned intensity) and planned non-suppression natural fires. In most forested areas, however, fuel structures are currently too hazardous to safely attempt prescribed ignitions without pre-treating the stand mechanically.

Planned non-suppression fires are fires resulting from unplanned ignitions (caused by either lightning or humans) in areas for which prescribed natural fire plans have been adopted specifying conditions under which such fires will be allowed to burn. Prescribed natural fire planning following specific fire management activities represents an important opportunity to have wildfire help meet watershed management objectives.

A key element to fuel management planning is the initiation of market uses for small trees and biomass removed from wildlands under fuels management programs.

BENEFITS

The intensity and temperature of most prescribed fire scenarios are significantly less than catastrophic wildfire and produce positive rather than negative ecosystem impacts. Benefits of prescribed fire include:

- ***Reduction of fuel buildup*** of dead wood, overcrowded, unhealthy trees and thick layers of pine needles and ground vegetation that can contribute to large wildfires.

- ***Thinning of overcrowded forests*** that have naturally been thinned by fire. These forests are generally healthier and more vigorous, and can recover faster and are more resistant to insect and disease attacks.

- ***Preparation of the site for new growth*** by removing excess vegetation. As the excess vegetation is burned, nitrogen and other nutrients are released, allowing the soil to be receptive for new plants to grow and allowing conifer seeds to germinate. Additionally, some forms of conifers and brush (knobcone pine, lodgepole pine manzanita, deer brush) rely on frequent fire for germination of seeds and new growth development.

- ***Creation of diverse vegetation for wildlife*** by having varying ages and types of plants available for animals to forage on and find shelter in. Wildlife that graze (deer, elk) benefit from new growth as young plants provide more nutrients. Fire can create more open stands that allow predators to be seen and down wood for small mammals and insects.

- ***Increase in water and spring yield*** by removing encroaching chaparral and shade tolerant species and decreasing evapotranspiration, increases occur in local springs and groundwater discharge to creeks. Significant increased flows are common after fires; and spring yield may increase as much as 200% (R. Bursy, undated).

CALIFORNIA VEGETATION MANAGEMENT PROGRAM (CVMP)

The CVMP is a cost-sharing program that focuses on the use of prescribed fire, and mechanical means, for addressing wildland fire fuel hazards and other resource management issues on State Responsibility Area (SRA) lands. The use of prescribed fire mimics natural processes, restores fire to its historic role in wildland ecosystems, and provides significant fire hazard reduction benefits that enhance public and firefighter safety. The goals of this program are to:

- Reduce fuel accumulations
- Prepare seedbeds
- Control competing vegetation
- Improve production of grazing and forest lands
- Manage of wildlife habitat
- Thin young trees
- Control of pests and disease
- Increase water yields
- Improve fish habitats
- Improve air quality
- Protect irreplaceable soil resources

CVMP allows private landowners to enter into a contract with CDF to use prescribed fire to accomplish a combination of management goals on both forestlands and grasslands. Since 1981, approximately 500,000 acres (an average of 30,000 acres per year) have been treated with prescribed fire under the CVMP in California. Of that total, approximately 30,000 acres have been treated with prescribed fire in the Cow Creek Watershed. Some of the first prescribed burns under the VMP occurred in the Cow Creek Watershed. The history of prescribed burning is discussed in Section 2.

Re-introduction of fire can provide significant ecosystem benefits and reduce future risk of catastrophic events. Any effort to reintroduce fire will require significant coordination efforts. The following recommendations have been developed for the Cow Creek Watershed.

CONLCUSIONS

The past 100 years of fire exclusion have resulted in significant fuel loading and potential for catastrophic fire.

Although it is widely known that current fuel loading is unacceptably high, no detailed local fuel inventory is available.

ACTION OPTIONS

1. Conduct a watershed-specific fuel inventory and identify most effective methods for fire management.

2. Develop a strategic fuels management plan emphasizing ecological and hazardous components.

3. Increase local public awareness of the need for expanded fuel management and of the catastrophic consequences of continued ignorance of vegetation management activities.

4. Construct and maintain strategically designed and located, large-scale networks of fuel reduction zones through extensive public/private sector coordination.

5. Expand the application of prescribed fire practices where they can be used safely and effectively.

6. Lobby or petition for resource allocations for fuel management and reduction in permit conditions.

7. Recognize the public benefits of fuel management by providing incentives (e.g., state income tax credits, or enact simpler permits for thinning and fuel reduction) to encourage private investment in fuel management.

8. Develop plans to reintroduce fire into the ecosystem to control fuel density and structure and improve vegetation diversity.

9. Work cooperatively with Air Board to streamline permitting and identify cost benefit analysis of fuels reduction.

10. Work with adjacent watershed groups to petition the Air Board for changes in regulations.

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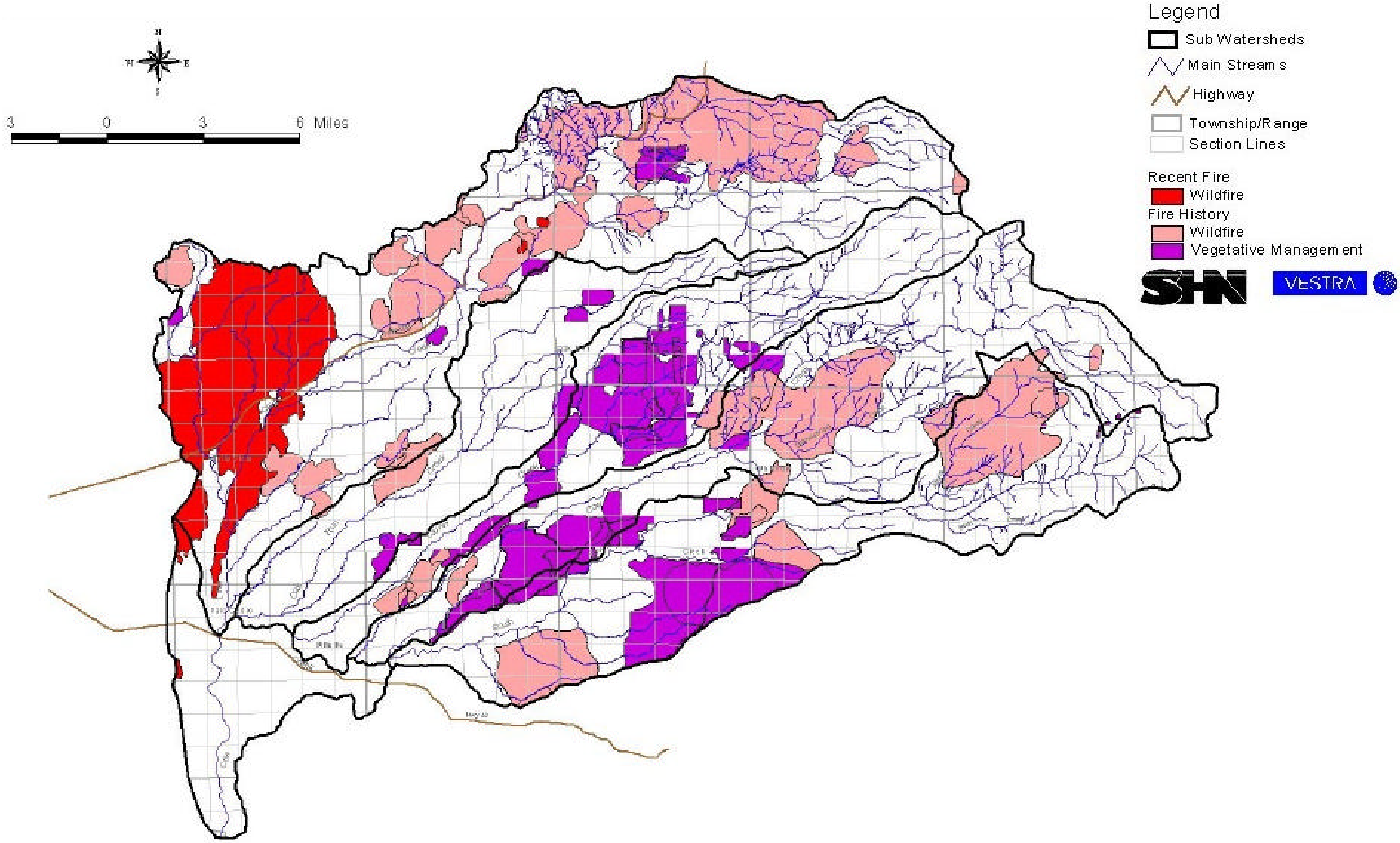
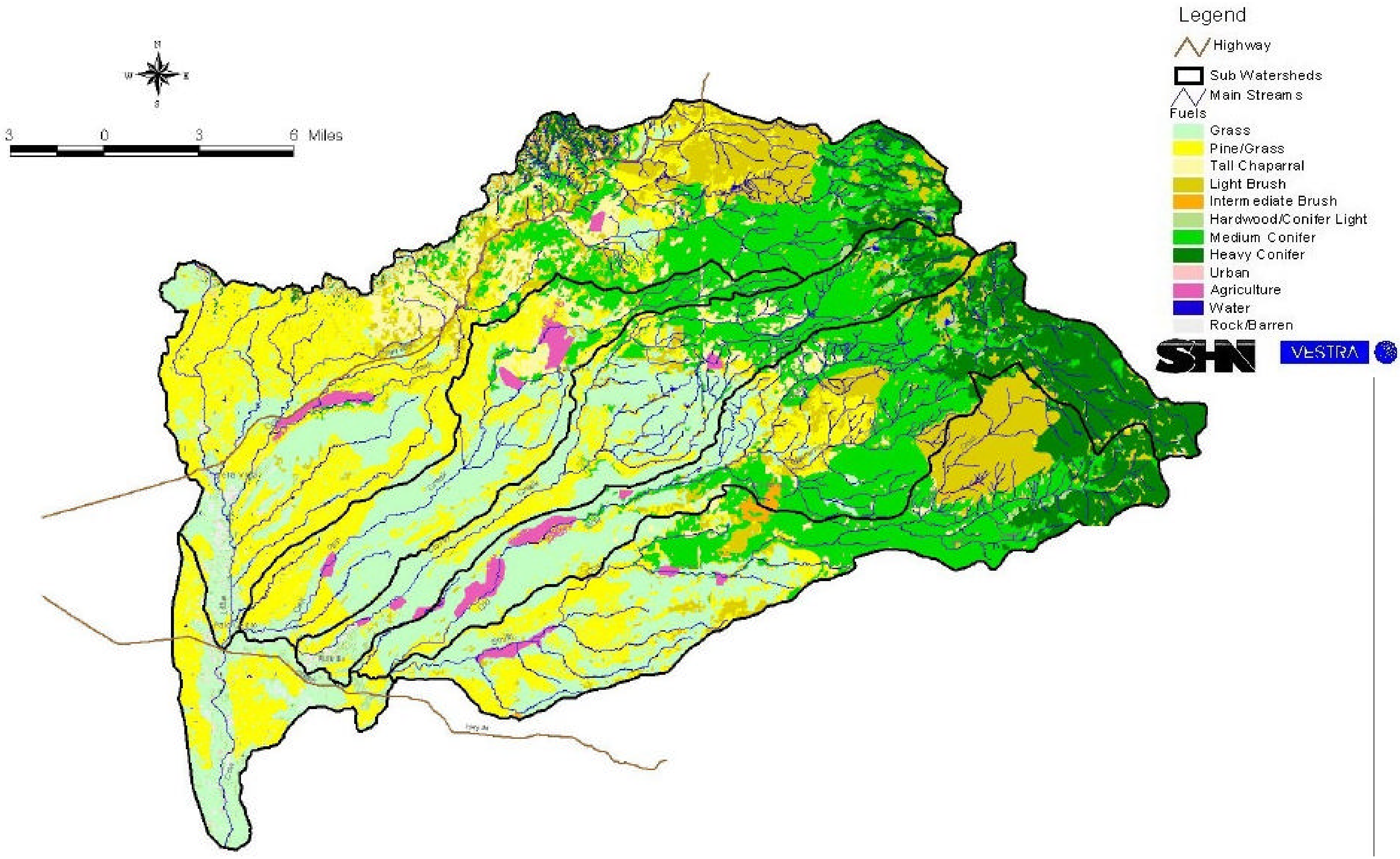


FIGURE 10-1
FIRE HISTORY
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

Reference: CDF



Reference: CDF 1990 Landsat, 30 meter

FIGURE 10-2
FUEL LOADING
COW CREEK WATERSHED ASSESSMENT
SHASTA COUNTY, CALIFORNIA

GLOSSARY

GLOSSARY

Acre-ft. Acre-foot, the quantity of water required to cover an acre to a depth of 1 foot. An acre-foot is equivalent to 43,560 cubic feet.

Age-class (1) A descriptive term to indicate the relative age of plants. (2) Refers to age and class of animal.

Alluvium Sediment deposited by streams and rivers. Stream deposits of comparatively recent time.

Ambient The natural conditions (or environment) at a given place or time.

Anadromous fishes Fishes that spend a part or their life in the sea or lakes, but ascend rivers at more or less regular intervals to spawn. Examples are salmon, some trout, shad, and striped bass.

Animal-unit An animal unit (AU) is one mature cow of approximately 1,000 pounds and a calf up to weaning, usually 6 months of age, or their equivalent.

Animal-unit-month The amount of forage required by an animal unit for 1 month.

Annual plant A plant that completes its life cycle and dies in 1 year or less.

Aquifer A geologic formation capable of transmitting water through its pores at a rate sufficient for water supply purposes. The term water-bearing is sometimes used synonymously with aquifer when a stratum furnishes water for a specific use. Aquifers are usually saturated sands, gravel, fractures, caverns, or vesicular rock.

Arid A term applies to regions or climates where lack of sufficient moisture severely limits growth and production of vegetation. The limits of precipitation vary considerably according to temperature conditions, with an upper annual limit for cool regions of 10 inches or less and for tropical regions as much as 15 to 20 inches.

AUM Abbr. For Animal-unit-month. (Usually no periods.)

Basal area The cross sectional area of the stem or stems of a plant or of all plants in a stand. Herbaceous and small woody plants are measured at or near the ground level; larger woody plants are measured at breast or other designated height. Syn. Basal cover.

Biochemical Oxygen Demand (BOD) The amount of oxygen required to decompose a given amount of organic compounds to simple, stable substances within a specified time at a specified temperature. BOD serves as a guide to indicate the degree of organic pollution in water.

Biological diversity The variety and variability of the world's organisms, the ecological complexes in which they occur, and the processes and life support services they mediate.

Biomass The total amount of living plants and animals above and/or below ground in an area at a given time.

Biota All living organisms of a region.

Bloom A readily visible concentrated growth or aggregation of plankton (plant and animal).

Browse (n) That part of a leaf and twig growth of shrubs, woody vines, and trees available for animal consumption. (v) Act of consuming browse.

Browse line A well-defined height to which browse has been removed by animals.

Brush Various species of shrubs or small trees usually considered undesirable for livestock or timber management. The same species may have value for browse, wildlife habitat, or watershed protection.

Brush management Manipulating woody plant cover to obtain desired quantities and types of woody cover and/or to reduce competition with herbaceous understory vegetation, in accordance with overall resource management objectives.

Bunch grass A grass so-called because of its characteristic growth habit of forming a bunch.

°C Degrees Celsius. Also known as degrees centigrade.

Canopy (1) The vertical projection downward of the aerial portion of vegetation, usually expressed as a percent of the ground so occupied. (2) A generic term referring to the aerial portion of vegetation.

Canopy cover The percentage of ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage of plants. Small openings within the canopy are included. Syn. Crown cover.

Cfs Cubic foot per second. The rate of discharge of a stream with a channel 1 square foot in a cross-sectional area and whose average velocity is 1 foot per second.

Chinook salmon A variety of Pacific salmon common to the Columbia River system that utilize tributary streams and the main channel of the Columbia and Snake for spawning and early stages of the life cycle.

Coliform Any of a number of organisms common to the intestinal tract of man and animals, used as an indicator of water pollution.

Community An assemblage of populations of plants and/or animals in a common spatial arrangement.

Community (plant community) An assemblage of plants occurring together at any point in time, while denoting no particular ecological status. A unit of vegetation.

Competition A process of struggling between or among organisms of the same species (intraspecific) or different species (interspecific) for light, water, essential elements, or space within a trophic level, resulting in a shortage of essential needs for some individuals or groups.

Confidence interval (95 percent) A calculated interval about the mean where a given mean monthly water temperature will fall with a probability of 95 times out of 100.

Consumptive use The amount of water used in such a way that it is no longer directly available. Includes water discharged into the air during industrial uses, or given off by plants as they grow (transpiration), or water which is retained in the plant tissues, or any use of water which prevents it from being directly available.

Continuous records Water-temperature records collected by (1) thermograph, (2) once-daily, or (3) twice-daily water-temperature observations.

Controlled burning Syn. Prescribed burning.

Cultivar (Derived from cultivated variety) A named variety selected within a plant species. Distinguished by any morphological, physiological, cytological, or chemical characteristics. A variety of plant produced and maintained by cultivation which is genetically retained through subsequent generations.

Cultivars (1) A variety, strain, or race of plant that has originated and persisted under cultivation or was specifically developed for use as a cultivated crop. (2) For cultivated crops, the equivalent of botanical variety, in accordance with the International Code of Nomenclature of Cultivated Plants – 1980.

Days of record The number of days water-temperature records are available for determination of monthly mean and extremes.

Debris Accumulated plant and animal remains.

Density (1) The number of individuals per unit area. (2) Refers to the relative closeness of individuals to one another.

Dissolved oxygen (DO) Amount of oxygen dissolved in water.

Diversion The physical act of removing water from a stream or other body of surface water.

Diversity A measure of the number of species and their relative abundance in a community.

Dominant (1) Plant species or species groups that, by means of their number, coverage, or size, have considerable influence or control upon the conditions of existence of associated species. (2) Those individual animals that, by their aggressive behavior or otherwise, determine the behavior of one or more animals resulting in the establishment of a social hierarchy.

Dormant (1) A living plant that is not actively growing aerial shoots. (2) A pesticide application made on crop plants that are not actively growing.

Drouth (drought) (1) A prolonged chronic shortage of water. (2) A period with below normal precipitation during which the soil water content is reduced to such an extent that plants suffer from lack of water; frequently associated with excessively high temperatures and winds during spring, summer, and fall in many parts of the world.

DWR California Department of Water Resources.

Ecology The study of the interrelationships of organisms with their environment.

Ecosystem An interacting system of organisms considered together with their environment; for example: watershed, wetland or lake ecosystems.

Ecotone A transition area of vegetation between two communities, having characteristics of both kinds of neighboring vegetation, as well as characteristics of its own. Varies in width depending on site and climatic factors.

Ecotype A locally adapted population within a species that has certain genetically determined characteristics; interbreeding between ecotypes is not restricted.

Edge effect (1) The influence of one adjoining plant community upon the margin of another affecting the composition and density of the populations. (2) The effect executed by adjoining communities on the population structure within the margin zone.

Effluent A discharge or emission of a liquid or gas, usually waste material.

Emission A discharge of pollutants into the atmosphere, usually as a result of burning or the operation of internal combustion engines.

Endangered species Any species which, as determined by the Fish and Wildlife Service, is in danger of extinction throughout all or a significant portion of its range other than a species of the class Insecta determined to constitute a pest whose protection would present an overwhelming and overriding risk to man.

Environment The sum of all external conditions that affect an organism or community to influence its development or existence.

Eradication (plant) Complete kill or removal of a noxious plant from an area, including all plant structures capable of sexual or vegetative reproduction.

Erosion The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. The following terms are used to describe different types of water erosion:

Gully erosion: The erosion process whereby water accumulates in narrow channels or depressions which are on an incline and, over short periods, removes the soil from this narrow area to considerable depths, ranging from 1 foot to as much as 100 feet.

Rill erosion: Wearing away of the earth's surface by water, ice or other natural agents under natural environmental conditions of climate, vegetation, etc., undisturbed by man.

Sheet erosion: The removal of a fairly uniform layer of soil from the land surface by runoff water.

Stream channel erosion: Lateral recessions of the stream banks and/or degradation of the streambed by stream flow action.

Erosion rate The amount or degree of wearing away of the land surface.

Escapement Adult fish that "escape" fishing gear to migrate upstream to spawning grounds.

Evapotranspiration The actual total loss of water by evaporation from soil, waterbodies, and transpiration from vegetation over a given area with time.

Exotic An organism or species that is not native to the region in which it is found.

Fauna The animal life of a region. A listing of animal species or a region.

Feral Escaped from cultivation or domestication and existing in the wild.

Fingerling A juvenile salmonid, generally the stage between dry and smolt. Roughly equivalent to a "parr".

Fish habitat An area in a stream or lake that is suitable for fish to live and which includes food, hiding cover, suitable water quantity and quality, spawning areas, etc.

Floodplain Nearly level land situated on one or both sides of a stream channel that is constructed by the stream in (historically) recent climate and overflow during moderate flow events. Lowland bordering a river, subject to flooding when stream overflows.

Flora (1) The plant species of an area. (2) A simple list of plant species or a taxonomic manual.

Fluvial Pertaining to or produced by the action of a stream or river.

Food-chain The dependence of organisms upon other in a series for food. The chain begins with plants scavenging organisms and ends wit the largest carnivores.

Forb Any broad-leafed herbaceous plant other than those in the Gramineae (or Poaceae), Cyperaceae, and Juncacea families.

Fry (sac fry or slevin) The stage in the life of a fish between the hatching of the egg and the absorption of the yolk sac. From this stage until they attain a length of one inch the young fish are considered advanced fry.

Ft Feet

Fuel Ladder Fuels which provide vertical continuity between strate. Fire is able to carry from ground, to surface, to crown.

Fuel moisture content The amount of water in a fuel, expressed as a percentage of the ovendry weight of that fuel.

Fuelbreak A strategically located block or strip on which existing flammable vegetation has been replaced by vegetation of lower fuel volume and/or flammability and subsequently maintained as an aid to fire control.

Fuels Any organic material, living or dead, in the ground, on the ground, or in the air, that will ignite and burn. General fuel groups are grass, brush, timber, and slash.

Gaging station A particular location on a stream, canal, lake, or reservoir where systematic measurements are made on the quantity of water flow.

Geographic Information System (GIS) A spatial type of information management system that provides for the entry, storage, manipulation, retrieval, and display of spatially oriented data.

Geomorphic Of or pertaining to the shape of the earth's surface features. Called fluvial geomorphology when describing the shape of a channel.

Ground water Water in the ground lying in the zone of saturation. Natural recharge includes water added by rainfall, flowing through pores or small openings in the soil into the water table.

Growing season That portion of the year when temperature and moisture permit plant growth.

Habitat The environment that is needed to support an individual plant or animal or a population or community of plants and animals. It must supply food, water, shelter and reproductive amenities.

Habitat type The collective area which one plant association occupies. The habitat type is defined and described on the basis of the vegetation and its associated environment.

Heavy metals A group that includes all metallic elements with atomic numbers greater than 20, the most familiar of which are chromium, manganese, iron, cobalt, nickel, copper and zinc but that also includes arsenic, selenium, silver, cadmium, tin, antimony, mercury, and lead, among others.

Herb Any flowering plant except those developing persistent woody stems above the ground.

Herbicide A chemical used to kill or inhibit the growth of plants.

Historic climax plant community The plant community that was best adapted to the unique combination of factors associated with the ecological site. It was in a natural dynamic equilibrium with the historic biotic, abiotic, climatic factors on its ecological site in North America at the time of European immigration and settlement.

Holdovers Fish that take up residence in reservoirs rather than completing migration to the sea; may complete migration the following year.

Hydrologic cycle The continual exchange of moisture between the earth and the atmosphere, consisting of evaporation, condensation, precipitation (rain or snow), stream runoff, absorption into the soil, and evaporation in repeating cycles.

Indicator species (1) Species that indicate the presence of certain environmental conditions, range condition, previous treatment, or soil type. (2) One or more plant species selected to indicate a certain level of grazing use.

Indigenous Born, growing, or produced naturally (native) in an area, region, or country.

Infestation Invasion by large numbers of parasites or pests.

Infiltration The intake of water into the soil profile. It connotes flow into a substance in contradistinction to the word percolation.

Infiltration rate Maximum rate at which soil under specified conditions can absorb rain or shallow impounded water, expressed in quantity of water absorbed by the soil per unit of time; e.g., inches per hour.

Instream structure Features such as logs, rocks, and root wads that create pools and provide resting and hiding areas for fish and their food supply.

Integrated pest management Controlling pest populations using a combination of proven methods that achieve the proper level of control of them while minimizing harm to other organisms in the ecosystem. Control methods include natural suppression, biological control, resistance breeding, cultural control, and direct control.

Introduced species A species not a part of the original fauna or flora of the area in question.

Invasion The migration of organisms from one area to another area and their establishment in the latter.

Land use class (GLA) The classification of land based on the primary use and associated management practices (i.e., rangeland, pastureland, hayland, native pastureland).

Lenitic or lentic environment Standing wter and its various intergrades, as lakes, ponds and swamps.

Limnetic zone The open-water region of a lake.

Littoral zone The shoreward region of a body of water.

Loess Material transported and deposited by wind and consisting of predominantly silt-sized particles.

Lotic environment Running waters, as streams or rivers.

Maintenance burning The use of prescribed burning to maintain vegetation in a desired condition or to maintain the desired composition. Most often used to reduce woody species.

Multiple use Use of land for more than one purpose; i.e., grazing of livestock, wildlife production, recreation, watershed, and timber production. Not necessarily the combination of uses that will yield the highest economic return or greatest unit output.

Noxious species A plant species that is undesirable because it conflicts, restricts, or otherwise causes problems under management objectives. Not to be confused with species declared noxious by laws concerned with plants that are weedy in cultivated crops and on range.

Noxious weed An unwanted plant specified by Federal or State laws as being especially undesirable, troublesome, and difficult to control. It grows and spreads in places where it interferes with the growth and production of the desired crop.

Open range (1) Rangeland that has not been fenced into management units. (2) All suitable rangeland of an area upon which grazing is permitted. (3) Untimbered rangeland. (4) Rangeland on which the livestock owner has unlimited access without benefit of land ownership or leasing.

Overstory The upper canopy or canopies of plants. Usually refers to trees, tall shrubs, and vines.

Oxygen-debt A phenomenon that occurs in an organism when available oxygen is inadequate to supply the respiratory demand. During such a period the metabolic processes result in the accumulation of breakdown products that are not oxidized until sufficient oxygen becomes available.

Palatability The relish with which a particular species or plant part is consumed by an animal.

Perennial plant A plant that has a life span of 3 or more years.

Periodic records Water-temperature data obtained on an irregular basis and less frequently than continuous records.

Prescribed burning The burning of forest or range fuels on a specific area under predetermined conditions so that the fire is confined to that area to fulfill silvicultural, wildlife management, sanitary or hazard reduction requirements, or otherwise achieve forestry or range objectives.

Public waters All waters not previously appropriated.

Range management systems Grazing systems applied on rangeland.

Rangeland Land on which the native vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs, or shrubs suitable for grazing or browsing use. Includes lands revegetated naturally or artificially to provide a forage cover that is managed like native vegetation. Rangelands include natural grassland, savannas, shrublands, most deserts, tundra, alpine communities, coastal marshes, and wet meadows.

Rearing habitat Living area for juvenile fish.

Redd A spawning nest, containing incubating eggs, made in the gravel bed of a stream or lake by a fish.

Resident fish Non-migratory fish such as certain trout, dace and sculpin.

Resident species Species common to an area without distinction as to being native or introduced.

Revegetation Establishing or re-establishing desirable plants in areas where the plant community is not adequate to meet management objectives by management techniques alone.

Rhizome A horizontal underground stem that usually sends out roots and aboveground shoots from the nodes.

Riparian Area, zone, and/or habitat adjacent to streams, lakes, or other natural free water, which have a predominant influence on associated vegetation or biotic communities.

Riparian ecosystems Ecosystems that occur along watercourses or waterbodies. They are distinctly different from the surrounding lands because of unique soil and vegetation characteristics that are strongly influenced by free or unbound water in the soil.

Riparian vegetation A water-influenced plant community; water-loving plants along streambanks such as willows and cottonwoods.

River basin The area drained by a river and its tributaries.

Run A group of fish that ascend a river to spawn.

Runoff That part of precipitation that appears in surface streams. This is the streamflow before it is affected by artificial diversion, reservoirs, or other man-made changes in or on stream channels. Usually expressed in acre-feet of water yield.

Salmonids Trout, salmon, chars, whitefish, and grayling.

Sediment Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

Sediment yield The sediment discharge from a unit of drainage area, generally expressed in tons per square mile of acre.

Seral Refers to species or communities that are eventually replaced by other species or communities within a sere.

Seral stages The developmental stages of an ecological succession.

Sere All temporary communities in a successional sequence.

Shaded fuelbreak A wide strip or block of land on which the vegetation has been modified by reducing the amount of fuel available, rearranging fuels so that they do not carry fire easily, and replacing particularly flammable fuels with others that ignite less easily and burn less intensely.

Silt (1) A soil consisting of particles between 0.05 and 0.002 milimeter in equivalent diameter or (2) a class of soil texture.

Silt loam A soil texture class containing a large amount of silt and small quantities of sand and clay.

Silty clay A soil texture class containing a relatively large amount of silt and clay and a small amount of sand.

Smolt The life stage of anadromous fish during which physiological changes prepare it for transition from freshwater to marine life; generally occurs at onset of active downstream migration.

Spawning beds Areas within a stream or lake containing clean gravel in which fish deposit eggs to complete their embryonic development.

Species composition The proportions of various plant species in relation to the total on a given area. It may be expressed in terms of cover, density, weight, etc.

Sq mi Square mile.

Stream glide That area of the water column that does not form distinguishable pools, riffles, or runs because it is usually too shallow to be a pool and too slow to be a run. Water surface gradient over the glide is nearly zero.

Stream reach A length of stream channel selected for use in hydraulic computations or for comparison of all of its attributes with other reaches.

Stream riffle Riffles are portions of the water column where water velocity is fast, stream depths are relatively shallow, and water surface gradient is relatively steep. Channel profile is usually straight to convex. Fish expend high amounts of energy in riffles to maintain position.

Stream system A stream and its tributaries into which water within the confines of a watershed will drain.

Succession The progressive replacement of plant communities on an ecological site that leads to the climax plant community. Primary succession entails simultaneous successions of soil from parent material and vegetation. Secondary succession occurs following disturbances on sites that previously supported vegetation, and entails plant succession on a more nature soil.

Surface fire A fire that burns surface litter, debris, and small vegetation.

Temperature station A site on a stream or drainage ditch where water-temperature records are obtained.

Topography The relative positions and elevations of the natural or man-made features of an area that describe the configuration of its surface.

Topsoil The surface plow layer of a soil; also called surface soil. The original or present dark-colored upper soild that ranges from a mere fraction of an inch to two or three feet thick. The original or present “A horizon”, varying widely among different kidns of soil. Applied to soils in the field, the term has no precise meaning unless defined as to its depth or the productivity in relation to a specific kind of soil.

Understory Plants growing beneath the canopy of other plants. Usually refers to grasses, forbs, and low shrubs under a tree or shrub canopy.

Upland areas The higher part of a region or tract of land; generally described as everything higher than the floodplain or water body; similarly: inland country, upcountry.

Urban area An area predominantly occupied by manmade structures: the Bureau of Census defines communities of over 2,500 as urban areas.

Vegetation type A kind of existing plant community with distinguishable characteristics in terms of the present vegetation that dominates the aspect of physiognomy of the area.

Vegetative management practices Practices that are directly concerned with the use and growth of plants. These include such practices as prescribed grazing and livestock exclusion.

Water quality The chemical, physical and biological condition of water related to beneficial use.

Water year A year begins October 1 and ends September 30. For example, water year 2967 begins October 1, 1966, and ends September 30, 1967.

Watershed (1) A total area of land above a given point on a waterway that contributes runoff water to the flow at that point. (2) A major subdivision of a drainage basin.

Watershed area All land and water within the confines of a drainage divide. Also, a water "problem area" consisting in whole, or in part, of land needing drainage or irrigation.

Weed (1) Any growing unwanted plant. (2) A plant having a negative value within a given management system.

Wetland Land where water on or near the soil surface is the dominant factor determining the types of plant and animal communities living in the soil or on its surface.

Wildlife Undomesticated animals (does not include feral animals), generally assumed to be living in their natural habitat.

Xeric Having very little moisture; tolerating or adapted to dry conditions.

Zoning (rural) A means by which governmental authority is used to promote a specific use of land; under certain circumstances. This power traditionally resides in the state, and the power to regulate land uses by zoning is usually delegated to minor units of government, such as towns, municipalities, and counties, through an enabling act that specified powers granted and the conditions under which these are to be exercised.