***** PLEASE NOTE *****

This document has 3 other documents associated with it.

This is the main text for the Shasta West Watershed Assessment and excludes the following pages:

A. All Figures
B. Appendices in Sections 4, 6, 8, and 9

All Figures are available as the following TWO documents:

1. "**ShastaWest_WA_Jun05_SecA-4_Figures**" for Sections 1 thru 4 Figures.
2. "**ShastaWest_WA_Jun05_Sec5-9_Figures**" for Sections 5 thru 9 Figures.

Appendices for Sections 4, 6, 8, and 9 are available in the following document:

1. "**ShastaWest_WA_Jun05_Appendices**"

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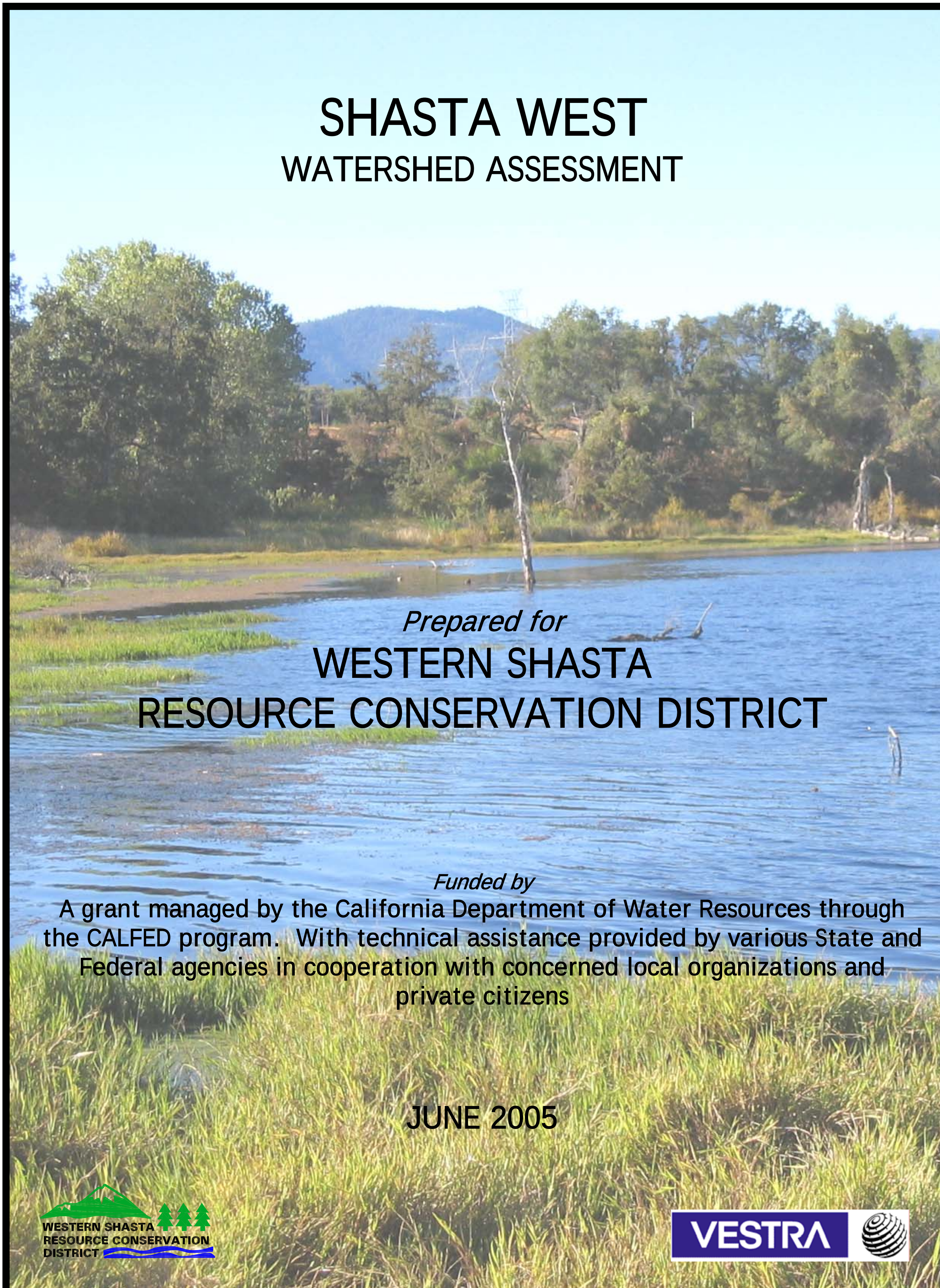

SHASTA WEST
WATERSHED ASSESSMENT

Prepared for

WESTERN SHASTA RESOURCE CONSERVATION DISTRICT

Funded by

A grant managed by the California Department of Water Resources through the CALFED program. With technical assistance provided by various State and Federal agencies in cooperation with concerned local organizations and private citizens

JUNE 2005

WESTERN SHASTA RESOURCE CONSERVATION DISTRICT

VESTRA

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VESTRA

JUNE 2005

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OBJECTIVE

The primary objective of the Shasta West Watershed Assessment Project is to gather and document readily available data on the physical, cultural, and demographic variables that characterize the Shasta West Watershed at the present and in the past, so that a solid framework can be established for the watershed. This framework will provide a means by which the watershed can be understood as an ecological system and will allow interested parties to understand the processes and interactions that occur within its boundaries. Of particular importance in the Shasta West Watershed is the human element and how humans have impacted and continue to impact the watershed's natural resources including fish, wildlife, and water quality, and other physical, chemical, and demographic characteristics. The project is primarily an existing conditions report that will be used as an educational tool to help guide residents and stakeholders in prioritizing future watershed projects within the watershed. This watershed assessment can be considered the initial step in developing our knowledge of the existing conditions within the Shasta West Watershed ecosystem. It will be amended and extended as new information becomes available.

SCOPE

Information collected from previous studies has been organized according to a five-step process consistent with the goal of the CALFED Watershed Program to promote collaboration and integration among community-based watershed efforts. This watershed assessment is intended to assist the efforts of the Shasta West Watershed Group in maintaining a viable stakeholder-driven means for assessing and implementing watershed-based projects and management. The basic approach to data collection and organization includes:

Step 1 – Characterization of the watershed
Step 2 – Description of current conditions
Step 3 – Description of reference (historical) conditions
Step 4 – Synthesis of information
Step 5 – Conclusions and recommendations

Information collected and organized in this watershed assessment has been developed in collaboration with the Shasta West Technical Advisory Committee.

FUNDING SOURCES

The watershed assessment project is funded through a California Department of Water Resources grant from the CALFED California Bay-Delta Authority Watershed Program. Many other contributions from state, federal, and private sources have made this assessment possible.

TECHNICAL ADVISORY COMMITTEE (TAC)

The Shasta West Watershed TAC members are made up of Western Shasta Resource Conservation District (WSRCD) staff and specialists from cooperating agencies. TAC members provided information and technical review for this project.

TAC Members include:

Glen Miller – United States Bureau of Land Management
Kathleen Schori – California Department of Forestry & Fire Protection
Steve Baumgartner – California Department of Fish and Game
Patricia Bratcher – California Department of Fish and Game
Eda Eggeman – California Department of Fish and Game
Fraser Sime – California Department of Water Resources
Terry Hanson – City of Redding
Lee Bunnell – California Native Plant Society
Ron Clementsen – United States Fish and Wildlife Service
Jack Williamson – United States Fish and Wildlife Service
Jerry Comingdeer – Landowner
Don and Heidi Weidlein – Landowner
Jack William – Landowner
Susan Weale – Landowner, Friends of Canyon Creek
Steve Femmel – Whiskeytown National Recreation Area
Carl Weidert – Pacific Advisory Committee
Beth Doolittle-Norby – California Regional Water Quality Control Board
J.R. Kaufman – Shasta Community Services District
John Stokes – Shasta County
Irwin Fust – Shasta County Board of Supervisors
Rayola Pratt – Shasta Services Guild
Brian Sindt – The McConnell Foundation
Craig Bailey – The Wildlife Society
Bob Carey – The Wildlife Society
Mike Grifantini – The Wildlife Society
Gary Nakamura – U.C. Extension
Gretchen Ring – Whiskeytown National Recreation Area
Bill Oliver – Wintu Audubon Society
Jack Bramhall – Western Shasta Resource Conservation District
Leslie Bryan – Western Shasta Resource Conservation District
Shiloe Braxton – Western Shasta Resource Conservation District

BACKGROUND

The WSRCD found the need to provide a comprehensive evaluation of environmental conditions within the hydrologic unit of the Shasta West Watershed. The Shasta West Watershed is considered a Category I Priority Watershed in the California Unified Watershed Assessment.

Watersheds with Category I status meet one or more of the following criteria:

1. Contains waterbodies listed as having impaired beneficial uses
2. Watershed identified by local groups as needing improvements
3. Watersheds with very high wildfire or fuel hazards, potential
4. Watersheds with proposed and listed aquatic and wetland threatened and endangered species
5. Watersheds with impairments in the quality of aquatic and riparian systems, as determined by the California Rivers Assessment professional judgment assessment
6. Watersheds with streams or riparian areas identified as not functioning or functioning at risk, from the Proper Functioning Condition Assessment (PFC) in California Rivers Assessment

DATA SOURCES

Data sources used to assemble the Shasta West Watershed Assessment come from federal, state, and local sources. Where possible, data sources are based primarily on published material; however, a significant amount of data is not available for this watershed. Both previously unavailable data such as academic thesis and reports prepared for planned developments as well as anecdotal observations were incorporated into the document, with TAC concurrence. Agencies responsible for providing available data include, but are not limited to, Department of Water Resources, Regional Water Quality Control Board, State Water Resources Control Board, Bureau of Land Management, United States Geological Survey, City of Redding, California Department of Fish and Game, Natural Resources Conservation Service, California Department of Forestry and Fire Protection, and the National Park Service.

Very limited data is available on the sub-watershed scale, therefore it has been difficult to develop and present information by sub-watershed. Sub-watersheds in the report are included in Table A-1.

Data available for the smaller creeks is limited and if a creek is not discussed, there was no data available.

PROJECT LOCATION

The Shasta West Watershed is located in Shasta County near Redding, California. The watershed includes Southwest Redding and Shasta County from the Redding city limits to Whiskeytown. The watershed includes sub-basins in Table A-1. A general location map is included as Figure A-1. A watershed boundary map is included as Figure A-2.

Table A-1 SUB-WATERSHEDS			
Sub-Watershed	**Tributary Length (miles)**	**Acres**	**Percent**
Oregon Gulch	5	2,538	8.4
Canyon Creek	3	2,118	7.1
Olney Creek	8	9,368	32.3
Middle Creek	4	2,837	9.5
Salt Creek	3	2,780	9.3
Jenny Creek	2	1,218	4.1
Rock Creek	4	4,163	14.5
Calaboose Creek	-	635	2.1
Redding Tributaries	-	2,906	10.3
Linden Channel	2	717	2.4
Total	**29**	**29,931**	**100**
Note: Sub-watershed boundaries were delineated using USGS topographic map and City of Redding GIS coverage. Areas were calculated using GIS.			

WATERSHED CHARACTERIZATION

Ownership

General ownership within the watershed is shown in Figure A-3. Land ownership in the Shasta West Watershed is approximately 20 percent public and 80 percent private. The number of acres in each ownership classification is shown in Table A-2.

Table A-2 LAND OWNERSHIP IN THE SHASTA WEST WATERSHED		
Ownership	**Total Acres**	**Percent**
Bureau of Reclamation	258	<1
National Park Service	700	2
Bureau of Land Management	4,062	14
Private	24,911	83
Total	**29,931**	**100**

Topography

The Shasta West Watershed encompasses approximately 30,000 acres. The slope gradient and aspect of the watershed vary significantly. A large portion of the watershed is part of the Sacramento Valley floor. The diverse watershed contains plutonic intrusions, meta-volcanics, and marine and non-marine sedimentary rocks of which can be roughly divided into three general north-south trending geologic belts of equal size: the western plutonic belt, central meta-volcanic belt, and the eastern non-marine sedimentary belt.

Elevation

The average elevation of the watershed is just below 600 feet above mean sea level (msl), with the surrounding mountains, including Mule Mountain, climbing 2,300 feet above msl. The town with the largest population, Redding, sits at approximately 550 above msl. Watershed topography with elevation bands is included as Figure A-4. A summary of USGS quadrangle maps within the watershed is included as Table A-3. The slope gradient and aspect within the watershed (Figure A-5) vary significantly, but the area within the City of Redding city limits is comparatively flat with a zero to ten percent slope.

Table A-3
SHASTA WEST WATERSHED
USGS 7.5 MINUTE QUADRANGLES

Igo	Redding	Enterprise
Whiskeytown	Shasta Dam	

CITIZEN ISSUES OF CONCERN

The WSRCD held public meetings to inform citizens of the watershed assessment project and to solicit input and concerns from property owners and other interested parties. Appendix A-A contains a consolidated list of the issues and concerns raised at these meetings.

ISSUES IDENTIFIED AND ACTION ITEMS

Appendix A-B contains a list of conclusions, recommendations, and action items developed during the assessment process to address citizen issues of concern listed in Appendix A- A.

GLOSSARY

A glossary of technical terms used in this document is included as Appendix A-C to assist the reader in understanding the technical sections.

Appendix A-A

Citizens' Issues of Concern

Citizens Comments and Concerns Regarding the Shasta West Watershed through May 26, 2004

Early in the watershed assessment a handout was produced to solicit public comments and concerns about the watershed assessment. The handout titled "Shasta West Watershed and You" asked the public three questions, 1. What do you value about living in the watershed? 2. What is your vision of this region 20 years from now? And 3. What actions do you think are necessary to achive that vision? Listed below is the citizens response to these questions.

Date	Area/Location	Comments	What is valued in the watershed	Vision	Actions necessary to achieve vision
6/18/03	Olney Creek, Sacramento Drive, near Allen's Golf Course	Creeks are one of Redding's most precious resources. Grew up enjoying the creek, and as a kid, fished in Olney. Has seen many changes to the system. One year, possibly 1985, saw pools full of steelhead. Not so now. In drought years, the ACID Canal leaks and feeds Olney Creek. Feels it is OK to leave the dams leaks.	Looking at the creek is an important part of life	Area is being developed	Protection
6/19/03	Rock Creek	Fish Barrier on old railroad bridge which is now part of the River Trail		Anadromous fish in creeks	Removal or correction of fish barriers, restore first 50' Rock Creek
6/20/03	Tadpole Creek	Development is occurring. Vegetation overgrowth, mysterious foam in creek during winter, soil erosion around bridge on her road. Has observed beaver, crawdads, and turtles. Daughter found arrowheads on her property.			
6/20/03	Throughout watershed	Developers including individual people are removing the large older trees in the watershed. Have no regard to age diversity.	Diversity of plants (species size and age) and animals	Protect, maintain, and restore native habitats	Planned "smart" growth, substantial native plant ordinance in City and County
6/20/03	Olney Creek, E of ACID Canal, owns approx. 1400 ft. of property on north side of Olney	Transients in area, trespassing problems. Has pulled out approximately 3000 lbs. trash, still has approximately 2000 lbs. concrete to remove. Is actively restoring his property by planting natives, and installing bird nest boxes.	Values native plants and animals, especially birds	Restored system	Limiting access to creek, restoration
6/20/03	Various creeks in the watershed				Fish passage restoration, public education
6/24/03, 7/03/03	Olney Creek, Plateau Circle	6/24/03 - Has neighbor that works on and stores cars. Neighbor spilled a couple gallons of gasoline which created air and water pollution. Neighbor tried to wash it away with garden hose, water makes it into Olney Creek. Spoke to County that responded that this kind of thing is common in the county. Fears	This is a sensational area with beautiful lakes, river, and forests	Public values and cares for the natural resources of the area	Targeted education on watershed systems, pollution etc.

		neighbors take their trash to a ranch in Shasta County for disposal rather than landfill. 7/03/03 – Neighborhood wetland is being impacted by dumped soil and teenagers riding various vehicles through it			
6/25/03, 7/02/03	Canyon Creek	Resident 18 years. Seen much development. Very concerned with developers not protecting creek system. 7/02/03 – Feels development is quickly changing the area by eliminating native vegetation and making the area uninhabitable for native fauna	Wildlife, quiet		
7/9/03	Olney Creek	Concerned about the illegal dumping that occurs i.e. vehicles, appliances, trash. Concerned horse riding trails are being closed. Feels it is due to the property owners wanting to stop access to ORV's. Wonders if a section of vegetation naturally or because of mining, or other causes	Values horse riding opportunities	Riding trails without trash	Clean up
7/10/03	Mary Lake area	Concerned with amphibian decline (has heard less toads/frogs in recent years), also herbicide and pesticide use			education
7/18/03	Watershed wide	Native vegetation is being replaced by non-natives	Uniqueness of area	Uniqueness of area	Retention of natural slope and vegetation as part of development requirements
	Watershed wide	Traffic increasing			
8/12/03	Watershed wide	Developers changing natural contours of land, everything looks the same after they are finished, losing the rural feel			
9/19/03	Oregon gulch	Concerned about losing open space, too much government regulation	Rural, open spaces		
9/28/03	Watershed wide	Rural qualities are being lost to development	Open space		
9/28/03	Watershed wide	Natural plant species being lost to non-native landscape plants			
9/28/03	Rock Creek	Fire danger, invasive species concerns			
9/28/03	Middle Creek	Invasive species concerns			
10/02/03	Watershed wide, urban creeks	Trash in open areas, creeks underground and forgotten		Clean spaces, open and appreciated creeks	
10/25/03	Watershed wide	Loves the outdoors	Birds, frogs, trees and flowers		Learn and protect

11/13/03	Watershed wide	Creeks not able to be seen in urban area			Daylight creeks
11/13/03	Watershed wide	Population increasing rapidly and greatly			Smart growth
11/13/03	Watershed wide	Fire danger			Reduce heavy fuel loads, education of landowners
11/13/03	Rock Creek	Fire danger			Reduce heavy fuel loads, education of landowners
2/28/04	Watershed wide	Fire danger, concerns about development			Smart growth
2/28/04	Watershed wide	Development	Rural, open spaces		Planned growth
2/28/04	Middle Creek	Fire danger			
2/28/04	Salt Creek	Fire danger			
2/28/04	Watershed wide	Much development is occurring quickly	Natural look and feel		Retention of natives and strategic land use
3/27/04	Watershed wide	Trash	Rural, open spaces		Education, enforcement
3/27/04	Oregon Gulch	Trash, fire danger, ORV use creating erosion and wildlife habitat degradation			Education, enforcement
3/27/04	Watershed wide	Urban sprawl	Rural open spaces, wildlife	A community that values the natural world as being important to quality of life	Planned growth to include wildlife corridors, native vegetation retention, education on how to live with wildlife

Appendix A-B

Summary of Issues Identified and Action Items

Appendix B

ISSUES IDENTIFIED AND ACTION ITEMS

SECTION A: INTRODUCTION

SECTION 1: GENERAL WATERSHED HISTORY

Action Items

Identify which creeks were mined.

SECTION 2: GEOLOGY AND SOILS

Issues Identified

Primary geological issue is erosion and sedimentation. This risk of erosion is greatly compounded by modifications of steep slopes and recreational uses such as OHV use. With sandy erosion prone soils, fine sediment, deposited in streams, may fill pore spaces of stream gravels used by spawning fish and benthic organisms.

Data Gaps

A detailed road inventory is needed to identify stream crossings, culverts, road types, and road maintenance issues in the watershed.

Action Items

Perform an erosion potential analysis by comparing the newly developed GIS soils layers produced by the NRCS and combine it with a topographic slope layer generated by 30 meter digital elevation models developed by the USGS. Using this map as a guide, develop or review BMP's for areas identified as having high erosion potential.

Perform a road inventory and analysis that surveys culverts, stream crossings, road design, construction, and type of road use.

SECTION 3: HYDROLOGY

Issues Identified

A concern in the Shasta West Watershed Assessment is that stream assessments in the assessment document were made by visual observations without the use of quality surveys.

Many of the Shasta West streams flow through urban areas and have been modified from their original conditions.

Data Gaps

There is a lack of data on the channel morphology characteristics outside of the City of Redding boundaries such as stream channel width, depth, slope, roughness of the channel materials, stream discharge and velocity, and sediment load and sediment size.

There is a lack of stream classification and stream prioritization in the watershed.

Low-flow stream flow data is unavailable and is needed to estimate the dependability of water supplies for fisheries and wildlife.

Incomplete information is known on the ecological effects of the ACID canal and its influence on the streams of the watershed

In the watershed, there is a lack of information on urban sub-surface stream locations that might produce opportunities for stream restoration efforts such as "daylighting".

Action Items

Survey the watershed using remote sensing or physical surveys and establish baseline geomorphic information and basic data such as stream channel slope and stream channel types and composition.

Classify streams according to the Rosgen stream classification system to develop basic knowledge of stream behavior, hydraulic and sediment relations, and to provide a consistent and reproducible frame of reference for communication by natural resource planners working with the Shasta West streams in a variety of disciplines.

Work with agencies and landowners to develop a stream monitoring program that includes installing and monitoring stream gauges on priority streams in the watershed in order to determine flow regimes.

Survey sub-surface stream sections to produce GIS layers and work with the City and County planners to investigate opportunities for stream daylighting.

Collaborate with Anderson Cottonwood Irrigation District to investigate the effects of the ACID canal upon the ecosystem and stream conditions in the watershed.

Work with the City of Redding to obtain data from the city's hydrology model and FEMA flood mapping models for streams in the watershed for a future update of the Shasta West Watershed Assessment.

SECTION 4: WATER QUALITY

Issues Identified

Sediment problems in Middle Creek were identified in the 1993 Erosion and Sediment Control Study, Middle Creek Watershed, but as long term solutions to address the problem of sediment delivery to the Sacramento River.

BMP's for water quality need to be reviewed and updated for the watershed.

Since 1890, urbanization and major channel modifications has elevated the number of low permeable surfaces resulting in increased stream flow and further stream channel modifications.

Improper refuse disposal in the western limits of the watershed needs to be addressed.

Water quality in all of the streams in the watershed show signs of being impacted by stormwater runoff and recreational activities such as illegal OHV use.

Existing water quality data is not readily accessible for resource planning.

Data Gaps

The watershed lacks comprehensive water quality data such as suspended sediment concentrations, water temperature, level of dissolved oxygen and biological oxygen demand, pH, acidity, alkalinity, specific conductance, turbidity and dissolved chemical constituents

The watershed lacks comprehensive data on groundwater levels.

Need to develop data on the effects of OHV use on water quality in the watershed.

Action Items

Work with agencies to develop a water quality monitoring program to gather baseline data for the priority streams of the watershed.

Work with agencies, landowners and organizations to assess and develop long term solutions for a sediment reduction program for the Middle Creek sub-watershed.

Assess the effects of stormwater runoff and non-point source pollution upon streams in the watershed after collecting baseline water quality data for priority streams identified in a water quality monitoring program.

Collaborate with DWR to process water quality data that is in hardcopy format into an easily accessible electronic format.

Collaborate with agencies to research and update BMP's regarding development and permeability issues.

Collaborate with agencies and landowners to monitor key OHV use areas to determine the effects upon water quality.

Collaborate between the City and County to provide a monitored OHV area, close to the city population, for legal OHV use in order to reduce the environmental impacts from illegal OHV use.

Work with landowners and agencies to implement a groundwater monitoring program to determine the level of ground water and the recharge rate to the underground aquifers.

Collaborate with landowners and agencies to perform a stream function analysis on the priority streams in the watershed to determine stream health in the watershed ecosystem.

SECTION 5: BOTANICAL RESOURCES

Issues Identified

Urban development is increasing in riparian areas of the watershed that can lead to a reduction of biodiversity.

Invasive non-native plants are a major issue in the watershed with a special concern for the spread of A-rated noxious weeds.

There is a need to improve knowledge of native species compositions and the problem with invasive exotic weeds replacing native communities in riparian areas.

Wetlands are a source of biodiversity and are under pressure from urbanization in the watershed.

Urban developments in the wildland interface may lack the knowledge about the effects of introducing non-native botanical species.

Description and assessment of vegetative communities in the watershed is limited by the quality of the vegetation mapping available. For the assessment LCCMMP imagery was insufficient for assessing riparian vegetation and wetland areas in the watershed and the accuracy of imagery was uncertain for differentiating the variety of hardwood types.

There are unknown effects of suburban and semi-rural development on native vegetative communities.

Historical copper smelting has changed the biodiversity in the watershed.

Data Gaps

Lack of data on types and rates of spread for invasive weeds.

Lack of high resolution vegetation typing data for the watershed.

Lack of floristic surveys that contain information about exotic invasive plants along watershed streams except for Salt and Canyon Creeks.

The amount and extent of wetland areas in the watershed are not known.

Lack of data on urban vegetation and the effects of urban development, such as fragmentation, on vegetative communities.

Insufficient information for a systematic assessment of botanical resources at the scale of all sub-watersheds.

Lack of data on Blue Oak growth and regeneration in the watershed.

There is little known data on the continuing effects of historical copper smelting activities in the region.

Action Items

Work with agencies to perform an invasive weed inventory and develop a GIS database to map known occurrences and control actions for CDFA and CalEPC A-listed weeds to track and estimate the rate of spread in the watershed. Gathered data should be used in conjunction with data from adjacent watersheds to gain knowledge on the spread of invasive weeds in the region.

Collaborate with agencies and organizations involved in the control of invasive plants to coordinate weed control efforts.

Acquire and analyze recent color aerial photographs for the watershed, verified by field investigation. This would be useful for assessing the extent and quality of the valley foothill riparian CWHR vegetation community and addressing uncertainty from the LCMMP mapping in regard to the various hardwoods and deciduous tree life forms.

Obtain historical and current aerial photographs and conduct a time-series analysis of aerial photographs in order to assess fragmentation of native vegetation communities. This type of analysis could also produce a rate of habitat fragmentation for the watershed.

Work with landowners and agencies to encourage the retention of riparian buffer zones to (1) maintain and/or enhance native riparian habitat, (2) benefit fish, wildlife, and native plant species, (3) provide buffering benefits to reduce the effects of stormwater runoff, siltation, and chemicals entering the watercourse and (4) to reduce potential damage from flooding.

Work with landowners to further analyze floristic surveys already conducted along Salt and Canyon Creeks. Consider undertaking similar surveys along other priority streams.

Work with landowners to survey wetlands and identify their interaction with streams and adjoining plan communities.

Collaborate with agencies to explore mechanisms for retaining and regenerating oak species. Pursue available funding for oak management.

Work with agencies to further the investigation of the long-term effects of copper smelting on the soil and vegetative conditions in the watershed.

SECTION 6: FISH AND WILDLIFE RESOURCES

Issues Identified

Vegetation typing and LCMMP imagery is insufficient for assessing the quality and quantity of wildlife habitats.

Native habitat is being reduced and fragmented by urban development.

There is a need to review BMP's in providing wildlife habitat parameters and species needs.

Mountain lion occurrences within the watershed can lead to conflicts with residences within the urban-interface habitat of the watershed.

The rate and pattern of urban and semi-rural development and its effects on wildlife habitat and populations have not been fully explored. In particular the impact of wildlife movement barriers, road kill, urban animal predation, on watershed wildlife and populations is unclear.

The viability of the upper reaches of streams for spawning and the successful emigration of newly hatched juvenile salmonids is unclear.

Existing riparian corridors and refugia habitats are under urban development pressures.

Deer population and health are effected by rural development.

Information on wildlife species were based mainly on CWHR modeling. No survey data was collected for the assessment to confirm the actual occurrences of different wildlife species in the watershed.

There is a need for better mapping of the terrestrial habitats and the pattern and rate of urban/semi-rural development.

Data Gaps

There is little data on mountain lion populations occurring in the watershed.

There is incomplete data on the viability of the upper reaches of the streams in the watershed to support spawning and juvenile salmonids.

Lack of data on the effects of the various types of recreation such as, but not limited to, bike riding, OHV use, horseback riding, swimming, fishing and hunting on fish and wildlife populations and habitat.

Lack of quality mapping of urban development, wildland habitat, riparian corridors and refugia habitat to define the urban-interface, rates of fragmentation and opportunities for conservation.

Data is lacking on the impacts and rate of impact on wildlife and birds from urban animal species such as cats, dogs and other domesticated animals.

Data is lacking on the impacts and rate of impact on wildlife and birds from predatory animals such as raccoons, fox, coyotes and other small predatory species.

Action Items

Work with the city and county to review and develop BMP's that retain open spaces areas for the needs of species that require certain stand sizes of habitat.

Work with the city and county to explore the use and/or development of incentive programs for landowners to retain and maintain native habitats.

Use developed educational materials and outreach programs to inform rural residences on the risk of living in Mountain Lion habitat.

Work with agencies to determine the viability of the upper reaches of the streams in the watershed to support juvenile salmonids.

Collaborate with agencies and educate the public on the effects of various forms of recreation on the fish and wildlife populations and habitat. Develop a plan to provide for recreation in a way that minimizes impacts on fish and wildlife species.

Collaborate with the city and county to develop a GIS database that can track urban development and wildlife habitats in the watershed.

Work with agencies and organizations to develop a wildlife monitoring program.

Evaluate habitat using the Guild approach or other comparable scientific method to prioritize habitat restoration and protection efforts. Information gathered could be used to link the habitats of the Shasta West watershed to other adjacent watershed habitat types after the development of a high quality vegetation map of the watershed.
Develop educational materials and outreach programs about the function and importance of fish and wildlife species and the idea of biodiversity for the watershed. Included in the materials should be education on the effects of domestic animals such as cats and dogs and escaped exotic pets on biodiversity and the watershed.

SECTION 7: LAND USE AND DEMOGRAPHICS

Issues Identified

Residential development on steep slopes and the use of open space easements as mitigation for developments on steep slopes in excess of 20%.

Residence of the watershed need to be informed on the effects of illegal refuse disposal in the watershed.

There is a lack of a consolidated recreation development plan for the watershed.

Federal Management Plans are not subject to local general plans or zoning ordinances. The practice of selling off BLM owned property for residential development in order to purchase areas of higher habitat value.

Unknown effects of power transmission lines and the associated footprint and maintenance accesses upon soils, wildlife, fisheries, and urban development.

Data Gaps

There is a lack of data on the effects of illegal refuse disposal in the watershed.

There is little data on the 'footprint' impacts of power transmission lines such as amount of cleared land, and access road miles.

There is a need to perform an economic survey of the value of wildland habitat in the watershed. Such surveys could use know economic valuation methods such as the "Contingent Valuation Method", "Travel Cost Method" and "Hedonic Regression Method" and others to estimate the economic value of wildland habitats in the watershed.

Action Items

Work with the City and County to assess the effects of illegal refuse disposal and develop and provide education on the effects of illegal trash dumping.

Encourage adherence to zoning and land use management plans and collaborate with appropriate agencies to review and update BMP's to protect ecological resources in the watershed.

Work with power line operators and agencies to assess power transmission line effects upon the watershed.

Work with agencies, landowners and users of the watershed to develop a comprehensive recreation use and development plan that incorporates the need for different types of recreation while minimizing negative effects upon the natural resources in the watershed.

Collaborate with local universities and agencies to perform an economic survey of the value of wildland habitat in the watershed in order to determine the habitat value.

SECTION 8: FIRE AND FUELS MANAGEMENT

Issues Identified

Dominate fuels in the watershed are at high and severe fire risk, which threatens wildland habitats and urban developments with large wildfires.

The completed Shasta West fuels management plan needs to be implemented.

Communities in the Shasta West watershed need to work together and with resource agencies to reduce the risk of fire.

Fuel mapping needs to be updated in the watershed.

Fuels management needs to continue to coincide with ecological goals of habitat preservation.

Data Gaps

Fuels mapping needs to be updated and corrected for inaccuracies in dominate vegetation types that will carry wildfire.

There is limited information on the fire history of the watershed.

Action Items

Acquire and analyze recent color aerial photographs for the watershed. Followed up by field investigation. Collaborate with agencies involved with fire management to determine what are the dominate vegetation types that will carry wildfire. All updated information should be presented to the FRAP program for review.

Work with agencies and landowners to support, fund and implement the Shasta West Fuels Management Plan. Review and update the fuels management plan as needed to address ecological needs, fuel type changes and continued urban development.

Collaborate with agencies and landowners to perform a thorough fire history study of the watershed. Locating historical fire sites, burn intervals and estimation of fire intensity would give insight into native fuel conditions of the watershed which could assist resource managers in planning fuel treatments that benefit both the urban population and the ecology of the watershed.

Encourage and collaborate with agencies and landowners to promote fuel management activities that promote wildland and urban protection as well as biodiversity and habitat improvement.

Advertise and encourage support for the Shasta West Fire Safe Council and the Shasta County Fire Safe program. Work with agencies to retain a full time watershed coordinator to help coordinate with the Fire safe program and other activities.

SECTION 9: CULTURE AND DEMOGRAPHICS

Issues Identified

There is a need for active watershed stewardship in the Shasta West watershed that involves community's agencies, resource users and organizations.

With urban development, cultural resources such as Native American heritage sites are at risk of being lost or damaged.

Historical natural resource data from agencies needs to be preserved in order to compare current management practices to historical conditions.

Resource managers need to identify environmental justice issues in the watershed in regard to environmental laws, regulations and policies.

Data Gaps

The quantity of historical cultural and natural resource data that may have been collected by agencies and organizations is unknown, leaving gaps in data for cultural risk and natural resource assessments.

There is a lack of complete cultural heritage assessments and prehistoric resource data for the watershed.

Action Items

Work with agencies and landowners to promote and support educational and volunteer initiatives that enhance public awareness and increase direct participation in watershed stewardship. Encourage residents and resource users to become active stewards in their everyday activities and through volunteer involvement. To help coordinate these activities, work to fund a full time watershed coordinator.

Collaborate with agencies and organizations such as the Northeast Information Center, Shasta Historical Society and the Wintu Tribe to perform comprehensive cultural resource surveys and document newly discovered resources. Work to bring the documentation into a centralized and consolidated database of cultural resources that would aid future urban development in locating and protecting cultural heritage.

Collaborate with agencies and organizations to locate and preserve historical natural resource data.

Appendix A-C

Glossary of Terms

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 ft.

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 or 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 unusually 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 material 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 stream with a channel 1 square foot in 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 95 of every 100 (95%) of values will be expected to occur.

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.

Cultivars A named variety selected within a plant species.

(derived from cultivated variety) 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.

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 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 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 fairly uniform layer of soil from the land surface by runoff water.

Steam channel erosion: Lateral recession 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 of 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 with the largest carnivores.

Forb Any broad-leafed herbaceous plant other than those in the Gramineae (or Poaceae), Cyperaceae, and Juncacea families.

Fry (sacfryorslevin) 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, measure of length

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 Equipment located on a stream, canal, lake, or reservoir for the purpose of systematic measurement and recording of elevation, depth, or quantity of 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. Fluvial geomorphology is the study of stream interaction with the surrounding geology.

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.

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 of 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 Standing water 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 uses 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 weed 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.

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, scrublands, 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 water bodies. 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.

River basin The area drained by a river and its tributaries.

Run A group of offish that ascend a river to spawn.

Runoff That part of precipitation that appears in surface streams. This is the stream flow 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.

Serai Refers to species or communities that are eventually replaced by other species or communities within a sere.

Serai stages The developmental states 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 0.5 and 0.002 millimeter 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 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 Seep. 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 position and elevations of the natural or man-made features of an area that describe the configurations of its surface.

Topsoil The surface plow layer of a soil; also called surface soil. The original or present dark-colored upper soil 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 kinds 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 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 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 any management system.

Wetland Land where water on or near the soil surface is the dominant factor determining the types of plants 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 A means by which governmental authority is used to promote a specific use of land; (rural) under certain circumstances. This power traditionally resides in the state, and the power to regulate land 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 conditions under which these are to be exercised.

HISTORY
SECTION 1

Section 1
GENERAL WATERSHED HISTORY

TABLES

FIGURES

Section 1
GENERAL WATERSHED HISTORY

INTRODUCTION

This section presents a brief history of the watershed emphasizing historic activities that have affected the natural systems within the watershed.

The Shasta West 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 fifteenth century. For thousands of years these native peoples managed the resources of the watershed to fit their needs, harvesting food and fiber, and in many instances managing the resources. In the last 150 years, Europeans have molded the watershed environment to fit their 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 Europeans, Native people also managed the landscape to meet their specific needs.

SOURCES OF DATA

The primary sources of data used to develop this section were published references documenting the history of Shasta County and California included in the references. TAC members provided additional information.

PRE-1850

Climate

No real time climate data is available before approximately 1900. In order to evaluate historic climate trends, scientists commonly use glacial cores, lakebed deposits, tree line inventory, and tree ring data. California has experienced a number of significant trends in both temperature and precipitation very different from what is today considered "normal." Around 1850, just as large numbers of Europeans entered western ecosystems, the region experienced a marked shift in climate. The changes were from the abnormally cool and moderately dry conditions of the previous two centuries (the "Little Ice Age"), to the relatively warm and wet conditions that characterized the past 150 years. This climactic shift is important to land managers for two interrelated reasons. First, the landscape changes that have occurred since 1850 may not be entirely anthropogenic but rather attributable in part to the shift in climate. Second, the landscape of the immediate period should not be considered an exact model for what the watershed would be today had Europeans never colonized the region. Thus, attempts to restore "natural conditions" as part of an overall management plan should focus not on the pre-European landscape but rather on the landscape that would have evolved during the past century and a half in the absence of Europeans (Stine 1996).

The period of mid-1600s to mid-1800s is characterized as having been abnormally cool and dry. Scientists believe the dry period was proceeded by several centuries of cool, wet conditions. Warm and relatively wet conditions by comparison are common for the last 150 years. This is documented from glaciers and tree rings as well as lake deposits.

Records show that after thousands of years of little or no glaciation (adding ice) the high elevation areas of the Sierra Nevada experienced an accumulation for several hundred years prior to 1850 (Clark and Gillespie 1995, Curry 1969). This accumulation corresponds to a period of cooling over much of the globe that began in the fourteenth or fifteenth century and continued through the middle of the nineteenth century. There is speculation that the small glaciers reached a peak extent around 1850 and retreated up to 87 feet between 1933 and 1941 (Matthes 1939, 1942a, 1942b). Theoretically, this minor glaciation of the mid-sixteenth through mid-nineteenth centuries is attributable to some combination of increased precipitation (leading to greater accumulation) and decreased temperature (leading to less melting and sublimation). The climate was relatively dry during the period, and it is possible that relatively low temperatures caused the advance of the ice (Matthes 1939). Various types of dendroclimatological evidence support this hypothesis. The dendroclimatic record (tree rings) verifies that climate was both relatively cool and relatively dry during the centuries preceding the California gold rush.

Graumlich's tree ring record from the southern Sierra provides the most detailed view of variations in the latest Holocene climate. That record confirms that the period from 1650 to 1850 was generally dry, although it points out an important exception not evident in the lake or glacial records: the interval 1713–32 was anomalously wet. Graumlich's work also provides corroboration that the period from 1650 to 1850 was, by both Holocene and modern standards abnormally cool (Graumlich 1993, Graumlich).

The tree ring studies also allow the temperature factor to be isolated from the precipitation factor, an advantage that neither the lake record nor the glacial record can provide. Graumlich concluded that:

- Growing-season temperatures reached their lowest level of the past millennium around 1600 and then remained low, by modern (1928–88) standards, until around 1850

- While the period 1713-32 was, by modern standards, characterized by relatively wet conditions, it was preceded by a century dominated by low precipitation and was followed by 130 years (particularly the intervals 1761–64) of anomalous drought

- The period 1937–86 has been the third-wettest half-century interval of the past 1,000 and more years

Hydrology

In the Sacramento River Watershed, multi-year droughts were recorded between 1912–13, 1918–20, 1929–34, 1947–50, 1959–61, 1976–77, and 1987–92. The 1929–34 drought represents the most severe period of recorded drought. This historical record has been supplemented using tree ring data to estimate runoff in the Sacramento River between A.D. 869 and 1977. This study was funded by the California Department of Water Resources (DWR) and was conducted at the Laboratory for Tree Ring Research at the University of Arizona. Based on tree ring data, the 1929–34 drought was less severe than epic droughts experienced around 1150 and 1350. These epic droughts lasted more than 100 years.

Information is very meager about floods in the Sacramento River basin prior to the 1850s. The primary sources of information during this period are histories of the early settlement that include eyewitness accounts from Indians and pioneer settlers. Notable floods are reported to have occurred around 1800 and in 1826, 1840, and 1847.

Between 1850 and 1900 major flooding occurred in 1850, 1862, 1867, 1881, and 1890. Flooding during the 1860s constitutes one of the greatest flood periods in the history of California. Major floods after 1900 occurred in 1904, 1907, 1909, 1911, 1928, 1955, 1964, 1967, 1969, 1970, 1974, 1983, 1986, 1995, and 1997. The 1904 flooding resulted in the highest peak flows to date in the Upper Sacramento River between Kennet and Red Bluff.

Native People

Early people in the watershed were likely Wintu. The Wintu are the northern most group of the Wintun people that inhabit a long narrow stretch of the western Sacramento Valley north of the San Francisco Bay to the Trinity, Sacramento, and McCloud Rivers.

The Wintu were organized into autonomous smaller tribal groups comprised of extended family. The basic social, political, and economic unit was the village. A sedentary foraging people, they occupied permanent villages near rivers and streams. Villages were territorial in that they claimed particular hunting and gathering areas as their own. Others who wished to use the land were required to obtain permission, and usually gave the owners “gifts” in payment for hunting and gathering on their territory.

Wintu villages ranged from 20 to 150 people. They usually included a central lodge and conical houses built in two or three foot depressions. They were covered with bark or pine bows. Hunting camps were typically located in the foothills of known deer foraging areas.

The Wintu were generally foragers who hunted, fished, and gathered wild plants. Hunting and fishing were the primary responsibility of the men, while women gathered wild plant foods and basket making materials. Although deer and acorns were the primary food sources, a wide variety of other plant and animal resources were also utilized. Other important subsistence animals were: brown bear, rabbits, gophers, wood rats, ground squirrels, and other small rodents. Grizzly bears were considered taboo and never eaten. Waterfowl and quail were taken using nets, snares, and traps.

Deer and bear were either snared or herded up canyons where marksmen waited on top with bows and arrows. Butcher camps were often located on top of these canyons to avoid hauling the animals to distant camps.

Spring and fall salmon runs were important fishing times for the Wintu. In the vicinity of the watershed, Chinook salmon were obtained from the Sacramento River. Although considered inferior to salmon, the Wintu fished for suckers, which were found in all streams and creeks. Salmon fishing was done with dip nets and spears, suckers were driven into fish weirs, and fishhooks were used to catch trout and whitefish. Fish poisons were utilized in small streams. Salmon were sun dried and stored in baskets for winter use. Steelhead, eels, and freshwater mussels were also caught.

Women did the gathering of vegetal foods. Acorns were a staple of Wintu diet as it was with most of California's Indian population. Men assisted with the acorn harvest by shaking the acorns from the branches while the women collected the fallen nuts. Acorns from black oak and valley oak were preferred. Acorns were dried, pounded into acorn meal, leeched in sand pits, and made into soup or baked into bread. Other important plant foods included: buckeyes, manzanita berries, clover, miner's lettuce, skunkbush berries, hazel nuts, pine nuts, wild grapes, and sunflower and cotton flower seeds. The Wintu used a variety of plant materials in their daily lives. Grasses were fashioned into baskets for cooking, storage, transporting goods, sifting, and as dishes. Bows for hunting were made of yew wood. Ash wood was used to make pipes. Logs were placed across streams for bridges, and wooden rafts were used for stream crossings. Obsidian was used for arrowheads and other sharp cutting type tools. Red and white were preferred over other colors of obsidian, and red obsidian was considered to possess a supernatural poison.

The Wintu carried on trade with their close neighbors, and they acted as middlemen in the movement of dentalium shells from the north and clam disk bead money, their primary currency, from the south. Clam disk beads, manufactured by the Pomo Indians, were used in the trade of goods up and down the Central Valley.

Chiefs conducted almost all formal trade and gift giving, utilizing some of the provisions provided by their village members. These exchanges between chiefs ensured village survival during times of shortages. Some of the items traded by the Wintu included: deer hides; clam; pine nut beads; acorns; baskets; and woodpecker scalps. In return they received bows, arrowheads, obsidian, dentalia, deerskins, and pelts.

Resource Use

Acorns, pine nuts, and young shoots represented 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. Most productive, in the presence of reoccurring fire, were grasses, bulbs, and sprouts.

Archeologists generally agree, however, that California Native peoples used fire to "manage" the ecosystems they inhabited. 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.

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. (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."

Karuk, Wintu, and Shasta people burned grass, brush, and riparian areas to improve raw materials used for basket making. One or two years after a fire, the prime shoots of the hazel stick were harvested for use as ribs in baskets (Blackburn and Anderson 1993). It was especially common in the fall for many tribes to use fire to drive game. 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. 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.

Early Contact

Trappers and early explorers of Spanish, Russian, and American descent, traditionally known as "mountain men," were the first Modern Europeans to enter the watershed. The first contact between Native people and European man is documented to have occurred in the 1820s as the Hudson Bay Company trappers traveled down the Pit River from the north. Since fur trapping was a difficult and time-consuming enterprise, the aboriginal economic system was exploited by encouraging the native inhabitants to gather the pelts in exchange for simple and inexpensive goods. These early fur traders exploited the fur bearing mammals of the area taking large quantities of otter, beaver and fox. By the early 1800s the Hudson Bay Company had established a trading operation based in the Columbia River Valley, and while the documentation is not precise, it appears that Hudson Bay personnel made contact with Northern California Indians during this period of time.

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. Population estimates showing the reduction in Wintu populations since 1700 are included on Table 1-1.

Credit for the first documented full-length passage of the Sacramento Valley belongs to Jedediah Strong Smith. Smith, leading a party of 18 men and 300 head of horses and mules, traveled along the east bank of the Sacramento River to a point near Red Bluff, where they crossed the river on April 11, 1828. Following Dibble Creek, the party headed in a northwesterly direction, passing through the southwest corner of Shasta County on their way to the coast.

Table 1-1 WINTU POPULATIONS SINCE 1700		
Year	**Population**	**Source**
1700	12,000	NAHDB Calculation
1770	12,000	Krober Estimate
1800	12,000	NAHDB Estimate
1848	8,000	Cook
1852	5,700	Cook
1880	1800	Cook
1900	1,000	NAHDB
1910	710	Census
1915	701	Cook
1930	380	1930 Census
1971	900	Cook
1989	2,885	Bureau of Indian Affairs
2000	3,200	NAHDB
Source: Four Directions Institute		

Later in the same year, Alexander Roderick McLeod explored the Sacramento River for the possibility of future fur trading adventures (Petersen 1965). McLeod's expedition followed the course of the Pit River from Goose Lake and Fort Nez Perce to Hat Creek, eventually passing through Cow Creek into the upper Sacramento River Valley. McLeod's route later became known as the Walla Walla Trail. McLeod's party built canoes at Canoe (Cow) Creek and continued down the valley on the Sacramento River.

Although these early explorers and fur trappers passed rapidly through the area, they remembered it and eventually told others. As settlements in surrounding areas such as Oregon and central California began to grow, emigrant routes connecting these areas were rapidly developed throughout the region.

One individual who apparently read these accounts of Northern California was Pierson Barton Reading. Although Reading was born into a wealthy New Jersey family in 1816, the family's good fortune seemed to decline during the 1830s. Bankruptcy, victimization by embezzlement, and widowhood were all factors that undoubtedly influenced Reading's decision to migrate to the new land of opportunity—California.

As a member of the Walker-Chiles party in 1843, and later as clerk and chief trapper for John Sutter, Reading investigated the northern reaches of the upper Sacramento River Valley (Petersen 1965). When Samuel Hensley, Reading's close friend, returned from a logging expedition near present-day Anderson, he convinced Reading to try to get a grant for property in the north valley. As a direct result, Reading assumed Mexican citizenship in 1844 and applied for a 26,633-acre land grant along the west side of the Sacramento River. John Sutter and John Bidwell, both grant holders themselves, testified that the land in question was unoccupied, except for the aboriginal inhabitants, and that Reading was worthy of recommendation. On December 4, 1844, the grant, entitled Rancho Buena Ventura, was issued to Reading. This grant included all land from Salt Creek on the north to the mouth of Cottonwood Creek on the south, a distance of fifteen miles, and was the northern-most Mexican land grant in California. Bordered on the east by the Sacramento River , it extended three miles to the west. Figure 1-1 shows the Reading Grant boundaries and early roads.

It is quite likely that agriculture would have always held Major Reading's attention had he not received word of the discovery of gold at John Sutter's Mill in 1848. Reading, one of the first to inspect John Marshall's find, undoubtedly recognized many similarities between the topography and geological characteristics of Marshall's stream to those creeks near his own property. Upon returning home after investigating Marshall's find at Coloma, Reading apparently began an immediate search of the gravel beds on his land.

Reading's first find occurred in the summer of 1848 on Clear Creek; however, since it was not considered to be a rich strike, Reading continued in his quest where he eventually came to the Trinity River. There, using only his pocketknife, Reading was able to dig out several flakes of gold. Within six weeks, Reading's group, consisting of 2 white employees and 62 Indians, collected over $80,000 in gold dust and nuggets. Although Reading returned home shortly after his discovery to continue a quiet life of farming, the news of his find quickly spread, thus ushering in a new era for western Shasta County.

In the late 1840s, sheep were introduced from the southern portion of California into the Redding area. The discovery of gold along Clear Creek in 1846 brought many more miners, herders, and settlers to the area. With the advent of hydraulic gold mining in Clear Creek and the Sacramento River, the settlement population continued to grow. 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.

1850-1890 RAILROAD AND HYDRAULIC MINING

Mining was the primary resource exploited by early watershed residents. The first European residents in the watershed were miners who mined for surface gold and moved on. The gold rush in Shasta County began in 1847. Initially the efforts included hydraulic mining of the surficial deposits in creeks and the Sacramento River. Later efforts included hard rock explorations in the upland areas of the Shasta West Watershed. The hard rock gold rush concentrated in the metavolcanic greenstone and granitic formations on the west side of the river. The lowland flood plain areas, along the Sacramento River, were used to graze cattle and sheep to supply the growing population of miners. Clear Creek is reported to have more free gold than any of the other creeks in the area (Allen 1989). However, gold was removed from just about every creek in the vicinity (Allen 1989). The streams, flowing into the Sacramento River from the Klamath Range in the west, were rich in placer gold and attracted several hundred miners prior to 1848 (Lydon and O'Brien 1974). By the spring of 1849, numerous camps had sprung up along the entire length of Clear Creek, with the most central of these areas being known as the Clear Creek Diggings. By 1855, mining localities, such as Briggsville, Horsetown (originally known as Clear Creek Diggings), Middletown, Muletown, Shasta, and Texas Springs, were all thriving communities. Figure 1-2 shows a panoramic view of Old Shasta from 1920.

In 1945 Major Reading established a camp in a grove of trees where four springs flowed out of the side of the hill. This became the location of Reading Upper Springs, which quickly became the gathering place and supply for the local placer mining operations. Later renamed Shasta, by 1851 the "town" had grown to be one of the largest towns in California and served as a supply center for mining and other settlements as far away as southern Oregon (Allen 1989) As far east as Lassen County and as far west as Trinity, the town was known for the good trails in and out of the area. At the peak of the period, as many as 200 freight wagons and 2,000 pack mules were coming and going daily (Allen 1989). The County seat was moved to Shasta in 1951. The area around modern day Redding (also know as Poverty Flats at that time) is reported to have been only one of the many places where hay was grown and cut to feed the horse and mule population.

While amenities were scarce in the early towns, women were even rarer. According to the 1850 Census, there were only 7 females among the 378 white residents in Shasta County. Despite apparent hardships, by 1853 at least 4,050 people lived in Shasta County: 3,448 men and 252 women. Of these, approximately 2,000 were miners averaging a yearly income of $1,246 (Peterson 1965).

The earliest miners to arrive in the study area found very rich deposits of coarse gold, which was easily acquired with the use of a shovel, pick, and pan. While the majority of these miners worked the gravel and sand bars on Clear Creek between Reading Bar and Muletown Bar, others preferred to mine the dry gulches where the gold was coarse. Most of these dry diggings occurred in the Horsetown-Dry Creek gulches, the Jackass Flat gulches, and Buljin Gulch. Although the first placer miners worked with shovel and pan, they soon learned to build rockers, long toms, and sluice boxes, which greatly increased the amount of gravel one man, could wash (Lydon and O'Brien 1974).

The mix of miners, originally predominantly single men, gradually changed to include families. Since the miners of this second wave were more stable in nature, they were not content to merely drift from camp to camp as conditions dictated. They began to band together to collectively work the remaining, more difficult, though still rich deposits. The miners in the Clear Creek area eventually formed the Shasta County Mining and Water Company in April of 1853. The purpose of this company was to bring a dependable supply of water to the general area of what is now Placer Road.

Greatly underestimating the cost of building a ditch, the new company collapsed and was subsequently bought by two Sacramento investors. By November 1855, the Clear Creek Ditch Company had completed the 41-mile ditch, and water began to flow its entire length. Figure 1-3 shows the location of the Clear Creek Ditch.

Following the initial gold rush, Chinese began immigrating into California in large numbers. By May 1852, the number of Chinese in the state was estimated to be close to 12,000, and in 1853 the town of Shasta had one of the largest Chinese populations in the State.

During the early part of the 1860s, prior to their forcible removal from the mines, the Chinese erected their own town on the southern outskirts of Shasta. This town, known as Hong Kong, had a three-story hotel, stores, saloons, gambling dens, a cemetery, and a Joss House.

By the close of the 1870s, mining continued to be the major economic activity in the study area and, in many ways, become even more intensified with the development of various hydraulic and lode mining techniques. Figure 1-4 shows a picture of hydraulic mining in 1933.

In 1870, the first stage line affiliated with the Oregon and California Railroad made the decision to reroute their coaches north up along the Sacramento Valley. The railroad followed suit, and gradually between 1872 and 1887, a community grew up around the train depot at Redding Station, seven miles east of Shasta in the area originally known as Poverty Flat. Without the significant cost that would have ensued if the rail had been raised to Shasta, the location provided the grade needed to get the railroad through the area. Figure 1-5 shows a photo of the Southern Pacific Railroad in Redding in 1890. In 1887 this community, now known as Redding, became incorporated. By 1888, the title of the county seat was transferred to Redding from Shasta.

Saw mills were constructed at Turtle Bay that operated from approximately 1896 to 1908, producing wood for the growing town. Much of the town was rebuilt regularly due to frequent fires.

By 1887, gold dredgers had worked most of the flood plains of all of the major creeks along the Sacramento River and the main river itself. Gold and silver are the only recorded minerals produced in the county from 1880 to 1863. At least 69 gold dredges are reported to have operated in the general area of Redding during the period 1860 to 1940. Dredge and lode mine locations in the watershed and those affecting the watershed are shown on Figure 1-6. The mines on the figure are listed in Table 1-2. From the 1860s, and well into the 1900s, the major gold producing districts in the watershed consisted of the Igo-Ono, Shasta-Whiskeytown, and Redding Districts. Gold Districts are shown on Figure 1-7. Hydraulic mining continued extensive operations until 1884 when it was prohibited by the passage of the Anti-Debris Act.

1890-1920 COPPER ERA

As a direct result of the shortage of gold, the years 1891 and 1892 witnessed an increase in activity at the lode gold mines near Redding, while placer activities at the gravel and river mines declined (Lydon and O'Brien 1974). The mines in the Old Diggings, Middle Creek, and Shasta areas were extensively worked, with stamp mills operating around the clock to process the ore (Lydon and O'Brien 1974).

Attempts were also made to operate drift mines in the vicinity of Centerville, Igo, and Ono around the turn of the century; however, the operational costs outweighed profits, consequently, these mines were short lived (Lydon and O'Brien 1974). Until the 1940s, dredging also played an important part in the gold mining and continued to be used to some extent in southern Shasta County (Petersen 1965). The first dredge in Shasta County was built by the Diestlehorst Brothers of Redding around 1895 and was located on the Sacramento River near the mouth of Middle Creek (Lydon and O'Brien 1974). Figure 1-8 shows a historic photo of gold dredging at Middle Creek in 1910.

Shasta County's copper mining era began when copper was discovered in the mid 1860s. Copper mining required significant investments in smelters, transportation systems, and manpower. The change to an industrialized society of the late 1800s created a huge demand for copper as a result of 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. Gold continued to maintain its importance well into the 1930s. This discovery of an apparently inexhaustible, broad, crescent-shaped deposit of ore to the north, east, and west of Redding in the early 1860s resulted in a new period of mining. Although copper formed the basis of this mineralized deposit, other mineral products including silver, iron, ore, pyrite, zinc, and gold were also present during this time that Shasta County led the state in copper production as well as in silver and iron ores (Peterson 1965).

Numerous mines throughout the region supported five copper smelters. Although none of the actual mines were located in the watershed, the impact of the mines on social, economic, and ecological aspects of the area cannot be overlooked. In the Copper Crescent, the most westerly of the smelters was the closest to the watershed and was located at Keswick, which was fed by the Iron Mountain Group of Mines. The smelter operated from 1896 to 1905. An injunction by the United States (U. S.) government (Forest Service), filed in 1905, closed the smelter operation. By 1902 the Mountain Copper Company, operator of the smelter, was the sixth largest producer of copper on the North American Continent and the ninth largest in the world (Peterson 1965). Many patented mineral claims remain in the watershed today although none are currently commercially mined. Figure 1-9 shows the location of these claims. Figure 1-10 shows a photo of downtown Redding from 1920. Figure 1-11 shows a historic photo of the copper smelter at Keswick from 1920.

Table 1-2
HISTORIC SHASTA WEST MINE SITES

Name	Type	Name	Type
B.H.K. Mining Company	Gold	Kanaka (Sunshine)	Gold
Benson Group	Gold	Kennett Smelter*	Smelter Site
Blue Gravel	Gold	Keswick Smelter*	Smelter Site
Boswell Group	Gold	Lady Slipper	Gold
Buena Vista	Gold	Menzel	Gold
Calumet	Gold	Milton	Gold
Central	Gold	Mineral Spuz	Sand and Gravel
Clear Creek Dredging Company	Gold	Mt. Shasta Mine	Gold
Cleveland	Gold	Oaks	Sand and Gravel
Coram Smelter	Smelter Site	Old Spanish*	Gold
Delamar/Winthrop Smelter	Smelter Site	Oro Fino Mine*	Gold
Desmond	Gold	Oro Grande	Gold
Dimension Stone Texas Springs	Pumice	Potosi	Gold
Eiller	Gold	Redding Sand and Gravel	Sand and Gravel
Eureka Tellurium (Telluride Consolidated)	Gold	Redding Transport Mix	Sand and Gravel
Evening Star	Gold	Reid	Gold
Ganim	Gold	Silver King	Silver
Gold Leaf	Gold	Stewart Masonry Supply	Pumice
Hummingbird	Gold	Texas Consolidated	Gold
Ingot Smelter	Smelter Site	Thurman Gold Dredging Company	Gold
JCL Mine	Copper	Walker	Gold
Jealous	Gold	West End	Gold
JF Shea Company	Sand and Gravel	Yankee John	Gold
JH Hein Company	Sand and Gravel		

*Not included in the watershed

The roasting of sulfide based copper ore produces sulfur dioxide gas. Sulfur dioxide is highly irritating to the respiratory system, has an adverse impact of plant life, and attacks metals, fabrics, and building materials. Although the smelter companies used huge smokestacks in an attempt to dilute the fumes, because of the weight of sulfur dioxide (almost twice the weight of air), it was readily dropped back to land. Even at low levels, sulfur dioxide is toxic to plant life. From the beginning of smelting in Shasta County, the effects of the smelters on the surrounding environment were a controversial issue. In the immediate vicinity of the smelters and miles in all directions, vegetation was destroyed. Though the majority of the businessmen in the county supported the copper companies, an ever-increasing number of agricultural interests opposed their operations. Agricultural interests had grown in importance in both Shasta and Tehama Counties, as had the interest and involvement of the U. S. government in conservation and resource management. The Shasta Forest Reserve was initiated in 1905. This reserve later became the Shasta-Trinity National Forest.

Most of the original small lawsuits filed by local farmers were denied, as juries were hesitant to take action against an industry that had provided so much development in Shasta County. Finally, the United States Government filed an injunction against the Keswick smelter. In the injunction the Mountain Copper Company argued that the "property of the United States was comprised of waste and desert land containing no growth of any value except a few shrubs and stunted trees that might be used for fuel." The company did, however, admit that smelter fumes had destroyed any timber that had been the U. S. government property. Despite the success of the U.S. government against the Keswick smelter, two new smelters were opened in the county in 1905 and 1906. By 1911 over 2,000 acres of fruit trees were established in Anderson and the Shasta County Farmers Protective Association was among the first citizen or special interest group to file a lawsuit over environmental issues. In 1909 the copper industry employed approximately 4,000 people, or one fifth of the county population. By 1920 the closure of the last (the Mammoth Smelter) brought a significant depression to Shasta County. The U.S. census shows a 30 percent decline in the population of the county from 19,000 in 1910 to less than 13,500 in 1920.

In the large areas of denuded vegetation, severe erosion developed. This erosion continued in all but the flat alluvial fans until after 1935. Eroding topsoil prevented vegetation from being established. In a 1921 report to the state legislature, State Forester Edward Munns estimated that smelter fumes had damaged over 180,000 acres of forested lands in Shasta County. Of this, 67,500 acres in the area of the Keswick, Kennett, and Coram smelters was classified as completely devastated. Munns, also, estimated that the barren hillsides around the smelters lost over five cubic yards of soil per acre annually. The lack of vegetation is believed to have contributed to flooding in the Sacramento River prior to the construction of the Shasta Dam. Following the completion of the Shasta and Keswick reservoirs in 1944 and 1950, the problems of continued erosion threatened the future storage capacity of those reservoirs. Between 1948 and 1962, the Bureau of Reclamation and U.S. Forest Service completed significant terracing, planting, and other attempts to control surface erosion.

The movement of people, consolidation of the industrial centers in the valley central to the transportation corridors has changed the demographics of the watershed. The county boundaries of Northern California were not delineated formally until after 1870. Prior to that time, Shasta, 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. Population estimates for Shasta County, 1850–1990, are presented in Table 1-3.

1914-1916 ACID CANAL

The Anderson-Cottonwood Irrigation District (ACID) began construction on a canal that would deliver Sacramento River water from Redding through Anderson to Cottonwood in 1914. The canal was completed by 1916. The project was a series of canals that distributes irrigation water to users. The intake to the canal is in the City of Redding at the Market Street Bridge where Market Street crosses the Sacramento River north of downtown. The ACID canal traverses the Shasta West Watershed north to south and crosses Calaboose Creek, Canyon Creek, Oregon Gulch, and Olney Creek.

The ACID canal is unlined and crosses tributaries in siphons (generally characterize crossings at streams and roads). Because the canal is unlined, it has the potential to influence the downstream flows in streams it crosses. The ACID also is a "losing" system, meaning that water from the canal seeps into shallow groundwater and affects local shallow groundwater levels.

1920s - 1930s DEPRESSION AND THE DOLDRUMS

According to *Redding the First 100 Years* by Edward Petersen, with the shut down of the mines surrounding Redding in the 1910s, the City's growth slowed considerably compared to preceding decades. The City maintained a population of approximately 4,000 people. In effect, Redding experienced a "Depression" of its own in the 1920s when the mines were shut down. Meanwhile, the rest of the country was "roaring" with excesses. The stock market crash of 1929 had little impact on Redding. According to Petersen, one resident said: "When the Depression struck Shasta County, its effect was not major; we already had nowhere to go but upward."

Dredging for gold at former placer mining sites and entertainment (hotels, theater) kept the City alive during the times of economic hardship. Tourism also increased due to improvements in the roads. In 1935, money was set aside as part of the Central Valley Project (CVP). This project would revive the economy in Shasta County. California applied to the Federal Emergency Administration of Public Works (FEA) for grants and loans, and created the Water Project Authority. The Committee on Rivers and Harbors in the House of Representatives recommended $12 million of federal money for construction of Kennett (Shasta) Dam because of the national benefits to navigation and flood control on the Sacramento River. After reviewing the investigations, the California Joint Federal-State Water Resources Commission, the United States Senate Committee on Irrigation and Reclamation, the Bureau of Reclamation, and the Army Corps of Engineers approved and recommended the plan (The Central Valley Project 2003).

The Central Valley Project is a complex operation of interrelated divisions. Shasta Dam acts as a flood control dam for the Sacramento River. Shasta Lake stores water for controlled releases downstream.

Table 1-3 SHASTA COUNTY DECENNIAL CENSUS DATA	
Decade	**Population**
1850	378
1860	4,351
1870	4,173
1880	9,492
1890	12,133
1900	17,318
1910	18,920
1920	13,361
1930	13,927
1940	28,800
1950	36,413
1960	59,468
1970	92,100
1980	115,715
1990	147,036
2000	163,256*

Source: University of Virginia Geospatial and Statistical Data Center.
* 2000 U.S. Census

1935 - 1945 SHASTA DAM

The impacts of Shasta Dam on the Shasta West Watershed were largely financial. The authorization for the construction of Shasta Dam in effect created a new boom. It utilized 16 construction companies, totaling approximately 1,000 men by its completion. By the time the 602 foot high, 3,500 foot wide dam was completed in 1944, the project had paid $17 million for the 19,000,000 man-hours of work that went into its construction (Petersen 1972).

The construction of Shasta Dam was a huge undertaking. Between 1938 and 1944 approximately 6.5 million cubic yards of concrete was mixed and poured into forms that would dam the Sacramento River and create Lake Shasta. A vast gravel source was required to make the volume of concrete for the massive dam. Between 1935 and 1939, officials sought a suitable gravel supply within a reasonable distance from the dam site. More than sixty deposits were evaluated within 100 miles of the dam site. (Rocca 1994) The selection was narrowed to two sites: one in the Kutras tract near the current Turtle Bay Museum (ten miles downstream from the dam) and the other in the Hatch tract near Cottonwood (thirty miles downstream). The Kutras tract was awarded the contract on the basis of a lower bid. The location also made the delivery of the gravel more cost-effective.

An estimated 5 million cubic yards of gravel was delivered to the dam site from the Kutras tract. The Kutras tract is located at the sharp bend in the Sacramento River that defines the northeastern corner of the Shasta West Watershed. The bend in the river creates an ideal location for gravel deposition on the inside (south) bank of the Sacramento River.

Though the watershed is not heavily mined, Crystal Creek Aggregate, located on Iron Mountain Road in the northwest portion of the watershed, still operates today (Allen 1989; Rocca 1994).

1940s - 1960s LUMBER MILLS

The history of lumber mills in the Redding area and the Shasta West Watershed begins in 1884 when the Loy brothers established a mill at Turtle Bay. The Loy brothers hoped to float logs from the Big Bend area to Turtle Bay. However, the sugar pine logs from Big Bend would not float and the mill ended in failure. This abandoned mill was reopened several times intermittently but was closed down in 1916. It was not until the 1940s that Redding became a lumber-manufacturing center (Johnson 1978).

The very early mills 1840–1920 were generally small and portable and a supplied local timber products. With few exceptions, the mills were located adjacent to the resources. Transportation of lumber and lumber products was difficult and very costly. If the mill transported the lumber, they left the waste material in the forest. Even the big mills like Bella Vista moved presawn cants and boards via flume leaving the waste in the woods. There was no dependable road system and no mechanism to move lumber over land besides the horse, mule, or oxen and wagon. Where available, transportation mechanisms were water from rivers and creeks used either to float lumber down rivers, such as the Pit and McCloud Rivers, to get "local logs to be milled" or to divert water in constructed flumes that moved precut lumber to population centers. Most of the mills that depended on shipping lumber to succeed, failed.

After World War I, the mills began to consolidate in the valleys aided by a better rail system; an increase in demand from distant population centers; and new efficient tractors and trucks. The mills were able to operate profitably with increased efficiencies in both mill equipment and transport equipment complimented by the increased product demand and growing labor force. During this period, many local mills continued to remain in their original locations and shipped cut lumber.

During and after World War II, this approach to timber and milling dominated the timber industry. Most mills relocated in the flat growing metropolitan areas near rail lines where there was an able work force and transportation network. This is when Redding and Anderson became milling centers. Most, if not all, of the larger mills were located east of the Sacramento River, outside of the Shasta West Watershed. The only known impact during this period would have been poor air quality from the many Teepee burners. These burners, used to dispose of waste products, were prohibited in the mid 1970s due to air quality concerns.

The threat of war increased the demand on lumber. In response, several small mills sprang up in Redding. In 1943, Redding Veneer and Box Company built a mill on Branstetter Lane. The Notley family, who subsequently purchased the Olney Creek sawmill, owned it. Various mills were located near Canyon Creek (at Canyon Bottom at Buenaventura and Highway 273). Redding became the hub of the lumber industry in the 1940s with many small mills making usable lumber out of the timbers cut in the surrounding area.

By the 1950s, large lumber companies began buying smaller companies and consolidating the milling industry in Redding. Lumber industry provided thousands of jobs in the 1940s and 50s. Iron

Mountain Road was the home of various mills in the 1940s, 50s, & 60s. The Iron Mountain Road site is now a lumber remanufacturing plant (Johnson 1978).

1960s WHISKEYTOWN DAM

Just as the construction of Shasta Dam maintained the economy of Redding and Shasta County in the late 1930s and 1940s, the Trinity River Project (TRP) and construction of Whiskeytown Dam sparked a construction boom in Redding that carried the city's economy through much of the 1960s. Although not located in the watershed, the dam and TRP provided significant benefit to the area. The city served as a railroad and highway terminal for equipment and materials. Just as with Shasta Dam, shantytowns sprung up overnight near construction sites. An estimated 750 men worked on the TRP at its peak in the spring of 1963. The total project cost $253 million, much of which was labor dollars to the growing Redding and Shasta County population. The dam is 4,000 feet long and 282 feet high. Whiskeytown Lake and Whiskeytown National Recreation area provide 36 miles of shoreline and 3,200 surface acres of water as well as significant recreational opportunity.

Whiskeytown Dam was completed in 1963 to dam Clear Creek. The dam is part of a complex system that is the holding basin for water that is piped from the Trinity River (held in a small dam near Lewiston) and later siphoned underground through the Spring Creek Tunnel to the Sacramento River. In the process of the water being held and transported, it is used to generate electricity via hydroelectric power plants.

1970 to PRESENT

The Central Valley Project and the Trinity River Project not only created jobs in the area during construction, but subsequent to the projects, future jobs and communities were left behind. Recreation on Shasta and Whiskeytown Lakes guarantees a steady flow of tourists through the Redding area and provides jobs for local residents. The dams also allowed for steady supplies of water and electricity that have also promoted growth in Shasta County and Redding. The dams provide flood control that has allowed development to encroach on the Sacramento River flood plain. The effect, which these developments have on ecosystems and habitat, is irreversible. A large area of the eastern portion of the Shasta West Watershed is paved and altered. Channels within the lower watershed (near 273) have been straightened and confined to prevent flooding. The effects of urbanization on natural resources of the Shasta West are discussed in the remainder of this document.

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SECTION 1: GENERAL WATERSHED HISTORY

Action Items

Identify which creeks were mined.

GEOLOGY
SECTION 2

Section 2

GEOLOGY AND SOILS

FIGURES

Section 2
GEOLOGY AND SOILS

INTRODUCTION

This section presents the geology and soil types in the watershed. Geology and soils are important as they relate to erosion susceptibility and water quality.

SOURCES OF DATA

The primary source of data used to develop the geologic portion of the section includes:

- Geology and base-metal deposits of West Shasta copper-zinc district, Shasta County, California: U. S. Geol. Survey Prof. Paper 285.
- Geologic map of the Redding Quadrangle, Shasta County, California.

The primary sources of data used to develop the soils section includes:

- Soil Survey of Shasta County Area, California

GEOLOLOGY

Geologic Setting

The Shasta West Watershed is situated along the eastern margin of the Klamath Mountains and along the intersection of the Eastern Paleozoic and Triassic Belts and the Great Valley Sequence. Regionally the Klamath Mountains consist of a series of easterly dipping arc-shaped terrains accreted to the continent over time, as a child would pull sand to build a castle with a cupped hand. Included in the arcs are plutonic and volcanic rocks of varying degrees of metamorphism, as well as marine and non-marine sediments.

The diverse watershed contains plutonic intrusions, meta-volcanics, and marine and non-marine sedimentary rocks of which can be roughly divided into three general north-south trending geologic belts of equal size: the western granitic belt, central metavolcanic belt, and the eastern non-marine sedimentary belt. A geologic map of the Shasta West Watershed is included as Figure 2-1. A soils map of the watershed is included as Figure 2-2. A glossary of terms is included at the end of the section.

Western Granitic Belt

The Mesozoic (approx. 70 to 248 million years ago) western granitic belt consists primarily of diorite and quartz diorite of the Mule Mountain stock. The Mule Mountain stock is a plutonic intrusion, and by definition less than 40 square miles of surface exposure. Exposed diorites and quartz diorites of the stock are typically light colored or buff; fresh exposures are not common within the watershed although some do exist. The lack of fresh exposures is largely due to the ease at which diorites weather, resulting in a highly erosive product commonly known as decomposed granite.

The western granitic belt also includes a small portion of the Shasta Bally batholith that crops out east of Swasey Drive between Placer Road and Highway 299 West. The composition of the Shasta Bally batholith and the Mule Mountain stock are similar. The batholith is described as a light colored, typically buff to gray, biotite-quartz diorite. As with the Mule Mountain stock the primary weathering product is decomposed granite (DG) with nearly half its volume consisting of silts and clays.

Central Metavolcanic and Marine Sedimentary Belt

The central metavolcanic belt is comprised of Devonian (approx. 375 to 400 million years old) metavolcanic and marine sedimentary rocks largely made up of the Copley Greenstone, although minor bands of the Balaklala Rhyolite are also present within the belt.

The Copley Greenstone, the oldest rock within the watershed, consists of partially metamorphosed mafic lavas and pyroclastic deposits. The greenstone is typically dark greenish gray to greenish black when fresh and whitish gray to buff when weathered. The Copley is commonly aphanitic (fine grained), and contains feldspar phenocrysts and amygdules of quartz, calcite, and chlorite (Albers and Robertson 1961). The keratophyric and spilitic pillow lavas and pyroclastic rocks of the Copley are approximately 3,700 feet thick and are overlain by the Tertiary rocks of the Nomaloki Tuff and Red Bluff Formation (Kinkel et al., 1956).

The Balaklala Rhyolite, although a minor contributor to the watershed, is present within the central belt. The rhyolite consists of moderately hard yellowish brown to olive gray volcanic flows, breccia, and tuffs containing quartz and feldspar phenocrysts in an aphanitic groundmass (Albers and Robertson 1961). The Balaklala Rhyolite is a primary source rock of zinc sulphide ore heavily mined during the 1800s and early 1900s in Shasta County. The rhyolite is important because of the possible negative effects of sulphide leaching.

Both the Copley Greenstone and the Balaklala Rhyolite were intruded by the Mule Mountain stock approximately 400 million years ago (Irwin and Wooden 1999). Marine sediments within the watershed include dark-colored argillite, phyllite, metasandstones, and cherts. These sediments are not likely to pose significant erosion and deposition issues within the watershed.

Eastern Non-Marine Sedimentary Belt

The eastern non-marine sediment belt is primarily made up of the Red Bluff Formation. The Red Bluff Formation caps the low-lying foothills west of Redding and largely overlies the metavolcanics and sediments of the central belt. In general, the Red Bluff formation consists of a reddish brown clayey to sandy cobble conglomerate. Clasts within the conglomerate range from pebble to boulder and are generally four to six inches in diameter.

SOILS

Soils within the Shasta West Watershed vary considerably in productivity, depth, and use as one travels from the eastern margin near the Sacramento River to the mountainous soils along the western margin. Primary conditions responsible for the varied soil characteristics throughout the watershed include parent material, elevation, and slope. Because soil development largely depends on the properties of the parent material, soil types can also be divided into three general bands in much the same manner as the geologic bands of the watershed.

Major soils found throughout the watershed include, from west to east, the Chaix, Diamond Springs, Auburn, and Newtown Series. Largely, the soils are the weathering products of their respective parent materials. Below are brief descriptions of these major soil types as well as other significant soil types found throughout the watershed. The descriptions are based on information obtained from the Shasta County Soil Survey published by the United States Department of Agriculture. A soils map showing soil series is included as Figure 2-2.

Western Granitic Belt

Chaix Series
The Chaix Series soils are located along the western margin of the watershed. The series is present among some of the highest elevations in the watershed with slopes ranging from 5 to 70 percent and elevations ranging from 1,000 to 4,000 feet above mean sea level (msl). The series consists of well-drained and somewhat excessively drained soils underlain by weathered granitic rocks. The Chaix Series is primarily used as watershed, woodland, and wildlife habitat. Annual precipitation of approximately 40 to 60 inches supports stands of mixed conifers and oaks as well as shrubs and grasses.

A representative soil profile contains a grayish brown surface layer consisting of neutral to medium acidic sandy loams and coarse sandy loams approximately nine inches thick. The subsoil is a brown, medium acidic heavy sandy loam. Decomposed granite is encountered at a depth of approximately 26 inches. Severe erosion of these soils is common.

Diamond Springs
The Diamond Springs Series is located throughout the northwestern corner of the watershed and consists of primarily well-drained soils underlain by granitic or metavolcanic rocks. Permeability of the Diamond Springs Series is typically moderate, runoff is medium to rapid, and the erosion hazard is medium to high. These soils are commonly found in upland areas with slopes ranging from 8 to 50 percent and elevations ranging from 1,000 to 2,000 feet above msl. The annual precipitation is approximately 40 to 50 inches supporting stands of live oak, ponderosa pine, and knobcone pine.

A representative soil profile contains a light brownish gray to pale brown, strongly acidic very stony sandy loam to sandy loam surface layer approximately 10 inches thick; the upper 5 inches of the subsoil is typically pink, strongly acidic sandy loam. The lower 24 inches is typically reddish yellow to yellowish red, strongly acidic sandy clay loam to sandy loam. The substratum is typically strongly acidic sandy loam. Weathered metadacite is encountered at a depth of approximately 54 inches. Diamond Springs Series soils are primarily used as watershed, woodland, and wildlife habitat.

Minor amounts of Kanaka, Boomer, and Auberry Series are also included within the western belt of the watershed. Although not described, the soils are included on the soils map included as Figure 2-2.

Central Belt

Auburn Series
The Auburn Series consists of well-drained clay loams underlain by metavolcanic rock, primarily greenstone (Copley Greenstone). These soils are present on upland areas with slopes from 0 to 70 percent, and elevations ranging from 700 to 1,500 feet above msl. Annual precipitation is approximately 35 to 50 inches, supporting stands of blue oak, interior live oak, gray pine, manzanita, and annual grasses.

Most Auburn soils are used primarily as range and dry-land pasture with minor areas of cropland. Auburn soils are suitable for watershed and wildlife habitat.

Goulding Series
Goulding soils are located throughout the central belt of the watershed in areas common to the Auburn Series. The series consists of well-drained soils that are also underlain by the Copley Greenstone. Slopes range from 10 to 70 percent with elevations ranging from 700 to 1,500 feet above msl.

The surface layer is a brown slightly acidic, very stony loam approximately five inches thick. The subsoil and substratum are pale brown, medium acid gravelly loams. Fractured greenstone is at a depth of 16 inches. The Goulding soils typically support stands of oaks and shrubs and grasses.

Eastern Belt

Newtown Series
The Newtown Series consists of well-drained and moderately well-drained soils that formed in old alluvium from mixed sources. Slopes range from 8 to 50 percent with elevations ranging from 500 to 1,000 feet above msl. The surface layer is brown, slightly acid gravelly loam and mixed very pale brown strongly acid clay and pale brow, slightly acid silty clay loam. At a depth of approximately 65 inches, the substratum is pale brown, neutral cobbly silty clay loam. The annual precipitation is 28 to 40 inches supporting grasses, forbs, oaks shrubs, and gray pine.

Perkins Series
The Perkins Series consists of well-drained and moderately well-drained soils that formed in mixed alluvium. Slopes range from 0 to 30 percent with elevations ranging from 600 to 800 feet above msl. 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 loams about 44 inches thick. The substratum is slightly acid, yellowish red gravelly clay loam that extends to a 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.

Churn Series
The Churn Series consists of well drained to moderately well-drained soils that formed in alluvium from mixed sources. Slopes range from nearly flat to gently sloping, 0 to 8 percent, with elevations ranging from 500 to 1,000 feet above msl. The surface layer is light yellowish brown, medium acid gravelly loam approximately nine inches thick. The upper part of the subsoil is light yellowish brown, medium acid gravelly loams about 4 inches thick overlying at least 60 inches of light yellowish brown, and strong brown, medium acid gravelly clay loam.

The annual precipitation is 30 to 40 inches supporting stands of blue oak, valley oak, interior live oak, poison oak, manzanita, gray pine, and annual grasses and forbs.

Tehama Series
The Tehama Series consists of well-drained soils that formed in mixed alluvium. Slopes range from nearly flat to gently sloping, 0 to 15 percent, at elevations that range from 500 to 600 feet above msl. A representative profile shows the surface layer to be pale brown loam about 30 inches thick overlying approximately 45 inches of pale brown and light yellowish brown silty clay loam. The silty clay loams are underlain by yellowish brown very gravelly clay loams.

Reiff Series
The Reiff Series is found primarily along the terraces, bottomlands, and flood plains of the Sacramento River. The soils consist of well-drained and moderately well-drained soils that formed in recent alluvium from mixed sources. Slopes are typically 0 to 8 percent at elevations ranging from 350 to 500 feet above msl. Annual precipitation is 25 to 40 inches.

A representative surface layer is grayish-brown to brown fine sandy loam approximately 18 inches thick. The substratum is brown fine sandy loam to a depth of approximately 43 inches, overlying brown loamy fine sand. Vegetation is moderately dense consisting of valley oak, canyon live oak, gray pine, and a variety of grasses, forbs, vines, and shrubs.

Minor soil types also included but not described within the eastern belt include the Anderson, Redding, Red Bluff, and Moda Series soils. Descriptions of each of these soil types are included in the Shasta County Soil Survey (USDA, 1974).

DATA GAPS

No major data gaps exist.

ISSUES

Primary geologic issues within the Shasta West watershed include both erosion and sedimentation. Probable sources of erosion and sedimentation are the decomposing granite (DG) sandy soils derived from the granites and granodiorites of the Mule Mountain stock and Shasta Bally batholith. The risk of erosion is greatly compounded by modifications of steep slopes on which much of the rock exists.

Sediment derived from the granitic rock includes abundant quartz and feldspar. Feldspar, a primary mineral of granitic rock and source of clay, is easily weathered in surface exposures. This, coupled with weathered granites being generally friable in nature, combines to form DG soil that is easily erodible and can be difficult to control once initiated. Sedimentation due to off-road vehicle use and development has impacted water quality historically in the watershed and remain an area of concern.

Fine sediment deposited in streams will fill pore spaces of stream gravels used by spawning fish and benthic organisms. Granitic soils tend to be coarse textured sediment with a high percentage of fine material in comparison to other soil types. Due to the coarse texture of the material, a large percentage of the soil moves as bedload in the streams. Because it moves as bedload, DG tends to affect the structure of the stream channel. This results in sediment deposition that reduced habitat quality for threatened and endangered anadromous fish populations.

Similar studies on decomposing granites have been completed on the Grass Valley Creek Watershed, which contains Shasta Bally batholith materials, are available at the California Department of Water Resources Northern Division in Red Bluff, California. Resources are also available from the Trinity County Resource Conservation District and the Natural Resources Conservation Service. These studies are included in the "References" section.

ACTION ITEMS

A road inventory and analysis of non-paved segments as well as an erosion susceptibility evaluation comparing soil type and slope would assist in identifying areas with higher erosion potential.

GLOSSARY OF GEOLOGY TERMS

Amygdule: A gas cavity or vesicle in a volcanic rock that is filled with minerals such as zeolite, calcite, quartz, or chalcedony.

Aphanitic: A rock containing a crystalline groundmass too fine to be seen by the unaided eye.

Argillite: Name used for unusually hard, fine-grained sedimentary rocks, such as shale, mudstone, siltstone, and claystone. Commonly black.

Clastic: Pertaining to a rock or sediment composed principally of broken fragments that are derived from preexisting rocks or minerals and that have been transported some distance from their place of origin.

Felsic: An adjective applied to light-colored minerals of igneous origin such as quartz, feldspars, feldspathoids, and muscovite; also applied to igneous rocks that are mainly composed of such minerals such as granite or rhyolite.

Granite: A plutonic rock in which quartz makes up 10 to 50 percent of the felsic components and the ratio of alkali feldspar to total feldspar is 65 to 90 percent.

Granodiorite: A group of coarse-grained plutonic rocks intermediate in composition between quartz diorite and quartz monzonite.

Greenstone: A field term applied to any compact, dark-green, altered or metamorphosed basic igneous rock that owes its color to the presence of chlorite, actinolite, or epidote.

Keratophyre: Generally applied to silicic lavas characterized by containing albite or albite oligoclase, chlorite, epidote, and calcite.

Mafic: Term used to describe the amount of dark-colored iron and magnesium minerals in an igneous rock. Complement of felsic.

Metamorphic: Any rock derived from other rocks by chemical, mineralogical and structural changes resulting from pressure, temperature, or shearing stress.

Phenocryst: A relatively large conspicuous crystal set in the finer grained ground mass of an igneous rock such as (for example) a rhyolite or granite.

Phyllite: A metamorphosed rock, intermediate in grade between slate and mica schist. Minute crystals of graphite, sericite, or chlorite impart a silky sheen to the surfaces of cleavage (or schistosity).

Pyroclastic: Pertaining to fragmented (clastic) rock material formed by a volcanic explosion or ejection from a volcanic vent.

Quartz diorite: A group of plutonic rocks characteristically composed of dark-colored biotite mica or amphibole (especially hornblende), dark-colored pyroxene (especially augite), light colored sodic plagioclase such as oligiclase or andesine, and quartz composing 5 to 20 percent of the light-colored constituents.

Quartz Monzonite: A plutonic (intrusive) rock in which quartz makes up 10 to 50 percent of the felsic components, and in which the ratio of alkali feldspar to total feldspar is 35 to 65 percent. With an increase in plagioclase feldspar and mafic minerals, it grades into *granodiorite*, and with more alkali feldspar, it grades into a *granite*.

Rhyolite: A group of silica-rich volcanic rocks with quartz and alkali-feldspar phenocrysts in a glassy to very finely crystalline groundmass and commonly exhibiting flow texture.

Spilitic: A group of altered basaltic rocks that characteristically have high albite (sodium feldspar) content. Named for its type member spilite. Spilite is altered basalt, characteristically containing amygdules or vesicles, in which the feldspar has been altered to albite and is typically accompanied by low-temperature, water-rich alteration products (minerals such as chlorite mica, calcite, epidote, chalcedony) characteristic of greenstone.

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SECTION 2: GEOLOGY AND SOILS

Issues Identified

Primary geological issue is erosion and sedimentation. This risk of erosion is greatly compounded by modifications of steep slopes and recreational uses such as OHV use. With sandy erosion prone soils, fine sediment, deposited in streams, may fill pore spaces of stream gravels used by spawning fish and benthic organisms.

Data Gaps

A detailed road inventory is needed to identify stream crossings, culverts, road types, and road maintenance issues in the watershed.

Action Items

Perform an erosion potential analysis by comparing the newly developed GIS soils layers produced by the NRCS and combine it with a topographic slope layer generated by 30 meter digital elevation models developed by the USGS. Using this map as a guide, develop or review BMP's for areas identified as having high erosion potential.

Perform a road inventory and analysis that surveys culverts, stream crossings, road design, construction, and type of road use.

HYDROLOGY
SECTION 3

Section 3
HYDROLOGY

TABLES

FIGURES

Section 3
HYDROLOGY

INTRODUCTION

Hydrologic information on the Shasta West Watershed is limited to general watershed characteristics, surface water gauge data, 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.

SOURCES OF DATA

Excluding a stream gauge on the Anderson-Cottonwood Irrigation District (ACID) canal, no surface water gauging stations are located within the Shasta West Watershed (USGS 2002 and DWR 2003a). Nearby flow stations are located along Clear Creek at French Gulch (1950 to 1993) and Igo (1940 to present). Flow stations are also located at the Spring Creek powerhouse (1964 to present) and on the Sacramento River at Keswick (1938 to present). Estimates of stream flow for the individual streams were predicted using a watershed area rainfall model.

WATERSHED CHARACTERISTICS

The Shasta West Watershed encompasses several small watersheds on the west side of the Sacramento River. The watershed extends from the Sacramento River in the north and east, Whiskeytown Lake to the west, and Clear Creek Watershed to the south. In general, the eastern half of the watershed is incorporated into the City of Redding. The entire watershed encompasses approximately 44.5 square miles or 30,000 acres. Sub-watersheds included in the Shasta West Watershed are outlined in Figure 3-1 and listed in Table 3-1. Water, from these tributaries, flows into the Sacramento River. Hydrologic conditions in the Sacramento River are not discussed in this section.

Table 3-1
SUB-WATERSHEDS

Sub-Watershed	Tributary Length (miles)	Acres	Percent
Oregon Gulch	5	2,538	8.4
Canyon Creek	3	2,118	7.1
Olney Creek	8	9,368	32.3
Middle Creek	4	2,837	9.5
Salt Creek	3	2,780	9.3
Jenny Creek	2	1,218	4.1
Rock Creek	4	4,163	14.5
Calaboose Creek	-	635	2.1
Redding Tributaries	-	2,906	10.3
Linden Channel	2	717	2.4
Total	**29**	**29,931**	**100**

Note: Sub-watershed boundaries were delineated using USGS topographic map and City of Redding GIS coverage. Areas were calculated using GIS.

Elevations within the watershed range from more than 2,300 feet above mean sea level (msl) at Mule Mountain along the western perimeter of the watershed to approximately 430 feet msl at the Sacramento River.

Annual precipitation within the watershed ranges from approximately 40 inches in the City of Redding to more than 60 inches in the northwestern portion of the watershed. On average, 75 percent of the annual precipitation occurs between November 1 and March 31. Although summer thundershowers commonly occur in the higher elevations, they account for only a small percentage of the total annual supply of moisture. On average, less than a half-inch of precipitation falls during July and August.

REFERENCE CONDITIONS

Limited data are available on reference conditions in the Shasta West Watershed relating to hydrology. Assuming annual surface flows in the Shasta West Watershed are correlated with annual flows in the Sacramento River, hydrologic conditions prior to the turn of the century can be estimated from Sacramento River data.

In the Sacramento River Watershed, multi-year droughts were recorded between 1912–13, 1918–20, 1929–34, 1947–50, 1959–61, 1976–77, and 1987–92. The 1929–34 drought represents the most severe recorded drought. This historical record has been supplemented using tree ring data to estimate runoff in the Sacramento River between A.D. 869 and 1977 (Meko, et al. 2001). This study was funded by the California Department of Water Resources (DWR) and was conducted at the Laboratory for Tree Ring Research at the University of Arizona. Based on tree ring data, the 1929–34 drought was less severe than epic droughts experienced around 1150 and 1350. These epic droughts lasted more than 100 years.

Although most of the activities associated with the Central Valley Project (CVP) did not occur within the watershed, the CVP activities had a significant impact on adjacent watersheds. The Spring Creek Conduit, which transfers water from Whiskeytown Lake to Spring Creek above Keswick Dam, crosses the northern portion of the watershed. The Spring Creek Conduit is 2.4 mile long and 18.5 feet in diameter. Major Central Valley construction projects in the vicinity of the Shasta West Watershed include (USBR 2003):

- Shasta Dam — 1940 to 1945
- Keswick Dam — 1940 to 1950
- Clair A. Hill Dam (Whiskeytown Lake) — 1960 to 1963
- Spring Creek Conduit — 1960 to 1964

The Anderson Cottonwood Irrigation District (ACID) canal is the most prominent man-made hydrologic feature within the watershed. The canal was originally constructed between 1915 and 1917. Water for the canal is diverted from the Sacramento River near Caldwell Park. Approximately 2,000 acres within the watershed receive irrigation water from ACID. The remaining water is used on agricultural properties located to the south. Water loss from the ACID canal during the irrigation season increases groundwater elevations in the immediate vicinity of the canal.

The eastern portion of the watershed has experienced significant urban development. Pavement and rooftops may cover up to 90 percent of the surface area in urban areas. These impermeable surfaces lead to increased storm water runoff and increased non-point source pollution. Assuming that the watershed is 1/3 open area, 1/3 rural residential, and 1/3 urban residential (see Section 7, "Land Use and Demographics"), peak storm runoff rates today could be more than 50 percent higher than pre-development levels (Dunne and Leopold 1978).

TRENDS

Statistically, average annual precipitation has not increased over the period of record. Therefore, it is unlikely that average annual flows have changed significantly. However, it has been documented that development increases peak flood flows. For example, it has been estimated that if 10 percent of a channel has been lined and 30 percent of a watershed has been urbanized, the 2-year peak flood flows will be approximately 50 percent greater than undeveloped flows (USGS 1977).

ESTIMATED SURFACE WATER RUNOFF

Long-term surface water flow data are not available for the Shasta West Watershed. For this reason, long-term flow data from Clear Creek between French Gulch and Igo were used to estimate average annual flows from the watershed's tributaries.

Assuming the rainfall/runoff characteristics of the watershed are similar to the rainfall/runoff characteristics of the Clear Creek Watershed between French Gulch (elevation 1,320 feet) and Igo (elevation 670 feet), it is possible to estimate flows for the Shasta West tributaries. The analysis was based on the following information:

- There are no stream gauges located within the watershed. The closest gauges are located in Clear Creek.
- Clear Creek flows were modified significantly with the construction of Whiskeytown Lake in early 1960s.
- Pre-1960 Clear Creek flows are available for French Gulch (elevation 1,320 feet above msl) above Whiskeytown Lake and Igo (elevation 670 feet above msl) below Whiskeytown Lake.
- Rainfall and runoff characteristics for Clear Creek between French Gulch and Igo were determined using rainfall and runoff data collected between 1950 and 1960. The runoff data was from the gauging stations and the precipitation data were taken from Redding Station 047296.
- Flow contribution from the watershed area between French Gulch and Igo for the period 1950 and 1960 was determined through subtraction.
- Rainfall land runoff characteristics for Clear Creek between French Gulch and Igo are similar to the rainfall and runoff characteristics for the watershed (i.e., cubic feet of runoff per square mile is the same).
- Monthly runoffs for streams within the watershed were determined using correlation with long-term flow data from Clear Creek between French Gulch and Igo.

The rainfall/runoff relationship for Clear Creek between French Gulch and Igo is shown in Figure 3-2. Using this relationship estimated monthly runoff in Olney Creek is summarized in Table 3-2 and estimated average monthly runoff for Olney Creek and Middle Creek are shown in Figure 3-3.

Based on the information summarized in Table 3-2 and in Figure 3-3, the Shasta West tributaries are predicted to go dry in July, August, and September in an average year. In reality, flows during the dry months vary based on precipitation patterns, and the larger tributaries, such as Rock and Olney Creeks, receive groundwater seepage throughout the summer months. This seepage may include normal groundwater discharge and seepage from the ACID canal.

Assuming that the average annual precipitation in the watershed is 51 inches (average of the Redding station between 1931 and 1979 and the Whiskeytown station between 1960 and 2003), 32 cubic feet per second represents approximately 58 percent of the annual precipitation. In other words, approximately 42 percent of the annual precipitation is lost to evapotranspiration and 58 percent enters the stream channel directly or indirectly. Similar results were obtained using a precipitation/soil moisture/evaporation model.

Assuming the rainfall/runoff model can be used to estimate runoff in the Shasta West Watershed, total estimated annual runoff from the 30,000-acre watershed is approximately 97 cubic feet per second, or 44,000 gallons per minute. In contrast, flow in the ACID canal on Sharon Street averages approximately 240 cubic feet per second or 108,000 gallons per minute, during the irrigation season between April and October.

Table 3-2
ESTIMATED MONTHLY RUNOFF
OLNEY CREEK

Month	Precip (inches)	Runoff (cfs/sqm)	Area (sqm)	Runoff (cfs)	Runoff (gpm)
Oct	2.53	0.7	14.6	11	4,700
Nov	6.87	2.3	14.6	33	14,800
Dec	8.66	4.1	14.6	60	27,100
Jan	9.80	5.4	14.6	79	35,500
Feb	7.84	5.0	14.6	73	32,700
Mar	7.22	3.8	14.6	56	25,100
Apr	3.63	2.7	14.6	39	17,600
May	1.94	1.3	14.6	19	8,600
Jun	0.99	0.5	14.6	8	3,400
Jul	0.23	0.0	14.6	0	0
Aug	0.31	0.0	14.6	0	0
Sep	0.98	0.0	14.6	0	0
Average	**---**	**---**	**---**	**32**	**14,100**

Note: Precipitation is average from Redding and Whiskeytown Stations. Runoff per square mile is from Clear Creek between French Gulch and Igo.

FLOOD HISTORY

There is scarce information about floods in the Sacramento River basin prior to the 1850s. The primary sources of information during this period are histories of the early settlement that include eyewitness accounts from Indians and pioneer settlers. Notable floods are reported to have occurred around 1800 and in 1826, 1840, and 1847.

Between 1850 and 1900 major flooding occurred in 1850, 1862, 1867, 1881, and 1890. Flooding during the 1860s constitutes one of the greatest flood periods in the history of California. Major floods after 1900 occurred in 1904, 1907, 1909, 1911, 1928, 1955, 1964, 1967, 1969, 1970, 1974, 1983, 1986, 1995, and 1997 (USAC 1999). The 1904 flooding resulted in the highest peak flows to date in the Upper Sacramento River between Kennet and Red Bluff.

Although 1983 was one of the wettest water years in California this century due to the "El Nino" weather phenomenon, the magnitude of the peak flows were not the highest of the century. By early May, snow water content in the Sierra exceeded 230 percent of normal, and the ensuing runoff resulted in approximately four times the average volume for Central Valley streams.

The largest and most extensive flooding in the Upper Sacramento River occurred in December 1996 and January 1997. The flooding followed a series of three storms delivered over a period of five days between Christmas and New Year.

Flood frequency flows were developed for the Shasta West tributaries in accordance with procedures presented in the Magnitude and Frequency of Flood Flows in California (USGS 1977). The ungauged stream procedure was used. The model inputs and results are summarized in Table 3-3. As shown, the two-year peak flood flow in Olney Creek is estimated to be 1,939 cubic feet per second or 870,000 gpm. The 100-year peak flood flow is estimated to be 4,318 cfs, or 1,938,000 gpm.

Table 3-3
ESTIMATED PEAK FLOOD FLOWS (cfs)
SHASTA WEST WATERSHED

Trib.	Area (acres)	Annual Precip. (inches)	Average Elev. (feet)	2-Year Return Period	5-Year Return Period	10-Year Return Period	25-Year Return Period	50-Year Return Period	100-Year Return Period
Oregon Creek	2538	51	750	599	850	1092	1071	1266	1386
Canyon Creek	2118	51	750	509	723	931	915	1082	1184
Olney Creek	9368	51	750	1939	2716	3445	3336	3944	4318
Middle Creek	2837	51	750	662	938	1204	1180	1395	1527
Salt Creek	2780	51	750	650	921	1183	1159	1371	1501
Jenny Creek	1218	51	750	309	442	572	565	669	732
Rock Creek	4163	51	750	935	1320	1687	1647	1948	2132

Calculated assuming that the area is 30 percent developed and the streams are 10 percent channelized (USGS, 1977).

For comparison, the return period for the major storm period that occurred during February and March 1983 is estimated to be between 5 and 15 years. The return period for the December 1996 and January 1997 storms is estimated to be between 95 and 104 years. In other words, the peak annual flows shown in the last column of Table 3-3 have a one percent chance of occurring in any one year and they last occurred in December 1996 and January 1997.

WATER RIGHTS AND DIVERSIONS

Although it was previously mentioned that most of the activities associated with the CVP did not occur within the watershed, water deliveries from the CVP continue to benefit the watershed. Water purveyors that divert water from the Sacramento River and Whiskeytown Lake include the City of Redding, Shasta Community Service District, Shasta County, and ACID. Except for ACID, these water diversions are for municipal and industrial use. Service district boundaries within the watershed are shown on Figure 3-4.

City of Redding has a contract with the Bureau of Reclamation to divert up to 6,140 acre-feet per year of water from the Spring Creek Conduit for purposes other than the commercial production of agricultural crops or livestock. Diverted water is conveyed to the Buckeye Treatment Plant. Similarly, the Shasta Community Services District has a contract to divert up to approximately 1,000 acre-feet per year, and Shasta County has a contract to divert up to approximately 500 acre-feet per year. Both of these diversions are located along the Spring Creek Conduit (USBR 2003). Water for the Spring Creek Conduit is diverted from Whiskeytown Lake. Water for Whiskeytown Lake is diverted from the Trinity River at the Lewiston Dam, located downstream from Trinity Lake. Data on the Centerville Community Service District was not available at the time of this report writing.

Other rights to impound and use small amounts of water have been established. These rights are summarized in Table 3-4.

Table 3-4
WATER RIGHTS SUMMARY

Application	Diversion	Use	Average Diversion	Storage (ac-ft/yr)	Diversion Dates
A018195	Olney Creek	Irrigation	---	190	11/01 – 04/01
C000522	Trib. To Olney Creek	Stockwatering	---	5	11/01 – 05/01
A010380	Trib. To Middle Creek	Domestic	13	---	01/01 – 12/01
A008997	Trib. To Middle Creek	Irrigation	1.25	---	05/01 – 07/01
A030212	Trib. To Middle Creek	Fire Protection	---	30	12/01 – 06/01
S007963	Trib. To Middle Creek	Domestic/Irrigation/ Stockwatering	1	---	01/01 – 12/01
A026565	Trib. To Unnamed Stream To Middle Creek	Irrigation	3.12	---	01/01 – 12/01
A007011	Trib. To Rock Creek	Domestic	3.5	---	01/01 – 12/01
A017707	Trib. To Rock Creek	Domestic	0.15	---	01/01 – 12/01
A018683	Trib. To Rock Creek	Domestic	.021	---	01/01 – 12/01
A027823	Trib. To Tadpole Creek	Fire Protection	---	0.3	10/01 – 06/01
A027822	Trib. To Tadpole Creek	Fire Protection	---	0.2	10/01 – 06/01
A018202	Trib. To Tadpole Creek	Stockwatering	---	11	11/01 – 04/01
A018202	Trib. To Tadpole Creek	Stockwatering	---	11	11/01 – 04/01
S014159	Trib. To Sacramento River	F&W Protection and Enhancement	---	100	01/01 – 12/01
A018195	Trib. To Sacramento River	Irrigation	---	190	11/01 – 04/01
Source: SWRCB (2003)					

GROUNDWATER

The Anderson Sub-basin of the Redding Groundwater Basin extends into the eastern portion of the Shasta West Watershed. In general, the Anderson Subbasin comprises the portion of the Redding Groundwater Basin bounded on the west and northwest by bedrock of the Klamath Mountains, the east by the Sacramento River, and the south by Cottonwood Creek. Major water-bearing deposits include continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene alluvium, Pleistocene Modesto, and Riverbank formations. Holocene alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and flood plain deposits. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer.

The Modesto and Riverbank formations consist of poorly consolidated gravel with some sand and silt deposited during the Pleistocene time. They are usually found as terrace deposits near the surface along the Sacramento River and its tributaries. The Tehama formation consists of locally cemented silts, sand, gravel, and clay of fluviatile origin derived from the Klamath Mountains and Coast Ranges. It is the principle water-bearing formation west of the Sacramento River (DWR 2003b).

The Redding Groundwater Basin does not extend into the western portion or foothill region of the watershed. Fractured bedrock is exposed in this portion of the watershed and the occurrence of groundwater depends on the occurrence of fractures. In general, wells installed in this area will yield sufficient water for domestic use, but not for irrigation or municipal use.

CHANNEL GEOMORPHOLOGY

Major stream channels within the study area were assessed with regard to geomorphic characteristics and channel condition. The primary objective of the stream channel assessments was to provide a general overview of various streams systems found within the study area as well as to provide a description of the overall character and condition.

No published information regarding channel geomorphology was found. Historical reference was, for the most part, provided by anecdotal accounts of local citizens. Some of these local citizens have lived in the study area for decades and taken a keen interest in studying the stream systems. Characteristics of each stream are summarized below. Field assessment of channel geomorphology involved field reconnaissance of each stream at multiple locations along its length. Photos were taken and observations were made regarding channel character, condition, and function.

GEOMORPHIC REGIMES

In general, the shape, form, and overall character of a stream channel is a consequence of the interaction of sediment discharge and the given bed and bank boundary conditions. Water and sediment flow within a channel react to bed and bank conditions such as roughness, pools and riffles, and sediment supply. The resultant channel morphology is a product of a continual adjustment process where the channel attempts to reach and maintain equilibrium by modifying its channel geometry (i.e. cross-sectional area) in response to, primarily, changes in flow or sediment input. Significant and rapid changes in runoff volumes or sediment input will force a response as the channel attempts to adjust to the new flow or sediment transport regime. The response can be either deposition or erosion, or both.

The historic bed and bank boundary conditions were formed in response to geologic formation that has occurred over several thousand years. As such, the basic characteristics of the streams we see today are, for the most part, the result of the mass wasting and fluvial surface erosion or deposition processes that continue today. Hydro-modification (modification of the channel such as channelization and bank stabilization) also dictates channel character by controlling channel geometry to an extent that it cannot form the required geometry to pass sediment and flow in equilibrium. The response here can also be erosion or deposition, or both.

With regard to historic bed and bank boundary conditions, the Shasta West Watershed can be subdivided into two unique geomorphic regimes based on rock type, topography, and erosional or depositional equilibrium state. These regimes include the Intraflow Region located in the western portion of the assessment area, and the Basin Region located in the eastern portion of the assessment area.

Intraflow Region

The Intraflow Region is located at elevations between 700 and 2,300 feet above msl. In this region the stream channels are sub-parallel in respect to each other, have relatively incised channels, and flow in an easterly direction. The two principal geomorphic processes shaping the landscape of this area include mass wasting and fluvial surface erosion. Mass wasting has occurred as slide failures that developed on the flanks of the channels. While this assessment did not include an analysis of the extent of mass wasting in the watershed, recent slide failures were found in the Middle Creek watershed demonstrating that this phenomena does, and will continue to, occur. Such failures have an immediate and prolonged impact on delivering large quantities of sediment to watercourses.

Basin Region

This region is located primarily in the eastern extent of the watershed and encompasses the area within the watershed where the principal streams intersect with the Sacramento River. Elevations above msl within this region range from 430 feet to 700 feet. Stream deposited sediments of the Tehama and Red Bluff Formations dominate this area.

The geomorphic processes occurring within this region consist 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, with some moderate slide failures occurring in the upper watershed.

CHANNEL MORPHOLOGY CHARACTERISTICS

Major stream channels within the watershed were assessed with regard to geomorphic characteristics and channel condition as follows.

Channel Character

- What is the basic channel type throughout most of its length? (flat gradient—meandering; steep gradient—step pools; bedrock dominated—confined)

- What types of features are found? (depositional areas; waterfalls (potential fish barriers); riparian vegetation; available floodplain)

- What are the sediment transport characteristics of the channel? (small—large particle sizes; point bar formation; floodplain retention of fine sediment)

Channel Condition

- What is the basic condition of the channel at the observation point? (lack or abundance of riparian vegetation; lack or abundance of available floodplain area; shape of point bars; excessive aggradation or incision; active bank erosion)

- Has the channel been modified in any way? (bank stabilization; floodplain encroachment; straightening; bridges, culverts or dams)

Note that conclusions made with regard to channel character and conditions are based on visual observations of the channel made upstream and downstream of the observation points. Further study is required to better qualitatively and quantitatively assess condition and function.

Rock Creek

Rock Creek flows from west to east, originating in the steep terrain east of Whiskeytown Lake. The channel is predominately bedrock controlled, with virtually the entire lower three miles (75 percent of total length) consisting of an almost continuous bedrock channel. The channel transports fine to coarse sediment, with maximum sizes reaching two-feet in diameter. The channel is mostly confined throughout its length, with very little floodplain and deposition areas.

The channel appears to be in relatively good condition from its confluence with the Sacramento River upstream to the developed area at the intersection of Walker Mine and Rock Creek Roads. Above this point the channel appears to be modified by straightening, bank stabilization, and several road crossings.

Middle Creek

Middle Creek flows from south to north until it reaches the town of Old Shasta where it turns east to the Sacramento River. The channel appears to be bedrock controlled, although it was not determined to what extent. The channel transports fine to coarse sediment, with maximum sizes reaching two feet. The channel is mostly confined throughout its length with some floodplain areas in the lower reach above its confluence with the Sacramento River. According to anecdotal information, a natural waterfall may exist at approximately river mile 1.5.

The channel appears to be in good condition from the mouth upstream to Highway 299. Some channel modification has occurred throughout its length, ranging from bank stabilization to road crossings. There is evidence of bank erosion in the lower reach as well as the upper reach where slide failures were observed.

Salt Creek

Salt Creek flows from southwest to northeast, originating in the gently rolling terrain near the intersection of Swasey and Lower Springs Roads. Salt Creek is an alluvial channel with some bedrock along its length. The channel transports fine to medium coarse sediment with maximum sizes reaching one foot. The channel is somewhat confined in the lower one-half of its length (Highway 299 to Sacramento River) and has broader floodplain areas above Highway 299 with significant sediment depositional areas.

The channel appears to be in relatively good condition from its confluence to its headwaters. There is minimal channel modification, consisting mostly of road crossings.

Jenny Creek

Jenny Creek flows from southwest to northeast through a heavily developed area of west Redding. The main channel originates at Mary Lake (formerly Falks Lake) and flows for approximately two miles to the Sacramento River. The channel is mostly confined, well vegetated, and transports mostly fine sediment (estimate). The condition of the channel is not readily visible and is not represented here.

Canyon Creek

Canyon Creek flows from northwest to southeast through a heavily developed area of west Redding. The lower reach consists of a flat-gradient, meandering alluvial channel while the upper reaches are mostly confined with some bedrock features. The channel transports fine to medium coarse sediment, with maximum sizes reaching six inches. A potential hydraulic control exists upstream of its confluence with the Sacramento River.

The channel appears to be modified throughout much of its length. Channelization, bank stabilization, and multiple road crossings have all served to disrupt flow and sediment transport to an extent where excessive erosion and deposition is prevalent throughout the lower and middle reaches. The channel (lower and middle reaches) does not exhibit typical morphology for this stream type: disconnection from floodplain in many areas; lack of pool-riffle sequence; and a lack of riparian vegetation along stream banks and upper floodplain areas.

Oregon Gulch

Oregon Gulch flows from west to east through a moderately developed area of southwest Redding. The lower reach consists of flat-gradient, meandering alluvial channel while the upper reaches are mostly confined with some bedrock features. The channel transports fine to medium coarse sediment, with maximum sizes reaching six inches. A potential hydraulic control exists close to where it crosses under Highway 273.

The channel appears to be have undergone modification similar to Canyon Creek. As with Canyon Creek, flow and sediment may not be transported through Oregon Gulch's channel properly.

Olney Creek

Olney Creek flows from west to east through relatively undeveloped areas east of Highway 273 and through moderately developed areas between Highway 273 and the Sacramento River. The lower reach consists of flat gradient, meandering alluvial channel while the upper reaches are mostly confined with significant reaches of continuous bedrock. The channel transports fine to coarse sediment, with maximum sizes reaching three feet or greater.

The upper reaches of Olney Creek appear to be in fair condition. While some development has occurred, including construction of small dams and water diversions, the channel is relatively stable in that there are no significant erosion or depositional areas. The lower reach, however, has undergone some modification in the form of channelization, road crossings, and bank stabilization. The extent of modification is less than that of Canyon Creek and Oregon Gulch and as a result, the channel exhibits typical morphology for this stream type —some available floodplain areas, pools and riffles, and riparian vegetation along stream banks.

Table 3-5 provides a summary of the discussion above. Figure 3-5 shows field reconnaissance observation points as well as known or potential fish passage barriers.

CHANNEL MORPHOLOGY CONCLUSIONS

Overall, channels in low to moderately developed areas appear to be in good condition and function well. Channel segments in heavily developed areas have undergone modification in some manner and may not function well. Encroachment within the floodplain, channelization, bank stabilization, and other forms of channel modification have affected the geomorphic character to an extent where these channel segments cannot form the necessary channel geometry to transport sediment and stream flow in a manner that does not result in continuous adjustment (i.e., bank erosion, bed scour, excessive sediment deposition).

This section of the watershed assessment provides only a cursory assessment of the character and condition of the major streams. As noted above, further study would be necessary to provide better knowledge of channel geomorphology. It is important to note that most restoration actions depend on, to some degree, restoration of natural form and function of the channel and floodplain as a means to achieve multiple objectives, including fish habitat enhancement, fine sediment reduction, and riparian habitat enhancement. As such, an understanding of the baseline geomorphic conditions is critical in any restoration planning exercise. Future planning and assessment strategies could include:

1) Stream Prioritization: Prioritize major streams based on a variety of criteria including water quality, biological value (particularly fish habitat), and need and opportunities for restoration

2) Stream Classification: Classify streams according to Rosgen Stream Classification System to develop basic quantitative and qualitative knowledge of natural channel conditions

3) Site Specific Studies: Once project reaches are identified, conduct geomorphic assessments which would include site reconnaissance, cross-section surveys, sediment

sampling, and determination of important geomorphic parameters (bankfull-discharge channel geometry and flows; sediment transport characteristics)

Table 3-5
GEOMORPHIC CHARACTERISTICS OF MAJOR STREAMS

Stream	Channel Character	Channel Condition
Rock Creek	1) Predominately bedrock channel - confined 2) Very little riparian vegetation 3) Waterfall at confluence with Sacrament River 4) Transports fine to coarse sediment (boulders) – very little storage within channel/floodplain	1) Good – from confluence with Sacramento River upstream to developed area at Walker Mine Rd. and Rock Creek Rd. 2) Channel appears to be modified by straightening, bank stabilization and several road crossings in upper reach
Middle Creek	1) Predominately bedrock channel – mostly confined 2) Very little riparian vegetation 3) Waterfall at ~ river mile 1.5 4) Transports fine to coarse sediment (small boulders) – some storage within channel and floodplain	1) Good – from confluence upstream with Sacramento River upstream to below Highway 299 2) Some channel modification along entire reach – some bank erosion in lower reach above River Trail
Salt Creek	1) Alluvial channel with some bedrock 2) Some riparian vegetation in lower reach 3) Potential hydraulic control (fish barrier) at Highway 299 crossing 4) Transports fine to medium coarse sediment – some storage within channel and floodplain	1) Good – from confluence upstream with Sacramento River upstream to Tilton Mine Rd. 2) Minimal channel modification in mostly upper reach
Jenny Creek	1) Mostly confined 2) Well vegetated in lower reach 3) Potential hydraulic control (fish barrier) at River Trail crossing 4) Transports mostly fine sediment	1) Unknown – no visual observations made for reach below Highway 299
Canyon Creek	1) Low gradient – meandering channel along lower reach; Mostly confined in upper reach 2) Some riparian vegetation in undisturbed reaches 3) Potential hydraulic control upstream of confluence with Sacramento River 4) Transports fine to medium coarse (cobble) sediment	1) Poor – from confluence with Sacramento River upstream to above Buenaventura Drive 2) Channel modification throughout entire lower and middle reaches
Oregon Gulch	1) Low gradient – meandering channel along lower reach; Mostly confined in upper reach 1) Some riparian vegetation in undisturbed reaches 2) Potential hydraulic control upstream of confluence with Sacramento River 3) Transports fine to medium coarse (cobble) sediment	1) Poor – from confluence with Sacramento River to above Highway 273 2) Channel modification throughout entire lower and middle reaches
Olney Creek	1) Low gradient – meandering channel along lower reach; Mostly confined in upper reach 2) Some riparian vegetation in undisturbed reaches 3) Potential hydraulic control upstream of confluence with Sacramento River 4) Transports fine to medium coarse (cobble) sediment	1) Poor to Fair – from confluence with Sacramento River to above Highway 273 2) Channel modification throughout entire lower reach 3) Minimal channel modification in middle and upper reaches

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SECTION 3: HYDROLOGY

Issues Identified

A concern in the Shasta West Watershed Assessment is that stream assessments in the assessment document were made by visual observations without the use of quality surveys.

Many of the Shasta West streams flow through urban areas and have been modified from their original conditions.

Data Gaps

There is a lack of data on the channel morphology characteristics outside of the City of Redding boundaries such as stream channel width, depth, slope, roughness of the channel materials, stream discharge and velocity, and sediment load and sediment size.

There is a lack of stream classification and stream prioritization in the watershed.

Low-flow stream flow data is unavailable and is needed to estimate the dependability of water supplies for fisheries and wildlife.

Incomplete information is known on the ecological effects of the ACID canal and its influence on the streams of the watershed

In the watershed, there is a lack of information on urban sub-surface stream locations that might produce opportunities for stream restoration efforts such as "daylighting".

Action Items

Survey the watershed using remote sensing or physical surveys and establish baseline geomorphic information and basic data such as stream channel slope and stream channel types and composition.

Classify streams according to the Rosgen stream classification system to develop basic knowledge of stream behavior, hydraulic and sediment relations, and to provide a consistent and reproducible frame of reference for communication by natural resource planners working with the Shasta West streams in a variety of disciplines.

Work with agencies and landowners to develop a stream monitoring program that includes installing and monitoring stream gauges on priority streams in the watershed in order to determine flow regimes.

Survey sub-surface stream sections to produce GIS layers and work with the City and County planners to investigate opportunities for stream daylighting.

Collaborate with Anderson Cottonwood Irrigation District to investigate the effects of the ACID canal upon the ecosystem and stream conditions in the watershed.

Work with the City of Redding to obtain data from the city's hydrology model and FEMA flood mapping models for streams in the watershed for a future update of the Shasta West Watershed Assessment.

WATER QUALITY
SECTION 4

Section 4
WATER QUALITY

TABLES

FIGURES

APPENDIX

Section 4
WATER QUALITY

INTRODUCTION AND SOURCES OF INFORMATION

Very limited water quality data is available for the Shasta West Watershed, as no comprehensive water quality studies have been conducted in the watershed to date. Therefore, the primary sources of water quality information used for this section were Regional Water Quality Control Board of Central Valley (RWQCB) case files associated with Middle Creek and Rock Creek sediment loading as well as limited water quality sampling from the Westside Sewer Interceptor project for Oregon Gulch and Olney Creek. This section also summarizes the City of Redding Storm Water Quality Improvement Plan (SWQIP) that was prepared to form a basis for improving storm water quality in urban streams. The Swasey sediment basin restoration project located on Middle Creek is also summarized.

VESTRA and the WSRCD contacted DWR via a formal request for any and all water quality data pertaining to creeks within the Shasta West Watershed. DWR responded to the request stating that no digital data was available, no reports had been published, and that the only data that has been collected is available on Microfiche. The Microfiche data would have to be viewed, handwritten from the screen, and input into a database.

VESTRA also contacted the City of Redding for storm water quality data. The City responded that no data was available. It is expected, due to future requirements by the RWQCB and the United States Environmental Protection Agency's (USEPA) National Pollution Discharge Elimination System (NPDES) Phase II Storm Water Program, that storm water quality data will be collected in the near future.

DATA LIMITATIONS

It is important to note that the water quality data that has been collected in the watershed was taken for specific purposes. The data collected as part of the Westside Interceptor Project was collected to assess whether or not Best Management Practices (BMPs) associated with construction activities were effective eliminating impacts to nearby streams. The Middle Creek sampling was performed to assess the impact of storm water on Middle and Rock Creeks.

The context of this data is important and should be considered when deciding what the data means. The data for Middle Creek and for the Westside Interceptor Project represent worst-case scenarios for inflows into the creek and may not represent average or normal conditions.

No comprehensive water quality study has been conducted for the Shasta West Watershed or any of the individual creeks in the watershed. Such a study could provide a basis for background conditions and statistical analysis of physical, chemical, and biological parameters in the watershed. Water quality issues of importance in the watershed include erosion from residential development, naturally occurring erosion from erodible soils, and urban storm water run-off within the Redding city limits.

REGULATORY BACKGROUND

The following excerpt defines the water quality standards for the waters of the Shasta West Watershed according to the RWQCB Basin Plan (Fourth Edition).

Water Quality Standards

Section 303 of the Clean Water Act (CWA), 33 U.S.C. §1313, provides for promulgation of water quality standards by states. The standards consist of designating uses of water and developing water quality criteria based on the designated uses (40 CFR §131.3(i)). The criteria are "elements of State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports a particular use" 40 CFR §131.3(b). Water quality standards for the Shasta West Watershed are presented in the Water Quality Control Plan for the Sacramento and San Joaquin River Basin (RWQCB, 1998).

The CWA requires states to protect beneficial uses of waters of United States within their jurisdictional boundaries. USEPA regulations to implement the CWA further require states to adopt water quality criteria (referred to as "objectives" in California) that protect the designated "beneficial uses" of water bodies. The designated beneficial uses, the water quality criteria to protect those uses and an anti-degradation policy constitute water quality standards.

A water quality standard defines the water quality goals for a water body, or portion thereof (in part), by designating the beneficial use or uses to be made of the water. States adopt water quality standards to protect public health or welfare, enhance the quality of water, and serve the purposes of the CWA. "Serve the purposes of the Act" (as defined in Sections 101 [a] [2] and 303 [c] of the CWA) means that water quality standards should, at a minimum:

- Provide, wherever attainable, water quality for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water. This goal is commonly restated as the water should be "fishable and swimmable"

- Consider the use and value of State waters for public water supplies, propagation of fish and wildlife, recreation, agriculture, industrial purposes, and navigation (USEPA 1994)

According to Section 13050 of the California Water Code, Basin Plans consist of a designation or establishment for the waters within a specified area of beneficial uses to be protected, water quality objectives to protect those uses, and a program of implementation needed for achieving the objectives. State law also requires that Basin Plans conform to the policies set forth in the Water Code beginning with Section 13000 and any state policy for water quality control. Since beneficial uses, together with their corresponding water quality objectives, can be defined per federal regulations as water quality standards, the Basin Plans are considered regulatory references for meeting state and federal requirements for water quality control (40 CFR 131.20).

A Basin Plan must identify all of the following (Water Code Section 13240-13244):

a) Beneficial uses to be protected

b) Water quality objectives
c) Program of implementation needed for achieving water quality objectives
d) Surveillance and monitoring to evaluate the effectiveness of the program

Basin Plans are adopted and amended by the RWQCB using a structured process involving peer review, public participation, state environmental review, and state and federal agency review and approval.

The Basin Plan for the Sacramento and San Joaquin River Basin, which includes the Shasta West Watershed, was first adopted in 1975. In 1989, a second edition was published. The second edition incorporated all the amendments which had been adopted and approved since 1975, updated the Basin Plan to include new state policies and programs, restructured and edited the Basin Plan for clarity, and incorporated the results of triennial reviews conducted in 1984 and 1987. In 1994 a third edition was published incorporating all amendments adopted since 1989, including new state policies and programs, restructuring and editing the Basin Plan to make it consistent with other regional and state plans, and substantively amending the sections dealing with beneficial uses, objectives, and implementation programs. The current edition or fourth edition incorporates two new amendments adopted since 1994. One amendment deals with compliance schedules in permits and the other addresses agricultural surface drainage discharges.

Since publication of the fourth edition, federal rules regarding USEPA approval of water quality standards have changed. When a state adopts a water quality standard that goes into effect under state law on or after May 30, 2000, it becomes the applicable water quality standard only after USEPA approval, unless the USEPA promulgates a more stringent water quality standard for that state, in which case the USEPA promulgated water quality standard is the applicable water quality standard for purposes of the CWA (65 FR 36046 codified at 40 CFR 131.21). This new regulation applies to all surface waters of the state.

The CWA establishes a goal that, where attainable, all waters will be fishable-swimmable (CWA Section 101[a][2]). In implementing this goal, USEPA requires that states designate all waters as "fishable-swimmable." In addition to the mandatory beneficial use protections, the CWA also requires the identification of other beneficial uses to be protected. Uses may be designated as either existing, or potential future uses. An existing use is any use that has existed in the stream at any time since November 28, 1975 (40 CFR 131.3). Existing uses must be fully protected and cannot be removed (40 CFR 131.12[a][1]). A potential use is a use that may or may not have existed in the water body since November 28, 1975. A potential beneficial use may only be removed or modified through a formal Use Attainability Analysis (UAA). To develop water quality standards, states first identify all attainable uses of a water body. Examples of such uses include aesthetic enjoyment, fishing, swimming, and protection of aquatic life and wildlife. States then adopt water quality standards for individual designated uses.

Water Quality objectives are set in the Basin Plans and the combination of beneficial uses and criteria to protect the identified use. 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 RWQCB 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

As noted earlier, California water quality standards include the designation and protection of beneficial uses and the water quality objectives adopted to protect these uses.

Beneficial Uses

Beneficial use designations are the foundation of water quality management strategies in California. State law defines beneficial uses of California's waters that may be protected against quality degradation to include (and not be limited to) "...domestic; municipal; agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves" (Water Code Section 13050[f]). Protection and enhancement of existing and potential beneficial uses are primary goals of water quality planning.

Significant points concerning the concept of beneficial uses are:

- All water quality problems can be stated in terms of whether there is water of sufficient quantity or quality to protect or enhance beneficial uses

- Beneficial uses do not include all of the reasonable uses of water. For example, disposal of wastewaters is not included as a beneficial use. This is not to say that disposal of wastewaters is a prohibited use of waters of the State, it is merely a use, which cannot be satisfied to the detriment of beneficial uses. Similarly, the use of water for the dilution of salts is not a beneficial use although it may, in some cases, be a reasonable and desirable use of water

- The protection and enhancement of beneficial uses require that certain quality and quantity objectives be met for surface and ground waters

- Fish, plants, and other wildlife, as well as humans, use water beneficially

The Basin Plan does not individually identify the beneficial uses of the tributaries in the Shasta West Watershed. The Basin Plan states, "the beneficial uses of any specifically identified water body generally apply to its tributary streams" (RWQCB, 1998). The Basin Plan does, however, identify beneficial uses of the Sacramento River. Therefore, all beneficial uses of the Sacramento River apply to all tributaries in the watershed, using the tributary rule.

Designated beneficial uses of the tributaries in the Shasta West Watershed are listed on Table II-1 of the Basin Plan. The beneficial uses include (RWQCB, 1998):

Municipal and Domestic Supply (MUN) Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.

Agricultural Supply (AGR) Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation (including leaching of salts), stock watering, or support of vegetation for range grazing.

Industrial Service Supply (IND) Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization.

Navigation (NAV) Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

Hydropower Generation (POW) Uses of water for hydropower generation.

Water Contact Recreation (REC-l) Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.

Non-contact Water Recreation (REC-2) Uses of water for recreational activities involving proximity to water, but where there is generally no body contact with water, nor any likelihood of ingestion of water. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Warm Freshwater Habitat (WARM) Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Cold Freshwater Habitat (COLD) Uses of water, that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Wildlife Habitat (WILD) Uses of water that support terrestrial or wetland ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats or wetlands, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

Migration of Aquatic Organisms (MIGR) Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.

Spawning, Reproduction, and/or Early Development (SPWN) Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

Numeric and Narrative Water Quality Standards

The numeric and narrative water quality standards identified in the Basin Plan are summarized below.

Temperature

Temperature objectives for COLD interstate waters, WARM interstate waters, and Enclosed Bays and Estuaries are as specified in the Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays of California including any revisions. There are also temperature objectives for the Delta in the State Water Resources Control Board's (SWRCB) May 1991 Water Quality Control Plan for Salinity. Narrative temperature objectives include:

- The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the RWQCB that such alteration in temperature does not adversely affect beneficial uses.

- At no time or place shall the temperature of COLD or WARM intrastate waters increase more than five degrees Fahrenheit above natural receiving water temperature. In determining compliance with the water quality objectives for temperature, appropriate averaging periods may be applied provided that beneficial uses will be fully protected.

Dissolved Oxygen

For surface water bodies outside the legal boundaries of the Delta, the monthly median of the mean daily dissolved oxygen concentration shall not fall below 85 percent of saturation in the main water mass, and the 95-percentile concentration shall not fall below 75 percent of saturation. The dissolved oxygen concentrations shall not be reduced below the following minimum levels at any time:

- Waters designated WARM 5.0 mg/l
- Waters designated COLD 7.0 mg/l
- Waters designated SPWN 7.0 mg/l

Nutrients (Biostimulatory Substances)

Water shall not contain biostimulatory substances that promote aquatic growths in concentrations that cause nuisance or adversely affect beneficial uses.

Other Parameters

The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.

Turbidity

Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases in turbidity attributable to controllable water quality factors shall not exceed the following limits:

- Where natural turbidity is between 0 and 5 Nephelometric Turbidity Units (NTUs), increases shall not exceed 1 NTU

- Where natural turbidity is between 5 and 50 NTUs, increases shall not exceed 20 percent

- Where natural turbidity is between 50 and 100 NTUs, increases shall not exceed 10 NTUs

- Where natural turbidity is greater than 100 NTUs, increases shall not exceed 10 percent

In determining compliance with the above limits, appropriate averaging periods may be applied provided that beneficial uses will be fully protected.

Exceptions to the above limits will be considered when a dredging operation can cause an increase in turbidity. In those cases, an allowable zone of dilution within which turbidity in excess of the limits may be tolerated will be defined for the operation and prescribed in a discharge permit.

Specific numeric limits are also identified in the Policy for Implementation of Toxic Standards for Inland Surface Waters, Enclosed Bays and Estuaries of California (SWRCB, 2000).

Sediment
The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.

Settleable Material
Waters shall not contain substances in concentrations that result in the deposition of material that causes nuisance or adversely affects beneficial uses.

Suspended Material
Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.

Bacteria
In a final report issued September 2002, the RWQCB of the Central Valley Region outlined an amendment to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins setting out guidelines addressing bacteria. The water quality objectives for bacteria for water bodies designated REC-1 are:

> In all waters designated for contact requirements (REC-1), the E. coli concentration, based on a minimum of not less than five samples equally spaced over a 30-day period, shall not exceed a geometric mean of 126/100 ml in any single sampling.

If any single sample limits are exceeded for E. coli, the Regional Water Board may require repeat sampling on a daily basis until the sample falls below the single sample limit or for 5 days, whichever is less, in order to determine the persistence of the exceedance.

When repeat sampling is required because of an exceedance of any one single sample limit, values from all samples collected during the 30-day period will be used to calculate the geometric mean (RWQCB, 2002).

GENERAL WATER QUALITY

Temperature

Water temperature is a fundamental parameter of water quality and an integral component of aquatic habitat. Chronic and significant water temperature exceedances above natural variability of a stream are likely to impact aquatic biota (Haynes, 1970 and Beschta et al., 1987). Furthermore, elevated temperatures can trigger conditions that affect other water quality parameters such as dissolved oxygen. Natural watershed parameters that impact stream temperature include (WFP, 1997):

- **Geography** (latitude, longitude, elevation)
- **Climate** (air temperature, relative humidity, wind velocity and cloudiness)
- **Stream Channel Characteristics** (stream depth, width, velocity, substrate composition and water clarity)
- **Riparian or Topographic Blocking** (percent shade, canopy, vegetation height, crown radius and topographic angle.)
- **Water Source** (mountain streams, low elevation runoff or groundwater)

Water temperature is important because fish and most aquatic organisms are cold-blooded. Consequently, their metabolism increases with increasing water temperature. Each aquatic species has an optimum water temperature. If the water temperature shifts from optimum, organisms become stressed. The optimum water temperature for coldwater species such as juvenile and adult trout is between 45 and 65ºF (Heiskary et al., 1988; USEPA, 1987; Edwards et al., 1983 and Stuber et al., 1982), and the optimum water temperature for warm water species such as adult bass is between 65 and 85ºF (USEPA, 1987; Newbury et al., 1993; Raleigh, 1982; Raleigh et al., 1984a; Raleigh et al., 1984b and Pauley et al., 1989)

At no time or place shall the temperature of COLD or WARM intrastate waters be increased more than five degrees Fahrenheit above natural receiving water temperatures. In determining compliance with the water quality objectives for temperature, appropriate averaging periods may be applied provided that beneficial uses will be fully protected.

Dissolved Oxygen

Dissolved oxygen is gaseous oxygen dissolved in water. It is generated by diffusion from the surrounding air, as a byproduct of photosynthesis and from turbulence. A simplified formula for the production of dissolved oxygen by photosynthesis is given by the equation (VanDemark et al., 1987):

Carbon dioxide	+	Water	Light	Oxygen	+	Carbohydrate Molecule
CO_2		H_2O	$\rightarrow$	O_2		(CH_2O)

In general, green plants and certain microorganisms produce oxygen by photosynthesis. Animals and other microorganisms consume oxygen and produce carbon dioxide.

Dissolved oxygen levels are usually reported in milligrams of oxygen per liter of water (mg/l). The unit mg/l is roughly equivalent to parts per million (ppm). Dissolved oxygen can also be expressed as percent saturation, or the actual mass of oxygen dissolved in water relative to the total amount possible based on temperature, pressure and salinity.

Key factors that effect dissolved oxygen concentrations in water include:

- Rate at which dissolved oxygen is produced by photosynthesis
- Rate at which dissolved oxygen is consumed by respiration
- Solubility of oxygen in water (solubility depends on temperature, pressure and salinity)
- Diffusion rate between the atmosphere and water (atmosphere contains 21 percent oxygen and water, at standard conditions, contains approximately 0.0005 percent dissolved oxygen)
- Turbulence caused by rocky bottoms or steep gradients (turbulence increases the transfer of atmospheric oxygen to water)

Photosynthesis, because it requires light, occurs during daylight hours. Respiration and decomposition, on the other hand, occur 24 hours per day. This difference alone can account for the large daily variations in dissolved oxygen concentrations. For example, during the night when the production of oxygen by photosynthesis does not counterbalance the loss of oxygen through respiration and decomposition, dissolved oxygen concentrations decline steadily. Dissolved oxygen concentrations are usually at their lowest point just before dawn, when photosynthesis resumes. Processes that impact dissolved oxygen concentrations are summarized in Table 4-1.

Table 4-1 DISSOLVED OXYGEN PROCESS				
Mechanism	**Seasonal**		**Diurnal**	
	Winter	**Summer**	**Day**	**Night**
Rate dissolved oxygen is produced through photosynthesis	Lower	Higher	Higher	Lower
Rate dissolved oxygen is consumed through respiration	Lower	Higher	Higher	Lower
Solubility of oxygen in water	**Higher**	**Lower**	Lower	Higher
Dominant Mechanism controlling dissolved oxygen concentration	Solubility		Photosynthesis	

Fish and other aquatic organisms require dissolved oxygen to survive. As water moves past gills or other breathing apparatus, microscopic bubbles of dissolved oxygen are transferred from the water into to their blood by diffusion. Like other diffusion processes, however, the transfer is more efficient above certain concentrations. In other words, although dissolved oxygen may be present, concentrations may be insufficient to fully support aquatic life.

Dissolved oxygen concentrations sufficient to fully support aquatic life depend on the organism and other parameters such as physical condition, water temperature, and presence of other chemicals or pollutants. Consequently, it is difficult to designate minimum dissolved oxygen concentrations for individual fish and other aquatic species. For example, at 41ºF, trout require about 50 to 60 milligrams (mg) of oxygen per hour. At 77ºF, they may require up to 5 or 6 times this amount. Typically, it is assumed that dissolved oxygen concentrations greater 6 and 8 mg/l are sufficient for the normal warm and coldwater fish activity, respectively (USEPA, 1987).

For surface water bodies outside the legal boundaries of the Delta, the monthly median of the mean daily dissolved oxygen concentration shall not fall below 85 percent of saturation in the main water mass, and the 95-percentile concentration shall not fall below 75 percent of saturation. The dissolved oxygen concentrations shall not be reduced below the following minimum levels at any time:

- Waters designated WARM 5.0 mg/l
- Waters designated COLD 7.0 mg/l
- Waters designated SPWN 7.0 mg/l

Nutrients

Algae are defined as phototropic, eukaryotic microorganisms. Algae that float or are suspended in water are called phytoplankton. Phototropic means that cell energy is derived from light and eukaryotic means a cell with a true nucleus. Examples of cells with true nucleus include protozoa, fungi, animal, and plant cells (VanDemark et al., 1987).

The predominate elements in all cells, including phytoplankton, are carbon, oxygen, hydrogen, nitrogen, phosphorus and sulfur. Together, these six elements account for more than 95 percent of the dry weight of a microbial cell. Carbon, oxygen and hydrogen are the primary constituents of most organic molecules and cell structures. Nitrogen is found primarily in amino acids, and phosphorus is found primarily in nucleic acids, phospholipids, teichoic acids and nucleotides. In addition to these six elements potassium, magnesium, calcium, and iron are required for many enzyme reactions (VanDemark et al., 1987).

Phosphorus usually limits cell growth in freshwater aquatic environments, and nitrogen usually limits cell growth in marine environments (Watersheds, 2003). In other words, if algae growth is limited or controlled by low levels of phosphorus or nitrogen, adding phosphorus or nitrogen to the water body will increase algae growth. In the absence of a controlling or limiting growth factor, algae blooms will eventually cloud the water and block the sunlight required for cell energy. As this process continues, the algae and other aquatic plants will die and decay. Dissolved oxygen is used as organic matter decays, resulting in depressed dissolved oxygen levels. This process is called eutrophication. The depressed dissolved oxygen levels may adversely impact cold and warm water fish species.

Water shall not contain biostimulatory substances that promote aquatic growths in concentrations that cause nuisance or adversely affect beneficial uses.

Phosphorus

Phosphorus is an essential element for algae and aquatic plants. Total phosphorus includes both organic and inorganic phosphate. Inorganic phosphates are rapidly taken up by algae (phytoplankton) and other aquatic plants. Phosphate occurs as orthophosphate, metaphosphate or condensed phosphate, and organically bound phosphorus. Orthophosphates are used for fertilizers and soluble in water. Metaphosphates are used in detergents and commonly found in wastewater discharge. Organically bound phosphorus is an essential component in proteins. Key sources of phosphorus include soil erosion, fertilizers, animal and human wastes.

The availability of phosphorus is usually the first limiting element in freshwater algae growth. For this reason, small increases in phosphorus concentrations can lead to excessive algae growth. Typical phosphorus levels in freshwater lakes range between 0.01 and 0.03 mg/l. To prevent eutrophication, the average annual total phosphate concentration should not exceed 0.10 mg/l in streams and 0.05 mg/l in streams flowing to lakes and reservoirs (MacKenthum, 1973 and MacDonald et al., 1991).

Nitrogen

Nitrogen, like phosphorus, is an essential element for algae and other aquatic plants. Unlike phosphorus, however, nitrogen comprises 79 percent of the atmosphere. Common forms of nitrogen are atmospheric nitrogen (N), ammonia (NH_3), nitrite (NO_2), nitrate (NO_3), and organic nitrogen. Natural sources of nitrogen in aquatic environments result from the conversion of atmospheric nitrogen into nitrates, ammonia by bacteria and blue-green algae, and the conversion of ammonia into nitrite and nitrite into nitrate. This conversion process is part of the nitrogen cycle. Organic nitrogen is found primarily in amino acids. Human sources of nitrogen include effluent from wastewater treatment plants and runoff from feedlots, pasture, and agricultural lands that have been fertilized.

Nitrites are relatively short-lived because they are quickly converted to nitrates by bacteria. Nitrites produce a serious illness (brown blood disease) in fish, even though they don't exist for very long in the environment. Nitrites react directly with hemoglobin in human blood to produce methemoglobin, which destroys the ability of blood cells to transport oxygen. This condition is especially serious in babies under three months of age for it causes a condition known as methemoglobinemia or "blue baby" disease (Straub, 1989).

In nitrogen-limited systems, concentrations of less than 0.3 mg/l nitrate-nitrogen will prevent eutrophication (Brooks et al., 1991 and Cline 1973). The U.S. Public Health Service has established 10 mg/l of nitrate-nitrogen as the maximum contamination level allowed in public drinking water. Selected nitrogen criteria are summarized on Table 4-2 (AWWA, 1990).

Table 4-2
NITRATE-NITROGEN CRITERIA

Designated Use	Limit (mg/l)
Nitrate	
Human Consumption	10.0
Aquatic Life	
Warm water fish	90.0
Industry	
Brewing	30.0
Nitrite	
Human Consumption	1.0
Aquatic Life	
Warm water fish	5.0
Nitrate plus Nitrite	
Human Consumption	10.0
Agriculture (Livestock etc.)	100.0
Aquatic life	
Estuaries (recommended)	
maximum diversity	0.1
moderate diversity	1.0

Other Parameters

Turbidity

Turbidity is a measure of the degree suspended particles, including organic mater such as algae and inorganic particles, such as silt and clay, scatter light passing through a water column. Light scattering escalates with increasing sediment load. Turbidity is commonly measured in Nephelometic Turbidity Units (NTU). Simply stated, turbidity is the measure of relative clarity of a liquid. The drinking water standard is 0.5 NTU. The most frequent causes of turbidity in lakes and rivers are plankton and soil erosion.

Conductivity.

Electrical conductivity is a measure of the total dissolved salts or dissolved ions in water. Electrical conductivity is reported in microSiemens per centimeter (uS/cm), or the electrical current (I) that passes through the water between two electrodes located exactly 1.0 cm apart. A constant voltage

(V) is applied across the electrodes. The current that flows through the water is proportional to the concentration of dissolved ions in the water—the more ions, the more conductive the water resulting in a higher electrical current which is measured electronically. Distilled or deionized water has very few dissolved ions and so there is almost no current flow across the gap.

PH

pH or potential of hydrogen is defined as the logarithm of the reciprocal of hydrogen ion concentration in gram atoms per liter. PH ranges between 0 and 14, where values less than 7 are identified as being acidic and values greater than 7 are identified as being basic. If a substance has a pH value of 7, it is considered neutral, neither acidic nor basic. Because the pH scale is logarithmic, a difference of one pH unit represents a tenfold, or ten times change. For example, the acidity of a sample with a pH of 5 is ten times greater than that of a sample with a pH of 6. Although this relationship is often overlooked, it becomes important if it becomes necessary to change pH of through dilution.

MIDDLE AND ROCK CREEKS STORM WATER EVALUATION

According to the RWQCB, the most extensive storm water sampling in the watershed occurred in the Middle Creek and Rock Creek subwatersheds. Middle Creek is subject to erosion according to an erosion inventory study performed by the Soil Conservation Service (SCS), now known as the Natural Resource Conservation Service (NRCS). In the upper reaches of Middle Creek, erosion rates are as high as 137 tons/acre/year on narrow country roads and 125 tons/acre/year on power line access roads. These are compared to background erosion rate estimates of five tons/acre/year. At least a portion of the sediment in these areas is expected to end up in Middle Creek. The high erosion rates are largely the result of erodible soils, lack of vegetation, and the proximity of the area to a stream course or drainage. Middle Creek is the only subwatershed with such a comprehensive study of erosion rates.

Figure 4-1 shows the Middle Creek subwatershed erosion hazard potential and erosion reduction treatment priority by region prepared by the SCS. As indicated in the figure, the majority of the subwatershed is characterized as high to severe with regard to erosion hazard and has an erosion reduction treatment priority of moderate to high. The area with the highest erosion hazard, and therefore highest priority for treatment, is predominantly in the western flank (uppermost portion) of the Middle Creek subwatershed. The Swasey Dam, which acts as a sediment catchment in Middle Creek is located just downstream of the most highly erodible soils.

Beginning in 1991, the RWQCB conducted storm water sampling on Middle Creek in order to evaluate the effectiveness of the recently completed (November 1990) sediment control work. The main sediment control device was a concrete sediment dam and reservoir located on Middle Creek near Swasey Drive, approximately a quarter-mile upstream from Highway 299. The purpose of the dam was to provide a catchment for sediment and allow less turbid water to pass over a spillway.

Results of the water quality sampling indicated that turbidity and settleable solids were elevated in the very upper reaches of the Middle Creek subwatershed (upstream of the dam). The sediment reservoir appeared to be working. The turbidity dropped from 500+ NTUs above the reservoir to 120 NTUs just downstream of the reservoir. Settleable solids were reduced from 1.8 ml/l to 0 ml/l (none detected). Samples taken just above Iron Mountain Road (approximately one mile downstream of Swasey Dam) showed further reduction of turbidity to 12 NTUs.

The RWQCB observed an increase in turbidity and settleable solids entering Middle Creek from surface runoff from an aggregate mine on Iron Mountain Road, approximately one mile north of Highway 299. Turbidity was measured at 490 NTUs and settleable solids were measured at 0.6 ml/l. Downstream of the confluence of Middle Creek and the surface drainage, turbidity was measured at 245 NTU and settleable solids were measured at 0.2 ml/l. The aggregate mine also appeared to contribute sediment impacted flow to Rock Creek.

After intermittent sampling during peak flows for three years, in 1994 the RWQCB recommended that Crystal Creek Aggregate should determine the source of the turbidity and sediment load and evaluate feasible erosion control measures. The RWQCB requested additional mitigation in the area of the sediment waste pile to prevent storm water runoff from carrying this material to surface drainages. The RWQCB stated that, although Crystal Creek Aggregate had some contribution to Rock Creek sediment, it was apparent that other sources were present. In response, Crystal Creek Aggregate implemented erosion control practices to reduce sediment loading in Middle and Rock Creeks (Appendix 4-A).

Results of sampling in 1993–1994 indicated that downstream of the confluence of Middle Creek and the Crystal Creek Aggregate drainage, the overall impact was negligible.

An RWQCB letter dated January 13, 1998, indicated that sampling through 1995 showed turbidity, settleable solids, and suspended sediment were greatly reduced from 1992 to 1993 levels. The RWQCB attributed higher sediment levels in the South Fork of Middle Creek possibly to Muletown Road.

The erosion control measures taken by Crystal Creek Aggregate appeared to be effective at reducing sediment loading in Middle Creek. The RWQCB concluded that the Middle Creek channel did not show evidence of accumulated sand deposits and the prime spawning areas (gravel beds at pool tails) looked clean.

Crystal Creek Aggregate is currently the only industrial facility in the Shasta West Watershed covered by an NPDES Waste Discharge Requirements Permit Order No. R5-2002-0160, NPDES No. CA0082767. The aggregate quarry and processing plant are located in the Keswick area. Surface water drainage from the plant is south to Middle Creek and north to Rock Creek. Wastes generated at the plant include domestic wastewater, aggregate wash water, dust control wastewater, and storm water runoff. The plant has four settling ponds in a series to intercept surface runoff from around the facility during periods of rainfall runoff and a stormwater storage pond to receive offsite flow from the west. A Stormwater Pollution Prevention Plan has also been developed for the plant that includes monitoring of the area at least twice each wet season.

SWASEY SEDIMENT BASIN

The following information was excerpted from the Final Report—Small Tributary Restoration: Middle Creek. This was a report on the Swasey Sediment Basin Cleanout Restoration Project on Middle Creek that was prepared by the WSRCD.

Middle Creek supports spawning runs of rainbow trout, steelhead, and salmon. Due to accelerated erosion within the watershed, the Coordinated Resource Management Planning (CRMP) group, WSRCD, and the NRCS jointly recommend implementation of a project to address the fine sediment input in Middle Creek. The result was the Swasey Sediment Dam Cleanout Project to remove fine sediment that accumulated behind a small concrete dam on Middle Creek. Sediment accumulation had been increasing due to housing and road development projects in the Middle Creek Watershed. The fine sediment would potentially negatively impact steelhead, rainbow trout, and salmon habitat in Middle Creek, and ultimately the Upper Sacramento River. A Technical Team was formed to examine the proposed plan, review, and approve each sediment removal activity. The United States Fish and Wildlife Service provided a grant for dredging the Swasey Sediment Basin on Middle Creek as frequently as necessary, in order to provide additional storage capacity for future sediment capture.

In 2003, the WSRCD filed an application for a section 401 Water Quality Certification for the Swasey Ditch sediment clean out project with the RWQCB. The RWQCB issued an Order for Standard Certification on October 30, 2003, in compliance with the Clean Water Act, allowing project activities to begin.

This program supports the objectives of the Anadromous Fish Restoration Program plan to "improve habitat for all life stages of anadromous fish through improved flows, water quality, and physical structure" and "involve partners in the implementation and evaluation of restoration actions." WSRCD set up sediment monitoring in the reservoir and obtained the necessary permits. The sediment basin was cleaned out in 1997, 1998, and 2000, with 150, 208, and 240 cubic yards removed, consecutively. Fine sediment continues to accrue at the Swasey Sediment Dam site; so further cleanouts will be necessary into the future.

CONSTRUCTION STORM WATER MONITORING FOR WESTSIDE SEWER INTERCEPTOR PROJECT

Construction of Phase 1 of the Westside Interceptor Project began in 2001. The purpose of the project was to relieve flows in the existing Clear Creek wastewater interceptor pipeline and provide sewer capacity for future growth for the west Redding area. The project consists of approximately 28,200 feet of 42-inch through 54-inch diameter sewer pipe. The interceptor generally runs north to south from Cypress Avenue to the existing Clear Creek interceptor at Girvan Road. The project was constructed by Kenko Inc. for the City of Redding. Under their NPDES General Permit for Storm Water Discharges Associated with Construction Activities, Kenko Inc. was required to collect storm water samples when construction activities caused runoff into adjacent creeks. Runoff was caused not only by storm water but also as a result of dewatering. The sewer line was placed beneath the surface where groundwater was very shallow. Shallow groundwater was pumped to the surface to allow for excavation of the sewer line trench. This had potential to cause runoff into nearby creeks.

Samples were collected from Olney Creek, Oregon Gulch, and Canyon Creek near Highway 273 (along which the interceptor was constructed). The samples were analyzed for parameters that would indicate whether or not sediment was entering the creek. These parameters included turbidity, total suspended solids (TSS), electrical conductivity (EC), pH, and dissolved oxygen (DO). The samples were collected by Kenko and submitted to the RWQCB. In cooperation with meeting the objectives of this assessment, the RWQCB made staff available to input the data into a database. No winter data were available because construction is only permitted from March through October to avoid storm water related water quality issues. Also, no background or upstream samples were available to compare to the construction samples to indicate whether there was an increase as the result of construction activities.

The NPDES Construction Stormwater Program was developed under the Clean Water Act (CWA) to prohibit the discharge of materials other than storm water and authorized non-storm water discharges. Where construction activity disturbs one acre or more, the General Permit requires all dischargers to:

- Develop and implement a Storm Water Pollution Prevention Plan (SWPPP) which specifies BMPs that will prevent all construction pollutants from contacting storm water and with the intent of keeping all products of erosion from moving off site into receiving waters

- Eliminate or reduce non-storm water discharges to storm sewer systems and other waters of the nation

- Perform inspections of all BMPs

Construction activities that are subject to the permit include clearing, grading, disturbances to the ground such as stockpiling, and excavation that results in soil disturbances of at least one acre of total land area (SWRCB, 2004).

Kenko, Inc. collected water quality data from Olney Creek from September 2001 through July 2002. The data that were made available indicate that turbidity in Olney Creek was briefly elevated in September 7, 2001, reaching a high of 8.7 NTUs. It is not known if this was the result of construction or some other event upstream. Turbidity levels returned to 0.7 NTU by September 10, 2001. The pH values in Olney Creek were detected between 7.26 and 8.09. Dissolved oxygen was measured during 2002 and was detected from 8.8 to 9.1 mg/l. Only two temperature values were collected, in April 2002 and June 2002. The temperature of Olney Creek was reportedly 48 degrees F in each case. TSS were analyzed but not detected in 2001. Electric conductivity was analyzed in 2002 and results indicated EC between 130 and 182 umhos/cm. Electric conductivity is a measure of how well a sample conducts electricity, which is a function of how much dissolved matter, is present in the sample.

Kenko, Inc. collected storm water quality data from Oregon Gulch from July 2002 through September 2002. Turbidity was detected from 1.1 to 18.9 NTUs. Electric conductivity, pH, DO, and temperature were sampled on July 30, 2002 and on September 3, 2002. EC was detected at 185 in July and at 187 in September. The pH was recorded at 7.71 and 7.44 for July and September, respectively. Dissolved oxygen was recorded at 8.1 and 7 mg/l.

SUMMARY STORM WATER QUALITY IMPROVEMENT

National Pollutant Discharge Elimination System – Stormwater Run-off

In 1990, EPA promulgated rules establishing Phase I of the NPDES storm water program. The Phase I program for Municipal Separate Storm Sewer Systems (MS4s) requires operators of "medium" and "large" MS4s, that is, those that generally serve populations of 100,000 or greater, to implement a storm water management program as a means to control polluted discharges from these MS4s. The Storm Water Phase II Rule extends coverage of the NPDES storm water program to certain "small" MS4s, but takes a slightly different approach to how the storm water management program is developed and implemented. The City of Redding is considered a small MS4 and therefore falls under the Phase II Rule.

According to the USEPA, polluted storm water runoff is often transported to MS4s and ultimately discharged into local rivers and streams without treatment. EPA's Storm Water Phase II Rule establishes a storm water management program intended to improve the nation's waterways by reducing the quantity of pollutants that storm water picks up and carries into storm sewer systems during storm events. Common pollutants include oil and grease from roadways, pesticides from lawns, sediment from construction sites, and carelessly discarded trash, such as cigarette butts, paper wrappers, and plastic bottles. When deposited into nearby waterways through discharges, these pollutants can impair the waterways, thereby discouraging recreational use of the resource, contaminating drinking water supplies, and interfering with the habitat for fish, other aquatic organisms, and wildlife (USEPA, 2000).

The City has completed a Notice of Intent to participate in the statewide general permit under the NPDES program. The SWQIP is the initial formal storm water quality improvement effort under the NPDES requirements. The SWQIP spells out the City's intent to evaluate and address the most significant storm water quality problems according to the traditional Maximum Extent Practicable (MEP). The City is to accomplish these goals by practicing BMPs, whereby an attempt is made to reduce pollutants that are causing or may cause significant water quality impacts. The City will utilize a watershed-based approach to identify the most controllable sources of pollutants and implement cost effective control measures for the highest priority sources of major watersheds. The SWQIP encourages the adoption of creeks by volunteer organizations as stewards.

Urban Storm Water Run-Off – Summary of Draft Storm Water Quality Improvement Plan

In January 2003, the City of Redding completed the Draft Storm Water Quality Improvement Plan (SWQIP) as part of the City of Redding Comprehensive Storm Water Management Plan. The SWQIP outlines and directs the City of Redding storm water quality improvement priorities and activities necessary to meet NPDES regulatory requirements for the years 2003–2008. The document was prepared knowing that it will be altered as appropriate to adjust to changes in available technology and changes in regulatory environment. The SWQIP's function is to improve water quality pursuant to requirements of the CWA and the Porter Cologne Act. The CWA is enforced through the NPDES.

According to the SWQIP, the City of Redding has 130 miles of storm drain pipe, 174 miles of open channels, 5,230 catch basins, and 45 detention basins. The City also has 431 miles of streets assisting in storm water drainage for approximately 33,000 residences and 5,720 commercial and industrial businesses. All storm water that enters this system eventually discharges to one of the creeks in the Shasta West Watershed and ultimately into the Sacramento River. Maps of the storm drain system and the creeks into which they discharge are included as Figures 4-2, 4-3, and 4-4.

SWQIP Components

The main components of the SWQIP address the following issues as they relate to storm water quality:

- *Public outreach, education and participation*—The strategy is to involve the community to allow the public to provide input and encourage stewardship of the watershed. The goal of the stewardship program is to improve urban creek health through direct improvements to the creek system and habitat. Initially this will entail identifying and prioritizing improvement projects.

- *Illegal discharge detection*—The goal is to prevent pollutants that are intentionally negligently poured, dumped, discharged, or accidentally spilled into the City of Redding drainage system from reaching waterways of the City of Redding and the Sacramento River. This component is strongly tied to the educational components where the goal is to educate the public and business sectors about proper waste disposal measures. This component also sets out measures for reporting, spill response, investigation, and cleanup.

- *New construction runoff*—The goal of this component is to protect local creeks by reducing the discharge of storm water pollutants that can result from new developments and major redevelopments. This component requires monitoring during construction.

- *Post construction management*—The goal of this component is to ensure adequate long-term operation and maintenance of BMPs. This component will result in an ordinance or other regulatory mechanism requiring the implementation of post-construction runoff controls, monitoring long-term compliance, and compliance inspections.

- *Good housekeeping/pollution prevention for municipal operations and facilities*—The goal of this element is to reduce discharges of pollutants in runoff and control non-storm water discharges that result from municipal operational and maintenance activities.

Fiscal Impact of Storm Water Quality Improvement Plan

According to the SWQIP, the implementation of the SWQIP will have a significant financial impact on the City of Redding. Estimates range from as low as $1.39 per capita per year for a permit meeting federal requirements to $19.00 per capita per year to meet California Phase I permitting requirements. The SWQIP averaged the anticipated costs, adjusted for the cost for inflation and contingency factors, and estimated a fiscal impact of $13.00 per capita per year for implementation of the SWQIP.

Funding options include the City General Fund, transferring funds from other utilities programs, additional sales tax, increased assessments on each developed parcel, inspection fees, developer impact fees, and CEQA review fees.

Evaluation Strategy

The City recognizes the difficulty in evaluating whether or not the goals of the SWQIP are being met. The SWQIP concedes that it takes years to see the impacts of BMPs and concludes that a 20-year database would be needed to conduct trend analysis with any degree of statistical certainty. However, the plan spells out that the effectiveness of the improvements will be evaluated and progress reported to the degree possible.

POTENTIAL WATER QUALITY ISSUES OF CONCERN

Septic Systems

At the request of the WSRCD, VESTRA contacted the Shasta County Environmental Health Department regarding the number and location of septic systems within the watershed. Shasta County personnel stated that while this information was not readily available, the County processes approximately 400 to 500 permits for septic system repairs or new installations each year (County-wide). Current regulations require that septic systems may only be installed on relatively large parcels (typically one acre minimum) and establish setbacks from surface water bodies, wells, and property lines. Early septic systems were installed with smaller minimum acreages and setbacks. However, due to limited groundwater in the western portion of the watershed, most residences with septic systems use surface water for drinking water, such as the Spring Creek siphon, and do not have wells. The County is not aware of any historic water quality issues, surface or groundwater, within the watershed that have resulted from septic systems.

Iron Mountain Mine

Iron Mountain Mine is a CERCLA environmental cleanup. While the southern portion of Iron Mountain Road is within the watershed boundaries, the surface drainage from Iron Mountain Mine does not pass through the Shasta West Watershed. The drainage from Iron Mountain Mine terminates in Spring Creek. Spring Creek enters the Sacramento River upstream of the Shasta West Watershed.

There are no other active or inactive mines with drainage issues in the Shasta West Watershed.

Off-Road Vehicle Trails

At the request of the WSRCD, VESTRA has contacted the Bureau of Land Management (BLM) field office in Redding regarding off highway vehicle (OHV) trails within the watershed. Water quality concerns regarding OHV trails include increased erosion and sedimentation into nearby surface waters. The BLM personnel are in the process of inventorying the OHV trails in the area. So far, they have identified 340 miles of OHV trails between the City of Redding and the Trinity County line near French Gulch. Specific numbers for the watershed have not been generated.

A significant erosion problem exists in the Oregon Gulch area of Kenyon Drive in the City of Redding. More than 250 acres of city property at the western end of Kenyon Drive have unimpeded access for off road vehicles. OHV activity has disturbed approximately 30 aces of erosive soil. Potential threats to water quality in this area include:

- Discharge of sediment laden runoff from disturbed erosive soil
- Release of sediment, oil, and fuel at the numerous in-stream vehicle crossings
- Release of mercury from disturbance of mine tailings adjacent to Oregon Gulch
- Dumping of household and hazardous waste adjacent to Oregon Gulch

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SECTION 4: WATER QUALITY

Issues Identified

Sediment problems in Middle Creek were identified in the 1993 Erosion and Sediment Control Study, Middle Creek Watershed, but as long term solutions to address the problem of sediment delivery to the Sacramento River.

BMP's for water quality need to be reviewed and updated for the watershed.

Since 1890, urbanization and major channel modifications has elevated the number of low permeable surfaces resulting in increased stream flow and further stream channel modifications.

Improper refuse disposal in the western limits of the watershed needs to be addressed.

Water quality in all of the streams in the watershed show signs of being impacted by stormwater runoff and recreational activities such as illegal OHV use.

Existing water quality data is not readily accessible for resource planning.

Data Gaps

The watershed lacks comprehensive water quality data such as suspended sediment concentrations, water temperature, level of dissolved oxygen and biological oxygen demand, pH, acidity, alkalinity, specific conductance, turbidity and dissolved chemical constituents

The watershed lacks comprehensive data on groundwater levels.

Need to develop data on the effects of OHV use on water quality in the watershed.

Action Items

Work with agencies to develop a water quality monitoring program to gather baseline data for the priority streams of the watershed.

Work with agencies, landowners and organizations to assess and develop long term solutions for a sediment reduction program for the Middle Creek sub-watershed.

Assess the effects of stormwater runoff and non-point source pollution upon streams in the watershed after collecting baseline water quality data for priority streams identified in a water quality monitoring program.

Collaborate with DWR to process water quality data that is in hardcopy format into an easily accessible electronic format.

Collaborate with agencies to research and update BMP's regarding development and permeability issues.

Collaborate with agencies and landowners to monitor key OHV use areas to determine the effects upon water quality.

Collaborate between the City and County to provide a monitored OHV area, close to the city population, for legal OHV use in order to reduce the environmental impacts from illegal OHV use.

Work with landowners and agencies to implement a groundwater monitoring program to determine the level of ground water and the recharge rate to the underground aquifers.

Collaborate with landowners and agencies to perform a stream function analysis on the priority streams in the watershed to determine stream health in the watershed ecosystem.

Appendix 4-A

Water Quality Data for Middle Creek

Appendix 4-B

Erosion and Sediment Control Study
Middle Creek Watershed

Appendix 4-C

Oregon Gulch - Erosion

BOTANICAL
SECTION 5

Section 5
BOTANICAL RESOURCES

TABLES

FIGURES

APPENDIX

Section 5
BOTANICAL RESOURCES

INTRODUCTION

The 30,000-acre Shasta West Watershed is remarkably diverse considering its urban situation. The city of Redding is nestled in native oak woodlands bisected by the Sacramento River and its tributaries. Conifer and chaparral covered hills rise toward mountainous terrain to the west. The Shasta West Watershed's location, near the northern end of the Sacramento Valley and the southern ends of the Klamath and Cascade mountain ranges, explain its botanical diversity. This section discusses the botanical resources present in the watershed. In addition to examining the current distribution of major vegetative communities, the problem of invasive exotic plants is explored. The potential for rare, threatened, and endangered plants existing within the watershed is also addressed. Fire, historical copper smelting, and recent residential and urban development are considered in terms of their effects on native vegetative communities. Finally, observations are summarized, data gaps are identified, and action items are suggested.

SOURCES OF DATA

A variety of literature provided general information on botanical resources of interest in the watershed. A complete bibliography of references is included at the end of this section. Additionally, satellite imagery was analyzed to help describe the current distribution of vegetative communities in the watershed, as described in Table 5-1. Black and white aerial photographs available online (www.gis.ca.gov) were used to visually check the accuracy of the satellite mapping.

Table 5-1
SATELLITE IMAGERY USED TO DESCRIBE THE CURRENT DISTRIBUTION OF VEGETATIVE COMMUNITIES IN THE SHASTA WEST WATERSHED

Data Set	Abbreviation	Description
Land Cover Mapping and Monitoring Program (www.frap.cdf.ca.gov)	LCMMP	2001 vegetation mapping using LCMMP system but cross-walked to the CWHR classification system. 2.5-acre (100 meter pixel) minimum mapping unit. Algorithms used to group pixels into larger polygons with similar vegetation characteristics.

Another source of data referred to in this section is the California Natural Diversity Database (CNDDB). It was used to identify known occurrences of rare, threatened, and endangered plants (www.dfg.ca.gov/whdab). Information on locally occurring invasive plants was provided by staff at the California Department of Agriculture and the Shasta County Department of Agriculture. Two floristic surveys along Salt and Canyon Creeks provided data on the diversity of native and exotic plants in the watershed. The results of these surveys are included as an appendix to this watershed assessment. Year 2000 census data was used to assess the effects of urbanization on natural vegetation.

Various experts and persons with local knowledge provided valuable information. Although not all of these individuals are explicitly cited as personal communications, they are Patricia Bratcher, Eda Eggeman, Pete Figura, Richard Lis, and David O. Smith of the California Department of Fish and Game; Irvin Fernandez of the Bureau of Land Management; Kerrie Perosco of the California Department of Food and Agriculture; Kevin Martya of the Shasta County Department of Agriculture; Ryan Burnett of the Point Reyes Bird Observatory; Don Burk of the California Native Plants Society; and Susan Weale of the Friends of Canyon Creek.

The data set used for vegetative mapping of the Shasta West Watershed was the Land Cover Mapping and Monitoring Program (LCMMP). The Fire and Resource Assessment Program (FRAP), a project of the California Department of Forestry and Fire Protection, maintains this database, which is downloadable from the internet (www.frap.cdf.ca.gov). The LCMMP mapping is based on multi-spectral LANDSAT imagery with a resolution of 30 meters by 30 meters (0.22 acres) per pixel. However, algorithms have been used to combine clusters of pixels that share similar vegetation characteristics into larger polygons. The minimum mapping unit is 100 meters by 100 meters (2.5 acres). One advantage of the pixel combination process is that information on percent vegetation cover (e.g., dense or open forest) is more meaningful at larger scales. LCMMP uses the "Calveg" vegetation classification system (USDA Forest Service, 1981). However, the data has been cross-walked into the California Wildlife Habitat Relationships (CWHR) classification system (www.dfg.ca.gov/whdab).

The CWHR system classifies vegetative communities in terms of vegetative community type, size class, and canopy closure density class. For the purposes of this assessment, CWHR size and density classes were used for describing structural conditions because they are convenient for describing both vegetative communities and associated wildlife habitats. The CWHR system stratifies vegetation into tree-dominated, shrub-dominated, herbaceous-dominated, and non-vegetative types. The key criterion for tree-dominated types is that at least 10 percent of the area is covered in trees. Size and density classes within vegetation types are explained in Table 5-2. The LCMMP data only includes size and density information for tree-dominated types.

Table 5-2
THE CALIFORNIA WILDLIFE HABITAT RELATIONSHIPS CLASSIFICATION SYSTEM FOR TREE-DOMINATED HABITATS

Classification Attribute	Classification Scheme		
Size	1	Average tree diameter:	< 1 inch
	2	Average tree diameter:	1-6 inches
	3	Average tree diameter:	6-11 inches
	4	Average tree diameter:	11-24 inches
	5	Average tree diameter:	> 24 inches
Density	S	Canopy closure:	10-25 %
	P	Canopy closure:	25-40 %
	M	Canopy closure:	40-60 %
	D	Canopy closure:	60-100 %

The CWHR system was developed to classify vegetative communities based on plot measurements collected on-the-ground. The minimum mapping unit for this process is generally 40 acres. In contrast, the LCMMP mapping is derived from satellite imagery and the minimum mapping unit is

Table 5-3 GROUPING OF LCMMP VEGETATION CATEGORIES INTO "LIFEFORMS" AND THE CROSSWALK BETWEEN CWHR AND CALVEG CLASSIFICATIONS		
Dominant Vegetation Lifeform	**CWHR Types Included in Lifeform**	**CALVEG Types Included in Lifeform**
Blue Oak and Foothill Pine	Blue Oak Woodland (BOW) Blue Oak-Foothill Pine (BOP)	Blue Oak (QD) Gray Pine (PD)
Various Hardwoods and Deciduous Trees	Montane Hardwood-Conifer (MHC) Montane Hardwood (MHW) Valley Oak Woodland (VOW) Montane Riparian (MRI)	California Black Oak (QK) Interior Live Oak (QW) Canyon Live Oak (QC) Valley Oak (QL) Freemont Cottonwood (QF) Knobcone Pine (KP) Gray Pine (PD)
Chaparral	Mixed Chaparral (MCH)	Whiteleaf Manzanita (CW) Northern Mixed Chaparral (CQ)
Herbaceous Plants	Annual Grassland (AGS) Cropland (CRP)	Annual Grass / Forbs (HG) Agriculture (AG)
Riparian*	n/a	n/a
Wetlands*	n/a	n/a
Knobcone Pine	Closed-Cone Pine-Cypress (CPC)	Knobcone Pine (KP)
Ponderosa Pine	Ponderosa Pine (PPN)	Ponderosa Pine (PP)
Urban	Urban (URB)	Urban / Developed (UB)
Other	Barren (BAR) Douglas-Fir (DFR)	Barren / Rock (BA) Douglass-Fir – Pine (DP)

Notes: The LCMMP imagery assigns primary and secondary CALVEG classifications to map polygons. This process facilitates cross walking with CWHR categories. For example, a polygon with a primary Gray Pine and a secondary California Black Oak classification may be cross walked to Montane-Hardwood Conifer.
* The LCMMP imagery is insufficient for mapping these lifeforms.

2.5 acres. Although the methods for transforming spectral data into CWHR classifications have been ground truthed to increase accuracy, the raw LCMMP data for the Shasta West Watershed should not be taken at face value. The classification and mapping of individual polygons cannot be assumed to reflect actual on-the-ground vegetative conditions in specific locations as small as 2.5 acres. However, grouping some of the raw categories in multiple ways can minimize the LCMMP data error. First, size and density information about CWHR types presented in this assessment was not made spatially explicit. Second, similar CWHR types were grouped into "lifeforms" that represent the dominant vegetation found in places in the watershed. This grouping was based on comparison of the LCMMP data with aerial photographs and on-the-ground knowledge. For example, LCMMP mapping of polygons classified as either the "Blue Oak-Foothill Pine" or "Blue Oak Woodland" CWHR types were grouped into the "Blue Oak and Foothill Pine" lifeform, because actual vegetation conditions were observed to be most often a mix of blue oak and foothill pine. The lifeforms represent groups for which mapping and acreage estimates were deemed most reliable. However, the finer grained data about CWHR types and size and density classes is identified, discussed, and qualified when reference to more specific information is warranted.

Satellite imagery is not well suited for mapping the distribution of narrow linear features such as valley foothill riparian vegetation. For this watershed assessment, the amount of riparian lifeform was coarsely estimated by buffering rivers and intermittent streams in the watershed by six meters on each side in areas where the LCMMP imagery showed forest vegetation.

Wetlands were delineated from water bodies shown on topographic maps.

DISTRIBUTION AND CONDITION OF VEGETATIVE COMMUNITIES

Table 5-4 provides estimates for the relative amounts of dominant vegetation lifeforms in the watershed. Mapping of these lifeforms is shown on Figure 5-1. Oak woodlands are the most widespread vegetative community. Chaparral is also widespread, but occurs in greater concentration in the Salt, Middle, and Rock Creek drainages. Together, knobcone pine and ponderosa pine dominated communities' cover less than 10 percent of the watershed, but these varieties continue in greater abundance to the west and north of the watershed. Although biologically important, riparian forest is estimated to cover only about 1 percent of the watershed.

Table 5-4
VEGETATIVE COMMUNITIES IN THE SHASTA WEST WATERSHED (LCCMP)

Dominant Vegetation Lifeform	Percent Area	Acres
Blue Oak and Foothill Pine	**34 %**	**10,150**
Various Hardwoods or Other Deciduous Trees	**7 %**	**2,000**
Chaparral	**25 %**	**7,500**
Herbaceous Plants	**4 %**	**1,200**
Riparian*	**1 %**	**300**
Wetlands*	**<1 %**	**50-150**
Knobcone Pine	**6 %**	**1,750**
Ponderosa Pine	**2 %**	**550**
Urban	**21 %**	**6,250**
Other	**<1 %**	**194**

*Notes: The estimated amounts for riparian and wetland lifeforms were not based solely on the LCMMP data. The amount of riparian lifeform was coarsely estimated by buffering rivers and intermittent streams in the watershed by six meters on each side in areas where LCMMP imagery showed forest vegetation. The amount of wetlands was estimated by delineating water bodies shown on topographic maps.

A study of black and white aerial photography for the watershed provided a quality check on the information presented in Table 5-4 and Figure 5-1. The LCMMP imagery sometimes confused the designation of lightly wooded areas versus shrub and herbaceous types. In other words, some areas were mapped as the blue oak and foothill pine lifeform may actually be chaparral or annual grassland. Misclassification was more likely to occur where low-density scattered oaks and pines exist over shrubs or grasses. This ambiguity is not a serious problem if one considers that the actual distribution pattern of oaks, foothill pine, shrubs, and grasses in the watershed is a mosaic rather than a well-separated assemblage of distinct types. The LCMMP imagery classified "urban" areas as covering about one quarter of the watershed. Inspection of the aerial photography shows that isolated semi-rural houses and suburban areas (e.g., cull de sac neighborhoods adjacent to trees or brush) were sometimes mistakenly categorized as the blue oak and foothill pine or chaparral lifeforms. In these situations, the vegetative type was often given a sparse (S) or open (P) density class by the LCMMP classification algorithms.

Figure 5-2a and 5-2b shows pictures of CWHR vegetative communities represented by the lifeforms identified from the LCMMP imagery. These pictures are from locations in the watershed. They illustrate the conditions described below.

Blue Oak and Foothill Pine

Oak woodlands are the dominant vegetative community in the watershed, accounting for 30 to 40 percent of the area. The vast majority of oak woodlands in the watershed can be categorized as the blue oak-foothill pine CWHR type. The structure of this CWHR habitat type is naturally quite complex. A mix of blue oak (*Quercus douglasii*) and foothill pine (*Pinus sabiniana*) characterize the overstory. Historically frequent fires and generally shallow soils maintained openings of grasses and shrubs within a patchy mosaic of trees. Intermittent streams further enhance the diversity of this habitat by bisecting the oaks with narrow bands of riparian vegetation, such as Fremont cottonwood (*Populus fremontii*) and willow (*Salix spp*.).

Blue oaks and foothill pines are well adapted to natural conditions in the watershed. Both species share a high tolerance for drought. In the past, frequent fires promoted the establishment of blue oak, a stump sprouting species. As isolated individuals in gaps after fires or dense stands following large fires, foothill pine also regenerated more successfully. Drier, harsher sites tend to support a chaparral and grass understory. Mesic sites are characterized by locally abundant occurrences of black oak (*Quercus kelloggii*) and poison oak (*Rhus diversiloba*). In the absence of fire, a denser vegetative community has developed across the blue oak-foothill pine type that includes interior live oak (*Quercus wislizenii* var. *wislizenii);* California buckeye *(Aesculus californica;,* whiteleaf manzanita (*Arctostaphylos viscida*); poison oak; and California redbud (*Cercis occidentalis*).

Despite the effects of fire suppression, edaphic conditions (e.g., soil and water) may be one factor limiting the trend towards overly dense stands of oak-pine woodland. The LCMMP data set suggests that blue oak and foothill pine woodland in the watershed is not universally overstocked. There is still considerable diversity in terms of stand canopy closure for this vegetation type (Figure 5-2a&b, Figure 5-3). The LCMMP imagery suggests that almost half of the blue oak and foothill pine woodland is in an open condition where canopy closure is below 40 percent. A visual inspection of the aerial photographs for the watershed confirms this conclusion. Dense clumps of oak and pine are broken apart by small openings containing grasses and shrubs. In the absence of regular fires, thin rocky soils and low water tables may contribute to the persistence of these openings. On the other hand, a significant amount of the less dense portions of blue oak foothill pine appears to coincide with areas of suburban or dispersed, semi-rural housing.

The total area of California oak woodlands has been reduced by about one third since European settlement (CalPIF, 2002). More recently, between 1945 and 1985, it is estimated that 1.2 million acres (16 percent) of California's remaining 7.4 million acres of hardwood woodlands were converted through woodcutting and other forms of clearing (Bolsinger, 1988). Today, urbanization and development fueled by the State's increasing population continue to "chip away" at oak woodlands. This trend is of particular relevance within the Shasta West Watershed. Invasion of non-native grassland species also degrade the quality of remaining oak woodlands.

Natural regeneration of blue oaks is widely recognized as a statewide problem. The results of research conducted over the last decade indicate that blue oak sapling populations may be insufficient to maintain current stand densities of oaks (Swiecki and Bernhardt, 1998). The causes of this problem are complex and not fully understood, but may include grazing and fire exclusion leading to overstocking of shrubs and invasion of non-native grasses (CalPIF, 2002). Swiecki and Bernhardt (1998) have developed a conceptual model for blue oak regeneration. They hypothesize that tenacious seedlings struggle for years in arid conditions under the suppression of parent trees. The "advance regeneration" builds up root capacity so that it is able to "release" and grow quickly after a parent tree dies or is otherwise removed. Swiecki and Berhardt warn that the reintroduction of prescribed frequent burning may counter-intuitively do more harm than good for blue oak regeneration. This is because blue oak is fire tolerant rather than fire dependent. The authors recommend that the release of oak seedlings and saplings (presumably by means of harvest) be timed to coincide with the narrow window of time when advance regeneration is in optimum condition.

Various Hardwoods and Deciduous Trees

The LCMMP imagery identifies 2,000 acres of other hardwood and deciduous CWHR types. Comparison of this imagery with aerial photographs suggests the classification of these CWHR types in the watershed may not be processed well by the LCMMP imagery. This lifeform includes LCMMP polygons classified as montane hardwood-conifer, montane hardwood, montane riparian and valley oak woodland CWHR types. In actuality, areas mapped as this lifeform may include the valley foothill riparian and valley oak woodland CWHR types, and concentrations of black oak or live oak within other CWHR types such as blue oak-foothill pine, mixed chaparral and closed cone pine-cypress.

The LCMMP imagery identifies 200 acres of the valley oak woodland CWHR type. Most of this area is mapped along the Sacramento River. Some of the places identified as valley oak woodland more closely resemble the valley foothill riparian CWHR type where valley oak is a dominant component in the overstory.

Black oak is generally found on wetter, higher elevation sites than where blue oak is dominant. Consequently, black oak becomes a more important species as one moves up drainages in the watershed. It may dominate small stands in places. Interior live oak occurs as a component of all forested communities in the watershed. Because of its thin bark and relative intolerance to fire, the abundance and distribution of live oak has likely increased throughout the watershed due to fire suppression. Because evergreen trees do not lose their leaves in winter, the wide spreading crowns of live oaks were disproportionately damaged by the heavy snows of December 2003.

Chaparral

The word "chaparral" comes from the Spanish word "chaparro" meaning scrub oak. Roughly, the shrub-dominated "mixed chaparral" CWHR type covers one quarter of the watershed. However, it is manzanita that characterizes the condition of this ecological community in the watershed. Scattered foothill or ponderosa pines and clumps of knobcone pine rise above dense seas of brush. In particular, thickets of manazanita that are practically impenetrable except for fire roads and tunnel-like trails, dominate the terrain between Middle and Rock Creeks.

A variety of mixed chaparral shrub species occurs in the watershed. The most common species is whiteleaf manzanita *(Arctostaphylos viscida),* which generally grows on shallow soils often derived from ultra-mafic material (Sawyer and Keeler-Wolf, 1995). It typically occurs at elevations from 500 feet to 3500 feet, and is common on south facing slopes. Associated shrub species include chamise *(Adenostoma fasciculatum);* greenleaf manzanita *(Arctostaphylos manzanita);* buckbrush *(Ceanothus cuneatus);*

mountain whitethorn *(Ceanothus cordulatus);* deerbrush *(Ceanothus integerrimus);* and scrub oak *(Quercus berberidifolia).*

The distribution of mixed chaparral in the watershed is concentrated in the Salt, Middle, and Rock Creek drainages. This may partially be the result of historic copper smelting operations around the Keswick area that exposed and denuded soils (Kristofors, 1973). Fire suppression is one reason for the dense, decadent, and homogenous quality of this vegetative type in the watershed. Chaparral is a fire-adapted community. It does well following catastrophic fire when manzanita and other brush species are often a transitional stage before succession to oak and pine forests. Many chaparral species have reproductive methods that are dependent on periodic fires. In the absence of fire, chaparral stands often become overly dense and decadent resulting in increased risk of high intensity wildfire. Also, manzanita and other chaparral species can be significant invaders to annual grassland and oak woodland types. When some brush species such as buckbrush become dominant, they start to lose their nutritional value for browse species, such as mule deer.

Herbaceous Plants

Vegetative communities dominated by herbaceous plants account for less than five percent of the Shasta West Watershed. Annual grassland and cropland are the two CWHR types in this lifeform. The vast majority classified by the LCMMP imagery is annual grassland. However, agricultural lands, such as strawberry fields south of Bonnyview Road, cover at least 100 acres throughout the watershed.

According to the LCMMP imagery, very few of the patches of grassland within the watershed are larger than 20 acres. Only 4 patches are larger than 50 acres, whereas over 50 mapped grasslands are less than 10 acres in size. The quality of grassland habitat has been degraded by the invasion of non-native grasses that replace native bunch grasses and reduce vegetation diversity and complexity. Fire suppression has permitted dense chaparral and woodlands to encroach and fill more of the watershed than was the case historically.

A degraded area near the Benton Airport is one of the larger patches of annual grassland in the watershed. Yellow star thistle (*Centaurea solstitialis*) and other noxious weeds dominate much of its area (Furnas, pers. obs., 2004).

Historically, California native grasslands included a large component of perennial bunch grasses. Throughout much of the Sacramento Valley and foothill areas, non-native annual grasses originally brought to California by European settlers have replaced native grasses. Native grasses often require fire for regeneration success and revitalization. Some of the native grasses and other native herbaceous plants that are associated with grasslands and may potentially occur in the watershed are:

- Purple needlegrass *(Nassella pulchra)*,
- California oatgrass *(Danthonia californica* var. *americana*),
- Small fescue (*Vulpia microstachys*),
- Squirrel tail (*Elymus elymoides*),
- Blue wild rye (*Elymus glaucus*)
- Bluedicks *(Dichelostemma capitatum)*,
- Indian soap root (*Chlorogalum pomeridianum* var. *divaricatum*),

- California brodiaea (*Brodiaea californica*), and
- Wild onion (*Allium* spp.)

Non-native grasses now dominate the Sacramento Valley and extend into the blue oak and foothill pine zone. Some common non-native grasses and associated non-native herbaceous plants that may potentially occur in the watershed include:

- Wild oat (*Avena fatua*),
- Foxtail chess *(Bromus madritensis),*
- Soft chess (*Bromus hordeaceus),*
- Ryegrass *(Lolium perenne),*
- Dogtail grass *(Cynosurus echinatus),*
- Barbed goatgrass (*Aegilops triuncialis*)
- Ripgut brome *(Bromus diandrus*), and
- Cheatgrass (*Bromus tectorum*)

Riparian

Throughout California, native riparian vegetation covers less than 5 percent of its historic range and makes up less than 0.5 percent of the State's land area (RHJV 2000). Information on the valley foothill riparian CWHR type in the watershed is limited. The LCMMP data is not well suited for mapping riparian vegetation. Also, the use of aerial photographs for evaluating riparian vegetation was beyond the scope of this assessment. In lieu of a more detailed assessment, 6-meter GIS buffering of Shasta West streams were used to roughly estimate the percent of valley foothill riparian in watershed at about 1 percent (e.g., 300 acres).

The availability of water either in rivers or close to the surface below intermittent streams makes narrow strips of riparian woodland in the watershed particularly productive. The valley foothill riparian CWHR type is characterized by Fremont cottonwood *(Populus fremontii)* and valley oak (*Quercus lobata*) in the overstory. California Sycamore (*Platanus racemosa*) is not an overstory component in Shasta West riparian woodlands. The understory of this vegetation types is typically a dense assemblage of water-loving plants including red willow *(Salix laevigata);* sandbar willow *(Salix exigua);* California blackberry *(Rubus ursinus);* mugwort *(Artemisia douglasiana);* blue elderberry *(Sambucus mexicana);* California button-willow *(Cephalanthus occidentalis);* mule fat *(Baccharis salicifolia);* California wild grape *(Vitis californica);* pipe vine *(Aristolochia californica);* and virgins bower *(Clematis ligusticifolia).*

The occurrence of the valley foothill riparian CWHR type in the watershed differs in form depending on whether it is found along the Sacramento River or the small tributaries that span the watershed. Riparian forest dominated by large valley oaks and cottonwoods exists in patches along the Sacramento River and lower portions of Olney Creek. It may also occur on the lower portion of other creeks. This ecological system has adapted to periodic inundation along a meandering floodplain where regeneration gaps are formed by the demise of larger trees killed by floods or windfall. This disturbance regime can lead to a structurally complex "gallery" of riparian forest. However, the channelizaton and urbanization of the Sacramento River through Redding has impaired riparian function and greatly reduced the occurrence of valley foothill riparian forest along the watershed boundary.

The two largest remaining patches of Sacramento River riparian forest within the watershed exist at the bends in the river at Turtle Bay and the South Bonnyview boat ramp. Much of the riparian forest to the south of the Bonnyview boat ramp lies on undeveloped private land and extends into non-riparian valley oak and grassland communities. To the north of the boat ramp, most of the remnant valley foothill riparian and adjacent valley oak woodland has been converted into a golf course and housing development. Patches of structurally complex valley foothill riparian dominated by valley oak persist along Olney Creek (Figure 5-4) and continue to the west of Highway 273. However, much of the mature riparian vegetation that was historically supported along the lower stretches of Olney Creek has been fragmented and narrowed in width by suburban housing and another golf course.

A shorter-statured and structurally less complex form of riparian vegetation exists along the watershed's foothill streams that include Canyon and Salt Creeks where small stretches of cottonwoods, willow, elderberry, and other riparian plants enhance blue oak-foothill pine and chaparral habitats. An excellent example can be viewed along Buenaventura between Highway 273 and Placer. This type of riparian habitat is more complex in flatter areas where the floodplain is wider and the water table is higher. In other places it is almost non-existent. The transition between mesic and arid conditions tends to make the areas around the watershed's intermittent creeks particularly rich floristically. A member of the local chapter of the California Native Plant Society inventoried the stretch of Salt Creek between the river trail and Highway 299. He found 221 different species of plants encompassing 70 different families (Fritchle, 2003). Another survey conducted along upper Canyon Creek identified 128 different species of plants of which many were exotic. The complete survey results are included as Appendix A to this watershed assessment.

Besides its rarity and floristic biodiversity, valley foothill riparian forest is key to the watershed because of its value to fish and wildlife. Riparian forest shades and contributes to the structure of stream habitats supporting resident trout and anadromous salmonids. It provides nesting cover for a variety of neo-tropical migrant birds that return to the watershed in the spring and summer to breed. Riparian forest also provides a sheltered corridor for animals moving through developed and fragmented environments as they move to areas higher up or west of the watershed.

In the watershed, invasive plants such as Himalayan blackberry (*Rubus discolor*), Johnson grass *(Sorghum halepense),* common fig *(Ficus carica),* and giant reed *(Arundo donax)* have significantly affected the Valley foothill riparian habitat. These exotic invaders displace native species and reduce habitat complexity. For example, giant reed has established itself extensively along Canyon Creek (Figure 5-4). It is so thick and tall that it excludes all other riparian vegetation in places (Furnas, pers. obs., 2004). Scotch broom (*Cytisus scoparius*) and tree of heaven (*Ailanthus altissima*) are also riparian invaders. To demonstrate the extent to which exotic plants are impacting riparian areas, it should be noted that 42 percent of the plants inventoried by Fritchle (2003) along Salt Creek were exotic in origin.

Wetlands

The LCMMP data set provides limited information on the distribution of wetlands within the watershed. Consequently, potential wetlands were identified from water bodies shown on topographic maps. The maps showed 14 small lakes and upland ponds totaling 49 acres. The average size of these water bodies was estimated at three acres. An additional 104 acres of backwater pools and ponds associated with the Sacramento River were also identified.

No information was readily available for assessing the quality of wetland vegetation in the watershed. In general, plants associated with hydric conditions grow in association with wet and seasonally wet areas. The fresh emergent wetland CWHR type is characterized by plants such as narrow leaf cattail (*Typha angustifolia*) and other monocots adapted to anaerobic saturated soil conditions. Rushes (*Juncus* spp.) and sedges (*Carex* spp.) often grow along the periphery.

No vernal pools were identified from the Natural Diversity Database as occurring in the watershed, although vernal pools are documented nearby to the east of the Sacramento River. Vernal pools are seasonally flooded depressions in the land underlain by a hardpan soil layer that limits drainage. They fill with water in the winter, flourish with life in the spring, and dry out in the summer. These pools occur singly or in complexes. They differ from other ephemeral wetlands in that they often support a specialized set of plants and animals including a relatively large number of threatened and endangered species.

Information collected as part of an environmental assessment for the proposed West Ridge Master Plan Project (NSR, 2003) identified 0.15 acre of vernal pools and 0.11 acre of intermittent pools within a 400-acre study area along the upper reaches of Canyon Creek. It is possible that there are other small vernal pools in the watershed. These habitats as well as other wetlands such as stock ponds may support vernal pool associated species such as fairy shrimp (*Branchinecta lynchi*) and tadpole shrimp (*Lepidurus packardi*) (Lis, pers. comm., 2004).

Knobcone Pine/Ponderosa Pine

Together, the closed-cone pine cypress and ponderosa pine CWHR types make up less than 10 percent of the Shasta West Watershed. Dense, even-aged stands of knobcone pine *(Pinus attenuate)* cover much of the northwest edge of the watershed above Swasey Drive and the town of Old Shasta. The LCMMP data show that two thirds of this community exists in dense conditions above 60 percent canopy cover. Knobcone is a serotinous species adapted to regeneration after catastrophic fire kills entire stands of mature trees. The heat of fire releases seed from resin sealed cones that otherwise remain closed on live trees for years. Small stands of knobcone pine are also scattered throughout the chaparral community common in the northeastern portion of the watershed.

The LCMMP data indicates that most of the 600 acres of ponderosa pine type that covers the upper Rock Creek drainage is in a highly open condition; 80 percent of the area of these ponderosa pine stands has less than 40 percent canopy cover, 50 percent has less than 25 percent cover. It is likely that the legacy of copper smelting (Kristofors, 1973) is a factor affecting soils and site potential for ponderosa pine in this region. Visual inspection of the area shows that much of the groundstory is covered by manzanita and other chaparral species (Furnas, pers. obs., 2003).

Urban

Significant change in the original vegetation of the 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 recognized as typical garden weeds and generally are not known to be non-native. Himalayan blackberries can be attributed to Mr. Luther Burbank who imported them to California because of their larger more flavorful fruit. This non-native has proliferated in the watershed and now lines the creek banks in many areas within the watershed. Star thistle, 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 areas after the ground has been disturbed. The majority of the original native grassland is gone. Many other ornamental plants have escaped yards and other urban plantings and have become critical problems in the watershed. These include scotch broom, tree of heaven, and giant reed. A list of most common non-native invaders is included in Table 5-5

According to the 2001 LCMMP imagery, predominately urban areas cover at least 20 percent of the watershed. Ironically, plant diversity may potentially be higher in urban areas than some native vegetative communities. However, the majority of plant species in the urban setting are exotic in origin. For example, the list of street trees listed on the City of Redding's "Comprehensive Tree Plan" (http://www.ci.redding.ca.us/devserv/pdfs/planning/treeplan.pdf) includes over 60 generally non-native trees. It is likely that residential gardens and landscaping throughout Redding include hundreds of species of mostly exotic shrubs and herbaceous plants.

Disturbed soils associated with urban development and road systems can facilitate the spread of invasive exotic weeds. In the Shasta West Watershed, invasive plants such as tree of heaven and yellow star thistle are common on disturbed sites in urban areas and along roads (Furnas, pers. obs., 2004)

EFFECTS OF HISTORICAL COPPER SMELTING ON VEGETATION

Between 1896 and 1919, Shasta County was one of the most industrious copper producing regions in the United States. Unfortunately, the pollution and erosion arising from the smelting operations had a lasting impact on the distribution and productivity of watershed vegetation. Smelting was undertaken near local mines in order to purify the copper ore. During the heyday of the mining era, the fumes were so noxious that the federal government intervened to force companies to shut down the smelters. Kristofors (1973) provides an excellent account of the mining history and its environmental impacts.

There were numerous mines and smelters along the Sacramento River and its tributaries between Keswick and the old town of Kennett (i.e., now flooded behind Shasta Dam). The smelter at Keswick was only in operation for nine years between 1896 and 1905 when it was forced to close by federal injunction. However, the smelter at Keswick employed an open air roasting process for pre-

Table 5-5 COMMON NON-NATIVE WEEDS	
Knapweed (all sp)	*Acroptilon repens; Centaurea diffusa, C. maculosa, C. pratensis, C. virgata*
Goat Grass	*Aegilops cylindrical*
Tree of Heaven	*Ailanthus altissima*
Pigweed (all sp)	*Amaranthus albus, A. blitoides, A. palmeri, A. retroflexus.*
Chamomile	*Anthemis cotula*
Giant Reed	*Arundo donux*
Wild Oat	*Avena fatua*
Wild and Black Mustard	*Brassica kaber, B. nigra*
Rescue Grass	*Bromus catharticus*
Japanese Brome	*Bromus japonicus*
Soft Brome	*Bromus mollis*
Ripgut Brome.	*Bromus rigidus*
Cheat Grass	*Bromus secalinus*
Downy Brome	*Bromus tectorum*
Musk	*Carduus nutans*
Italian	*Carduus pycnocephalus*
Wild Caraway	*Carum carvi*
Bachelors Button	*Centaurea cyanus*
Yellow Star Thistle	*Centaurea solstitialis*
Nettleleaf Goosefoot	*Chenopodium murale*
Oxeye Daisy	*Chrysanthemum leucanthemum*
Chicory	*Cichorium intybus*
Poison Hemlock	*Conium maculatum*
Fleabane	*Conyza bonariensis*
Hawksbeard	*Crepis setosa*
Bermuda Grass	*Cynodon dactylon*
Scotch Broom	*Cytisus scoparius*
Teasel	*Dipsacus fullonum*
Quack Grass	*Elytrigia repens*
French Broom	*Genista monspessulana*
Mallow (all sp)	*Hibiscus tronum, Malva neglecta*
Velvet Grass	*Holcus lanatus*
Foxtail Barley	*Hordeum jubatum*
Hare Barley (Common Foxtail)	*Hordeum leporinum*
Klamath Weed	*Hypericum perforatum*
False Dandelion	*Hypochaeris radicata*
Prickly Lettuce	*Lactuca serriola*
Peavine	*Lathyrus latifolius*
Perennial Pepperweed	*Lepidium latifolium*
Italian Ryegrass	*Lolium multiflorum*
Horehound	*Marrubium vulgare*
Sweetclovers (all)	*Melilotus officinalis*
Creeping Woodsorrel	*Oxalis corniculata*
Littleseed Canarygrass	*Phalaris minor*
Buckhorn Plantain	*Plantago lanceolata*
Rabbitfoot Polypogon	*Polypogon monspeliensis*
Buttercup	*Ranunculus acris, R. repens, R. testiculatus*
Himalayan Blackberry	*Rubus discolor*
Curly Dock	*Rumex crispus*
Common Rye	*Secale cereale*
Sowthistle	*Sonchus arvensis, S. uliginosus, S. asper, S. oleraceus*
Johnsongrass	*Sorghum halepense*
Medusahead	*Taeniatherum caputmedusae*

Table 5-5 (continued) **COMMON NON-NATIVE WEEDS**	
Dandelion	*Taraxacum officinale*
Field Pennycress	*Thlaspi arvense*
Puncturevine	*Tribulus terrestris*
Common and Mouth Mullein	*Verbascum blattaria, V. thapsus*
Hairy Vetch	*Vicia villosa*

treating the ore. This method was particularly dirty in its proliferation of fumes to the surrounding landscape. It is reported that the high levels of sulfur dioxide released from the ore quickly destroyed all vegetation within a radius of several miles. This denudation would have included large portions of the Rock and Middle Creek drainages. After the loss of large areas of vegetation, rains eroded away topsoil through sheet erosion and gully formation. The erosion has had lasting effects on soil productivity and may help explain the occurrence of brush fields and open pine forests in the northwestern portion of the watershed. As late as 1939, much of the lower and northern portions of the Rock Creek drainage were reported as still remaining in a semi-barren condition.

The channeling of winds down through the Sacramento Canyon from Kennett dispersed toxic fumes from multiple smelters across the entirety of the watershed. Concentrations of sulfur dioxide as low as 0.3 parts per million can damage plants. During the mining era severe damage to agricultural plants was experienced as far south as Anderson.

EFFECTS OF URBANIZATION ON VEGETATION

The LCMMP data shows that over 20 percent of the Shasta West Watershed was urban in 2001. This mapping corresponds to the most developed and highest density urban areas in West Redding. However, some of the areas mapped as open canopy forest or chaparral are actually the edges around suburban development and individual houses scattered throughout a semi-rural matrix of homes and natural vegetation.

Suburban and semi-rural development in the watershed tends to fragment and degrade natural vegetative communities and wildlife habitats. For example, residential sites and associated roads system can facilitate the spread of invasive exotic plants that displace native vegetation. Residential development also increases the need to prevent natural fires in order to protect property and lives. Based on the amount of private land in the watershed, as much 60 percent of watershed is subject to some degree of degradation of natural vegetative communities, due to suburban and semi-rural development. This amount is in addition to those areas permanently altered by high-density urban development.

An example of fragmentation in the wildland-urban interface in the Canyon Creek drainage is shown in Figure 5-6. An examination of year 2000 census data provides a supplemental source of data for analyzing where native vegetation fragmentation may be occurring. The census data shows that outside of the heavily urbanized downtown and the Highway 273 corridor areas, the Jenny Creek, Canyon Creek, and lower Olney Creek drainages have the highest population densities (e.g., 1,000-2,000 people per square mile). The middle portions of Oregon Gulch and Salt Creek drainages have moderate population densities of between 100 and 1,000 people per square mile. Rock Creek and the upper regions of Olney, Middle, and Salt Creek drainages contain significant amounts of undeveloped public land and have as few as 10 people per square mile. Larger patches of undeveloped land typically provide higher quality wildlife habitat. However, lands managed by the Bureau of Land Management and the National Park Service cover less than 20 percent of the watershed.

SPECIAL-STATUS PLANTS

Special-status plants are species that are protected under the California and federal Endangered Species Acts, or other regulations. Special-status plants are also species considered sufficiently rare by the scientific community that they qualify for consideration and/or protection pursuant to the California Environmental Quality Act (CEQA).

Categories of special-status plants include:

- 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), or listed as rare 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 the California Native Plant Society (CNPS) to be "rare, threatened, or endangered in California" (Lists lB and 2 in CNPS 2001)
- 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 CNPS 2001), which may be included as special-status species on the basis of local significance or recent biological information

Review of available literature (Munz and Keck, 1968; Hickman, 1993; CalFlora, 2003) and searches of the CNDDB (March 2003 data) and the CNPS Inventory of Rare Plants (CNPS, 2001; CNPS, 2003) indicate that no special status plants are part of the Shasta West Watershed. However, numerous special-status plants are currently in the vicinity of the watershed (Table 5-5). It is possible that many of these plants may occur within the watershed, but have not yet been documented. However, it is also possible that the habitats and ecological settings necessary for many of these plants do not occur (or are very infrequent) in the watershed. In particular, the soil conditions that support vernal pool associated rare plants are uncommon in the watershed, but are common in the nearby Stillwater and Millville plains areas, and other local areas east of Interstate 5 (Figura, pers. comm., 2003).

A review of the two floristic surveys along Salt and Canyon Creeks (Fritchle 2003) was conducted to further assess the potential for special status plants occurring in the watershed. None of the special status plants listed in Table 5-5 was reported found in the surveys.

EXOTIC INVASIVE PLANTS AND OTHER NOXIOUS WEEDS

Some experts consider invasive species to be a serious threat to global biodiversity second in importance only to direct habitat loss and fragmentation. Invasive plants are usually non-native species that spread easily and displace native species. Due to the state's varied topography, geology, and climate, the problem of these "weeds" in California is widespread and serious. Invasive plants can adversely impact native vegetative communities by altering patterns of nutrient cycling, hydrological processes, and the intensity of fire (Bossard et. al., 2000).

Giant reed (*Arundo donax*) is an example of a weed that invades riparian areas in the watershed and chokes out native vegetation. This plant was brought to North America for cultivation and use as roofing material. By 1820, it was already abundant along the Los Angeles River. Unfortunately, giant reed consumes three times more water than native plants (Shasta County Weed Management Area, undated). A variety of other exotic invaders are also a serious threat to California native grasslands

The California Department of Food and Agriculture (CDFA) uses an action-oriented pest-rating system. The rating assigned to a pest by the CDFA does not necessarily mean that one with a low rating is not a problem. The rating system is meant to prioritize response by CDFA and County Agricultural Commissioners. Plants on the CDFA's highest priority "A" list are defined as plants, "of known economic importance subject to state-county enforced action involving eradication, quarantine regulation, containment, rejection, or other holding action." According to the CDFA, there are five plants from the CDFA "A" list known to occur in Shasta County (Perosco, pers. Comm., 2003). These plants are listed in Table 5-5. However, the "A" lists plants named are more likely to be found in eastern Shasta County (Martin, pers. comm., 2003).

A group of technical experts called the Exotic Pest Plant Council (CalEPPC) has 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 pose serious problems in wildlands (i.e., natural areas that support native ecosystems, including national, state, and local parks; ecological reserves; wildlife areas; national forests; BLM lands; etc.). Plants found mainly in disturbed areas, such as roadsides and agricultural fields, and plants that establish sparingly and have minimal impact on natural habitats are not included on the list. The 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.

CalEPPC-listed plants found in Shasta County are listed in Table 5-7. According to staff at the Shasta County Department of Agriculture (Martin, pers. comm., 2003), Scotch broom (*Cytisus scoparius*); giant reed (*Arundo donax*); rattlebox (*Sesbania punicea*); skeleton weed (*Eriogonum spp.*); tree of heaven (*Ailanthus altissima);* puncture weed (*Tribulus terrestris*); yellow star thistle (*Centaurea solstitialis*); and various *Euphorbia* (e.g., oblong spurge) are the invasive plants likely to be encountered in the watershed.

It is typically easier to control small populations of weeds before they become established in an area. Once a species of invasive plant has spread into a native vegetative community or cultivated land it can be very difficult to eradicate. Abundantly produced seeds allow many weeds to spread quickly; grow on a variety of soils; spread rapidly; and re-colonize a site after a control treatment. Deep, spreading root systems also help some weeds to spread and recover after control efforts. Weed control methods include cultural control (e.g., management of livestock grazing); physical control (e.g., burning, hand pulling), chemical control (e.g., selective or non-selective herbicides); and biological control (e.g., insects that eat the weed, selective grazing by goats). Several years of repeat treatments as well as a combination of methods are often part of an effective strategy for eradicating a weed species from an area.

Weed Management Areas are local organizations that bring together various private and government officials to cooperatively coordinate efforts for controlling the spread of common invasive plants. Over the last few years, Shasta County Weed Management Area control projects in Shasta West Watershed have included removal of scotch broom along Highway 299 and rattlebox along Highway 273 (Martin, pers. comm., 2003). Aside from state and federal agencies, other local organizations involved in invasive plant control include, Redding Rotary, The City of Redding, The Western Shasta Resource Conservation District, local area schools, and concerned citizens.

Table 5-6 SPECIAL-STATUS PLANTS KNOWN FROM THE VICINITY OF THE SHASTA WEST WATERSHED							
Common Name	**Scientific Name**	**Legal Status* (Fed/CA/CNPS List/CNPS R-E-D)**	**Distribution****	**Habitat****	**Known from Shasta West ?**	**Other Nearby Occurrences?**	**Estimated Potential for Occurrence in the Shasta West Watershed**
Henderson's bent grass	*Agrostis hendersonii*	None/None/3/3-2-2	Scattered occurrences in Shasta, Tehama, Butte, Calaveras, and Merced counties	Seasonally wet areas in valley and foothill grassland; vernal pools	No	Near Airport Road and Hwy. 44; also near Clough Creek (northwest of Palo Cedro)	Unlikely – lack of vernally wet grassland/woodland habitats and/or vernal pools
Pointed broom sedge	*Carex scoparia*	None/None/2/3-2-1	One verified California occurrence in Shasta County; also known from Oregon, other states	Generally occurs in open wet areas; meadows, shores, springs, etc.	No	Near the Anderson-Cottonwood Irrigation Ditch south of Anderson	Could potentially occur in open riparian habitats
Fox Sedge	*Carex vulpinoidea*	None/None/2/2-2-1	Shasta, Tehama, and Butte, and Siskiyou counties in California; also known from AZ, OR, other states	Wet areas; marshes and riparian woodlands	No	Near the junction of Spring Gulch Road and Highway 273 in Anderson	Could potentially occur in marshes and riparian habitats
Northern clarkia	*Clarkia borealis* ssp. B*orealis*	None/None/1B/2-1-3	Known from scattered occurrences in northern Shasta County	Openings within chaparral, foothill woodlands, forest margins	No	Near both O'Brien and Salt Creek Inlet (Shasta Lake area)	Could potentially occur in chaparral and woodland areas
Silky cryptantha	*Cryptantha crinita*	None/None/1B/3-2-3	Known from several larger creeks in Shasta and Tehama counties	Open streambeds with cobble, gravel bars streambeds	No	Stillwater Creek, Cow Creek, Dry Creek, Olinda Creek, Anderson Creek	Could potentially occur along large creeks with open bars and/or cobble areas
Four-angled spikerush	*Eleocharis quadrangulata*	None/None/2/3-2-1	Butte, Tehama, Shasta, and Merced counties in California; many other states	Marshes, lake and pond margins	No	Stillwater Plains; also known Salzman Gulch (west of Happy Valley)	Could potentially occur near ponds, reservoirs, riparian areas

Table 5-6 (continued)
SPECIAL-STATUS PLANTS KNOWN FROM THE VICINITY OF THE SHASTA WEST WATERSHED

Boggs' Lake Hedge-hyssop	*Gratiola heterosepala*	None/SE/1B/1-2-2	Known from Sacramento and San Joaquin Valleys, as well as the Modoc Plateau	Vernal pools, lake and pond margins; generally occurs in areas of clay soils	No	Numerous occurrences in the Battle and Paynes Creek drainages in northern Tehama County	Could potentially occur near pond and reservoir margins; however , probably unlikely due to lack of vernal pools in Shasta West, as well as no known occurrences west of I-5, despite significant survey history for this plant
Red Bluff dwarf rush	*Juncus leiospermus* var. l*eiospermus*	None/None/1B/2-3-3	Butte, Tehama, and Shasta counties; one occurrence reported in Placer County	Vernal pool margins; vernally wet areas in chaparral and woodlands	No	Several occurrences in the vicinity of Airport Road, north and south of Highway 44; Stillwater Plains area	Unlikely – lack of vernally wet grassland/woodland habitats and/or vernal pools
Legenere	*Legenere limosa*	None/None/1B/2-3-3	One occurrence reported from Shasta County; also known numerous areas in the Sacramento Valley, as well as Lake, Napa, San Mateo, Alameda, and Santa Clara counties	Vernal pools, seasonal ponds	No	Stillwater Plains	Unlikely – lack of vernally wet grassland/woodland habitats and/or vernal pools
Bellinger's meadow foam	*Limnanthes floccosa* ssp. *bellingeriana*	None/None/1B/3-3-2	Shasta County (from the vicinity of Lake Britton to Ingot); Oregon	Vernal pools and seasonally wet meadows/swales in woodlands; often in rocky sites with shallow soils	No	Near Highway 299 4.5 miles south of Ingot	Unlikely – lack of vernally wet grassland/woodland habitats and/or vernal pools; also, Ingot is the westernmost known occurrence
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	Vernal pools and other seasonally wet habitats; typically underlain by volcanic substrates	No	Stillwater Plains, Millville Plans	Unlikely – vernal pools and seasonally wet meadows/swales not present in Shasta West

Table 5-6 (continued)
SPECIAL-STATUS PLANTS KNOWN FROM THE VICINITY OF THE SHASTA WEST WATERSHED

Ahart's parnonychia	*Paronychia ahartii*	None/None/1B/3-2-3	Shasta, Tehama, and Butte counties	Rocky volcanic grasslands ("scablands"), vernal pool edges, often occurs on soils with a subsurface hardpan (e.g., Redding and Tuscan series)	No	Millville Plains	Unlikely – rocky, volcanic grasslands and vernal pools/swales not present in Shasta West
Howell's alkali grass	*Puccinellia howellii*	None/None/1B/3-3-3	One occurrence in western Shasta County	Alkaline/salt springs and seeps	No	Willow Creek, near its junction with Crystal Creek	Unlikely – alkali springs/seeps not known, or at least very uncommon in Shasta West
Oval-leaved viburnum	*Viburnum ellipticum*	None/None/2/2-1-1	North Coast and Klamath ranges; Sierra Nevada Foothills; other states	Chaparral, brushy areas within ponderosa and foothill pine habitats	No	Clikapudi Trail, Shasta Lake; near Platina	Could potentially occur in chaparral, woodlands, or forests

Status
Federal List: FT = threatened
State List: SE = endangered,
CNPS Lists:
List 1B: Defined by CNPS as "plants rare, threatened, or endangered in California and elsewhere"
List 2: Defined by CNPS as "plants rare, threatened, or endangered 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. These plants often have taxonomic concerns, or are otherwise poorly known.
CNPS Rarity –Endangerment-Distribution (R-E-D) Code - To increase the refinement of assigning plants to categories, CNPS uses a scheme that combines three complementary elements that are scored independently. These components are:
R (Rarity) - addresses the extent of the plant, both in terms of numbers of individuals and the of its distribution
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) - embodies the perception of the plant's vulnerability to extinction for any reason
1 Not endangered.
2 Endangered in a portion of its range.
3 Endangered throughout its range.
D (Distribution) - which focuses on the overall range of the plant
1 More or less widespread outside California.
2 Rare outside California.
3 Endemic to California.
Habitat and Distribution - determined by reviewing information from CNPS 2001, Hickman (1993), and the CNDDB (March 2003 data).

Table 5-7 CDFA LIST "A" NOXIOUS WEEDS PRESENT IN SHASTA COUNTY	
Scientific Name	**Common Name**
Onopordum acanthium	Scotch Thistle
Carduus natans	Musk Thistle
Centaurea maculosa	Spotted Knapweed
Centaurea diffusa	Diffuse Knapweed
Linaria genistifolia dalmatica	Dalmatian Toadflax
Source: Perosco, pers. Comm.. 2003	

OBSERVATIONS

The following observations with regard to botanical resources in the watershed were summarized from the information discussed in this Section.

- Blue oak –foothill pine is the most abundant CWHR vegetation type in the watershed. Although fire suppression has likely increased the density of vegetation, rocky soils and low water tables may be one reason that much of the oak-pine woodland in the watershed remains structurally diverse and frequently contains gaps dominated by herbaceous plants and shrubs. On the other hand, oak woodlands have been degraded by the invasion of exotic species and are under great development pressure in the watershed and throughout the State.

- Riparian vegetation is a priority for protection and restoration because of its biodiversity, rarity and coincidence with fish and wildlife corridor habitat. Remnants of the valley foothill riparian CWHR vegetation type occur along the Sacramento River and its tributaries in the watershed. However, the quality of this habitat has been impacted by fragmentation and invasion by exotic species.

- Mixed chaparral is the second most abundant CWHR type in the watershed. It is most prevalent in the Middle and Rock Creek drainages where soils were most damaged by the effects of historical copper smelting.

- Large grasslands are uncommon in the watershed. However, there are numerous inclusions of small grass patches within other vegetative communities. The historic problem of introduced European annual grasses and other invasive weed species has dramatically altered the composition of grasslands found within the watershed.

- The overall amount of ponderosa pine and knobcone pine lifeforms in the watershed is relatively low, but these areas form part of the ecological transition to extensive montane vegetation communities immediately west of the watershed.

- High-density urban development has permanently altered natural vegetation communities over 20 percent of the watershed. Based on the amount of private land in the watershed, suburban and semi-rural development has led to varying degrees of degradation of native vegetative communities on as much as an additional 60 percent of the watershed. The Bureau of Land Management and the National Park Service manage less than 20 percent of the watershed.

Table 5-8
CalEPPC LIST OF INVASIVE PESTS

Rank	Scientific Name	Common Name	Verified in Shasta West
Red Alert : Species With Potential To Spread Explosively ; Infestations Currently Restricted			
	Centaurea maculosa	Spotted knapweed	
	Hydrilla verticillata	Hydrilla	
	Lythrum salicaria	Purple loosestrife	
List A-1 = Most Invasive Wildland Pest Plants; Widespread			
	Arundo donax	Giant reed, arundo	X
	Bromus tectorum	Cheat grass, downy brome	X
	Centaurea solstitialis	Yellow star thistle	X
	Cortaderia selloana	Pampas grass	
	Cytisus scoparius	Scotch broom	X
	Genista monspessulana	French broom	
	Lepidium latifolium	Perennial pepperweed, tall whitetop	
	Rubus discolor	Himalayan blackberry	X
	Taeniatherum	Medusahead	X
	Tamarix chinensis, T. gallica, T. parviflora & T. Ramosissima	Tamarisk, salt cedar	
List A-2 = Most Invasive Wildland Pest Plants ; Regional			
	Ailanthus altissima	Tree of heaven	X
	Cardaria draba	White-top, hoary cress	
	Elaeagnus angustifolia	Russian olive	
	Ficus carica	Edible fig	X
	Mentha pulegium	Pennyroyal	X
List B = Wildland Pest Plants of Lesser Invasiveness			
	Carduus pycnocephalus	Italian thistle	X
	Centaurea melitensis	Tocalote, Malta star thistle	
	Cirsium arvense	Canada thistle	
	Cirsium vulgare	Bull thistle	X
	Conium maculatum	Poison hemlock	
	Hypericum perforatum	Klamath weed, St. John's wort	X
	Myriophyllum aquaticum	Parrot's feather	
	Phalaris aquatica	Harding grass	
	Robinia pseudoacacia	Black locust	X
	Spartium junceum	Spanish broom	
	Vinca major	Periwinkle	X
Need More Information			
	Descurainia Sophia	Flixweed, tansy mustard	
	Isatis tinctoria	Dyers' woad	
	Ludwigia uruguayensis	Water primrose	
	Pinus radiata cultivars	Monterey pine	
	Pyracantha angustifolia	Pyracantha	X
	Salsola tragus	Russian thistle, tumbleweed	X
	Salvia aethiopis	Mediterranean sage	
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
	Melilotus officinalis	Yellow sweet clover	X
	Nerium oleander	Oleander	X
	Silybum marianum	Milk thistle	X
	Xanthium spinosum	spiny cocklebur	X

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SECTION 5: BOTANICAL RESOURCES

Issues Identified

Urban development is increasing in riparian areas of the watershed that can lead to a reduction of biodiversity.

Invasive non-native plants are a major issue in the watershed with a special concern for the spread of A-rated noxious weeds.

There is a need to improve knowledge of native species compositions and the problem with invasive exotic weeds replacing native communities in riparian areas.

Wetlands are a source of biodiversity and are under pressure from urbanization in the watershed.

Urban developments in the wildland interface may lack the knowledge about the effects of introducing non-native botanical species.

Description and assessment of vegetative communities in the watershed is limited by the quality of the vegetation mapping available. For the assessment LCCMMP imagery was insufficient for assessing riparian vegetation and wetland areas in the watershed and the accuracy of imagery was uncertain for differentiating the variety of hardwood types.

There are unknown effects of suburban and semi-rural development on native vegetative communities.

Historical copper smelting has changed the biodiversity in the watershed.

Data Gaps

Lack of data on types and rates of spread for invasive weeds.

Lack of high resolution vegetation typing data for the watershed.

Lack of floristic surveys that contain information about exotic invasive plants along watershed streams except for Salt and Canyon Creeks.

The amount and extent of wetland areas in the watershed are not known.

Lack of data on urban vegetation and the effects of urban development, such as fragmentation, on vegetative communities.

Insufficient information for a systematic assessment of botanical resources at the scale of all sub-watersheds.

Lack of data on Blue Oak growth and regeneration in the watershed.

There is little known data on the continuing effects of historical copper smelting activities in the region.

Action Items

Work with agencies to perform an invasive weed inventory and develop a GIS database to map known occurrences and control actions for CDFA and CalEPC A-listed weeds to track and estimate the rate of spread in the watershed. Gathered data should be used in conjunction with data from adjacent watersheds to gain knowledge on the spread of invasive weeds in the region.

Collaborate with agencies and organizations involved in the control of invasive plants to coordinate weed control efforts.

Acquire and analyze recent color aerial photographs for the watershed, verified by field investigation. This would be useful for assessing the extent and quality of the valley foothill riparian CWHR vegetation community and addressing uncertainty from the LCMMP mapping in regard to the various hardwoods and deciduous tree life forms.

Obtain historical and current aerial photographs and conduct a time-series analysis of aerial photographs in order to assess fragmentation of native vegetation communities. This type of analysis could also produce a rate of habitat fragmentation for the watershed.

Work with landowners and agencies to encourage the retention of riparian buffer zones to (1) maintain and/or enhance native riparian habitat, (2) benefit fish, wildlife, and native plant species, (3) provide buffering benefits to reduce the effects of stormwater runoff, siltation, and chemicals entering the watercourse and (4) to reduce potential damage from flooding.

Work with landowners to further analyze floristic surveys already conducted along Salt and Canyon Creeks. Consider undertaking similar surveys along other priority streams.

Work with landowners to survey wetlands and identify their interaction with streams and adjoining plan communities.

Collaborate with agencies to explore mechanisms for retaining and regenerating oak species. Pursue available funding for oak management.

Work with agencies to further the investigation of the long-term effects of copper smelting on the soil and vegetative conditions in the watershed.

Appendix 5-A

Salt Creek and Canyon Creek Floristic Surveys

CANYON HOLLOW BRIEF SPECIES SURVEY AND ENVIRONMENTAL IMPACT ASSESSMENT

The area that encompasses Canyon Hollow is between approx. 600–900 ft. elevation and represents both valley grassland and foothill woodland vegetation zones. The terrain of flat grassland surrounded by gently sloping hills with Canyon Creek in the middle makes this a unique and sheltered riparian area. A riparian habitat is defined as areas with plant communities affected by sub/surface hydrologic features (stream) with vegetation species distinct from surrounding areas, as well as similar species exhibiting more robust growth forms ("A System for Mapping Riparian Areas in the Western United States," U.S. Fish and Wildlife Service, December 1997). This was evidenced by observations of two water dependent wildflowers: Spiranthes romanzof fiana (Hooded Ladies Tress) and Genus Mimulus guttatus (Seep-Spring Monkey Flower) growing near/in the creek. S. romanzof fiana is an orchid noticeable for spiraled inflorescence. Canyon Creek has subsurface ground water flow that sustains riparian vegetation year round. There are several flood tolerant species living near the stream and seasonal vernal pools that are evident in times of heavy rains. There is also a wetland with 18 inches or more of saturated soil for times of one week or more that support flood tolerant vegetation. One of the problems resulting from the construction of a road would be a drastic increase in sediment runoff and other forms of nonpoint source pollution such as oil and other automobile waste products. Sediment can cover fish spawning grounds and their eggs preventing emergence of recently hatched fish. According to the USDA Riparian Handbook: "Sedimentation is a major cause of the decreased quality of fisheries throughout the United States." The impact assessments, done by Fish and Game and the City of Redding, were on non point source pollution resulting from traffic of 180 additional homes, not including the planned 400–500 new homes for the northern ridge, resulting in erosion on both sides of the canyon.

There was no Rosgen assessment of stream conditions performed on Canyon Creek by either the California Department of Fish and Game or the City of Redding. We inquired why a Rosgen assessment was not performed, and were told that it was not needed since the stream would not be relocated. If the planned project road crosses the stream channel four or more times in 4,000 feet, we feel a Rosgen assessment is needed to plan for future erosion patterns that will be increased by further loss of oaks and other vegetation that prevent erosion, "data on the discharge at Channel capacity or on the gauge height of the bankfull condition are not published or even determined in a systematic manner despite their importance to planners, environmentalists, and everyone interested in floods and flooding." (L. Leopold 1978, US Fish & Wildlife River Restoration Guidelines) The four level classification system of a Rosgen assessment takes into consideration the geomorphic and morphological aspects of the stream including number of channels, entrenchment ratios, width/depth ratios, sinuosity and slope. Determining bankfull depth and width involves the location where channel ends and floodplain begins. Canyon Creek's sinuosity parameter (stream length divided by valley length) would be considered an intense meander causing the road to cross the stream several times (four or more in 4000 feet) and increasing risk of nonpoint source pollution from sediment runoff and vehicular traffic. In addition flooding events and road damage due to inadequate information of Canyon Creek stream data would necessitate greater road maintenance at taxpayer expense.

These risks could be avoided by using the existing Power Line Road that would connect Country Heights to Placer. Canyon Hollow is home to many of California's native oaks of the Genus Quercus. Oaks in the state of California are in serious decline due to habitat loss. Canyon Creek is considered a mixture of Valley Grassland and Foothill Woodland, both of which support many species of Quercus

(Oaks).

There are many negative effects resulting from clearing oak woodlands. "'These trees [blue oaks] also reduce erosion of steep slopes and provide essential habitat for numerous animal species. Many areas once covered by extensive oak woodlands now have few trees or none at all." ("California vegetation" by Holland/Keil). The houses on the top of the hill will be at risk from erosion the more trees removed. Paul Edgren has already removed many more oaks than should have been allowed to maintain the region's oak woodland habitat biodiversity. Due to the number of trees previously removed we feel there is a violation of the city ordinance regarding tree removal. This may also be a violation under the Oak Woodlands Conservation Act, Bill AB 242. Oak woodland habitat is vanishing rapidly throughout the state due to habitat loss and Sudden Oak Death disease caused by a pathogen Phytophthera Ramorum. "Loss of oak woodland habitat is analogous to what would occur to wildlife if other habitats, such as wetlands, riparian or old-growth coniferous forests, were substantially altered. In addition, these habitats support the greatest number of wildlife species of any comparable habitat in the State."
- California Department of Fish and Game, 1993

We began an oak woodland evaluation (as defined by the California Oak Foundation's Baseline Oak Tree, Savanna, and Woodland Conservation Ordinance) on Canyon Hollow and determined that with 40 to 59 percent of the canopy cover from blue oak stands the canopy cover class code is moderate and habitat index would be considered Habitat 2: Blue Oak - Foothill Pine Woodland. This refers to and is intended to preserve oaks with diameter at breast height (dbh) over 6 inches, with dbh measured at four and ½ feet above grade. We have identified the presence of Quercus douglasii (Blue Oak), Quercus chrysolepsis (Canyon Live Oak), Quercus lobata (Valley Oak) Quercus dumosa (Scrub Oak), Quercus kelloggii (CA Black Oak), and others we have not yet identified. Since The proposed road through Canyon Hollow would result in the removal and death of over 85 percent of the oaks on the floodplain as well as possible additional damage from the soil compaction and/or vibration of heavy vehicles on the mycorrhiza of their roots. There is no realistic method for a road though Canyon Hollow to comply with the above ordinance. This ecosystem also contains a diverse community of animals that would be damaged by the intrusion of a road. Amphibians are declining globally due to wetland habitat loss. Canyon Creek supports a variety of frogs and salamanders that will be adversely affected by the erosion of the proposed road. Ensatina eschscholtzii, a species of salamander with many brilliantly colored subspecies is becoming more difficult to find in Northern California make Canyon Hollow their home. We have seen several birds, wild turkeys, mockingbirds, thrushes and a sighting of a Golden Eagle (Aquila chrysaetos) .

In conclusion we feel the previous environmental impact assessments done in June of 1995 and Fish and Game's April 17, 2002 report were inadequate to assess the cumulative impact of this proposed project on Canyon Hollow. The proposed road and paved trail will cross Canyon Creek total of eight (8) times in 4,000 feet. There is no way to predict future stream erosion and sedimentation without performing a Rosgen assessment. The least impact option would be to use the already existing Power Line road and connect the remaining short straight segment to the Country Heights subdivision. Please take these factors into consideration and do not allow a road or further development in Canyon Hollow.

SALT CREEK BRIEF SPECIES SURVEY

SALT CREEK, Redding 4/29/3
21 species (N) native (E) exotic
Between Eureka Way and the Sacramento River Trail, number month{s) of bloom* L is late. Note: new family names according to the AGP system 1998, Old family name in parentheses.

***Pteridophyta* - Ferns and Fern-allies**
Dryopteridaceae - Woodfern Family
(N) *Polystichurn imbricans* - Sword Fern
Polypodiaceae - Polypody Family
(N) *Polypodium hesperium* - Western Polypody
Pteridaceae - Brake Family
(N) *Adianthum jordanii* – Calif. Maiden-hair
(N) *Aspidotis densa* - Indian's Dream
(N) *Pelleae mucronata* var *mucronata* - Bird's-foot Fern
(N) *Pentagramma triangularis* - Goldback Fern
Isoetaceae - Quillwort Family
(N) *Isoetes nuttallii* - Quillwort
Selaginellaceae - Spike-moss
(N) *Selaginella Wallacei*

***Gymnosperms* – Coneifers**
Pinaceae - Pine Family
(N) *Pinus ponderosa* - Ponderosa (uncommon)
(N) *Pinus sabiniana* - Foothill Pine, Gray or Ghost

Dicots
Alismataceae - Water Plantain Family
(N) *Alisma plantago-aquatica* - Water Plantain 6
Anacardiaceae - Sumac or Cashew Family
(N) *Rhus trilobata* - Sumac; Smooth, Skunkbush, Lemonade
(N) *Toxicodendron diversilobum* - Poison Oak
Apiaceae [*Umbelliferae*] - Carrot Family
(N) *Lomatium dasycarpum ssp tomentosum* - 4
(N) *Lomatium dissectum*
(N) *Lomatium hallii* - 4
(N) *Perideridia howellii* - Yampah 6
(N) *Sanicula bipinnata* - Purple Sanicle 4
(N) *Sanicula crassicaulis* - Pacific Snakewroot 4
(E) *Scandix pectin-veneris* - Venus' Needle
(E) *Torilis arvensis* - NOXIOUS WEED
Apocynaeceae - Dogbane Family
(N) *Apocynum cannabinum* - Indian Hemp 6-7
(E) *Nerium oleander* – Oleander 6-7

Aristolochiaceae - Pipevine Family

(N*)* *Aristolochia calif.* - Pipevine

Asclepiadaceae – Milkweed Family

(N) *Asclepias fascicularis* - Narrow-leaf Milkweed

Asteraceae [Compositae] - Sunflower Family

(N) *Achilla millefolium* - Yarrow
(N) *Artemisia douglasiana* - Mugwort
(N*)* *Baccharis pilularis* - Coyote Brush
(N) *Baccharis salicifolia* - Mule Fat
(N) *Brickellia californica* - Brickellbush 7-9
(E*)* *Carthamus leucocaulas* - Whitstem Distaff Thistle NOXIOUS
(E) *Centaurea solstitialis* - Yellow Star-Thistle NOXIOUS WEED
(N) *Chrysothamnus parryi* - Rabbit Brush
(E) *Cichorium intybus* - Chicory 6-7
(N) *Cirsium occidentale* - Cobweb Thistle 5-6
(N) *Eriophyllum lanatum* - Woolly Sunflower
(N) *Grindelia camporum* - Gumweed 6-9
(N) *Helianthella californica* - Sunflower 5
(N) *Hemizonia congesta* - Hayfield Tarweed 6-8
(N) *Hemizonia fitchii* - Tarweed 6-7
(N) *Hemizona cormbosa* - Showy Tarweed 8-9
(E) *Katyca serriola* - Prickly Lettuce
(N) *Lagophylla ramossima ssp ramossima* 8-9
(N) *Layia glandulosa* - White Layia 6-8
(N) *Leontodon taraxacoides* - Hawkbit
(E) *Tragopogon dubius* - Yellow Salsify
(N) *Wyethia glabrata* - Mule Ears 4
(N) *Xanthium strumarium* - Cocklebur

Boraginaceae - Borage Family

(N) *Amsinckia intermedia* - Fiddleneck
(N) *Amsinckia lycopsoides* - Fiddleneck
(N) *Amsinkia menziesii* var *menziesii* - Fiddleneck
(N) *Criptantha flaccida* - 4
(N) *Cynoglossum grandi* – Hounds Tongue 2-4
(N) Pectocarya pusilla

Brassicaceae - Mustard Family

(N) *Barbarea orthoceras* - Wintercress
(N) *Draba verna* - (circumborial annual mat forming)
(E) *Raphanus raphanistrum* - Jointed Charlock 6-9
(N) *Thysanocarpus curvipes* - Fringe-pod Mustard

Calycanthaceae - Sweet-shrub or Calycanthus Family

(N) *Calycanthus occidentalis* - Spicebush, Sweetshrub 5-6

Caprifoliaceae - Honeysuckle Family

(N) *Lonicera hispidula* var. *vacillens* - Harry Honeysuckle
(N) *Lonicera interupta* - Chaparral Honeysuckle
(N) *Sambucus mexicana* - Blue Elderberry

Caryophyllaceae - Pink Family

- (E) *Petrorhagia prolifera* - Grass Pink,. Wild Carnation
- (E) *Stellaria media* - Common Chickweed

Convolvulaceae - Morning-glory Family

- (N) *Calystegia occidentalis* - Western Morning Glory

Cucurbitaceae - Gourd Family

- (N) *Marah fabaceus* - California Manroot 4
- (N) *Marah oreganus* - Coast Manroot

Cuscutaceae – Dodder

- (?) *Cuscutaceae* sp. – Dodder

Ericaceae – Heath Family

- (N) *Arctostaphylos manzanita* – Greenleaf Manazita 1
- (N) *Arcostaphylos viscida* – Whiteleaf Manazita 1-3

Euphorbiaceae - Spurge Family

- (E) *Chamaesyce maculate* – Spotted Spurge
- (N) *Euphorbia crenulata* – Chinese Caps 4-6

Fabaceae – Legume Family

- (N) *Cercis occidentalis* – Redbud 3
- (E) *Lathyrus* sp. – Pea L4
- (E) *Lotus pinnatus* 4-5
- (N) *Lotus micranthis* - native
- (N) *Lotus purshianus* var *purshianus* – Spanish Lotus 5-6
- (N) *Lupinis bicolor* – Lupin 4-5
- (N) *Lupinis nanus* - Lupin 4-5
- (E) *Melilotus alba* – White Sweet Clover 6
- (E) *Robinia pseudoacacia* – Black Locust Tree L4-5
- (E) *Trifolium dubium* - Shamrock
- (N) *Trifolium willdenovii* – Tomcat Clover L4-5
- (N) *Vicia Americana* var *americana* 4
- (E) *Vicia sativa* ssp *nigra* – Narrow Leaved Vetch 4
- (E) *Vicia villosa* ssp *varia* - Winter Vetch 4

Fagaceae – Oak Family

- (N) *Quercus douglasii* – Blue Oak
- (N) *Quercus garryana* var *breweri* – Brewers Oak
- (N) *Quercus wislizenii* – Interior Live Oak
- (N) *Quercus kelloggii* – Black Oak

Gentianaceae – Gentian Family

- (N) *Centaurium muehlenbergii* – Centaury 6
- (N) *Swertia albicaulis* – Frasera

Geraniaceae – Geranium Family

- (E) *Erodium dissectum* – Crainesbill 3
- (N) *Geranium carolinianum* -

Hippocastanaceae – Buckeye Family

- (N) *Aesculus californica* – Calif. Buckeye 5

Hydrophyllaceae – Waterleaf Family

- (N) *Eriodictyon calif.* – Yerba Santa, Mountain Balm L4-5
- (N) *Nemophila pedunculata* 4
- (N) *Phacelia egena* - 4

Hyperiacaceae – St. John's Wort Family
(E) *Hypericum perforatum* – Klamath Weed 5-6
Lamiaceae – Mint Family
(E) *Marrubium vulgare* - Horehound
(E) *Mentha pulegium* – Pennyroyal TOXIC
(N) *Scutellaria anthirrhinoides* – Scullcap L4-5
Linaceae – Flax
(E) *Linum bienne* – Threadleaf Flax

Moraceae – Mulberry Family
(E) *Ficus carica* – Edible Fig
Oleaceae – Olive Family
(N) *Fraxinus latifolia* – Oregon Ash
Onagraceae – Evening Primrose Family
(N) *Clarkia modesta* - Diamond Clarkia 5
(N) *Clarkia sp.* – like Clarkia purpurea 5
(N) *Gayophytum diffusum ssp. diffusum* 8-9
Papveraceae – Poppy Family
(N) *Eschscholzia calif.* – Cal Poppy 4-5
Plantaginaceae - Plantain Family
(E) *Plantago lanceolata* – English Plantain
(N) *Plantago subnuda* - Plantain
Polemoniaceae – Phlox Family
(N) *Linanthus sp.*
Polygalaceae – Buckwheat Family
(N) *Eriogonum vimineum* – Wicker Buckwheat
(N) *Eriogonum nudum* – Naked Buckwheat 7-9
(E) *Rumex acetosella* - Dock
(N) *Rumex salicifolius* – Willow Dock
Portulacaceae – Purslane Family
(N) *Claytonia parviflora sp. parviflora* 3
(N) *Claytonia perfolata* – Miners Lettuce 3
Primulaceae – Primrose Family
(E) *Anagallis arvensis* – Scarlet Pimpernel
(N) *Dodecatheon hendersonii* – Shooting Star 3-4
Ranunculaceae – Buttercup Family
(N) *Aconitum columbianum* - Monkshood
(N) *Clematis lasiantha* – Pipestems 4
(E) *Ranunculus muricatus* – European annual Buttercup 4
(N) *Ranunculus occidentalis* – Buttercup 3-4
Rhamnaceae – Buckhorn Family
(N) *Ceanothus cuneatus* – Buckbrush 3
(N) *Rhamnus californica* – Coffeeberry 4
(N) *Rhamnus croceae* – Redberry 4
Rosaceae – Rose Family
(N) *Cercocarpus betuloides* – Mtn. Mahogony 3
(N) *Heteromeles arbutifolia* - Toyon
(E) *Malus pumila* – Domestic Apple or sylvestris

(N) *Potentilla glandulosa* – Cinquefoil 5
(N) *Prunus virginiana* var *demissa* – Western Chokecherry L4
(E) *Pyracantha angustifolia* - Firethorn
(E) *Pyrus sp.* - Pear
(N) *Rosa californica* - Rose
(E) *Rubus discolor* – Himalayan Blackberry

Rubiaceae – Madder Family
(N) *Cephalanthus occidentalis* var *cal.* – Button Willow
(N) *Galium aparine* – Bedstraw Goosegrass big-leaf
(N) *Galium californicum* ssp *cal.* - ?
(N) *Galium porrigens* var *tenue* – Climbing Bedstraw
(E) *Sherardia arvensis* - Field Madder

Rutaceae – Rue Family
(N) *Ptelea crenulata* – Hop Tree L4

Salicaceae - Willow Family
(N) *Populus fremontii* - Fremont Cottonwood
(N) *Salix lasiolepis* - Arroyo Willow 2
(N) *Salix sp.* - Willow (ID again)

Santalaceae – Sandalwood Family
(N) *Comandra umbellata ssp californica* - Bastard Toad-flax

Saxifragaceae - Saxifrage family
(N) *Lithophragma affin* - Woodland Star 4

Scrophulariaceae - Figwort Family
(N) *Castilleja attenuata – (Orthocarpos)* Valley Tassels
(N) *Caatilleja sp* - Indian Paintbrush
(N) *Keckiella lemmonii* - 5-6
(E) *Kickxia elatine* - Cancerwort, Fluellin
(N) *Mimulus guttatus* - Monkey-Flower
(N) *Pedicularis densiflora* - Indian Warrior 3
(E) *Verbascum blatteria* – Moth Mullen 6-9

Simaroubaceae – Quassia or Simarouba Family
(E) *Ailanthus altissima* - Chinese Tree of Heaven

Styracaceae - Styrax Family
(N) *Styrax officinalis* var *redivivus* - Snowdrop

Tamaricaceae - Tamarisk Family
(E) *Tamarix parniflora* - Tamarix

Ulmaceae - Elm Family
(E) *Celtis australis* - European Hackberry

Verbenaceae - Verain Family
(N) *Verbena lasiostachys* - Western Verbena

Viscaceae - Mistletoe Family
(N) *Phoradendron sp.* Mistletoe species

Vitaceae - Grape
(N) *Vitis californica* - California Grape

Zygophyllaceae - Caltrop Family
(E) *Tribullus terrestris* - Puncture Vine, Caltrop

Monocots

Agavaceae – Agave Family (*Liliaceae)*

(N) *Chorogalum pomeridianum* – Wavey Leaved Soaproot 6

Alliaceae – Onion Family (*Liliaceae)*

(N) *Allium peninsulare* – Purple flowered Onion

(N) *Allium amplectins* – White flowered Onion

Cyperaceae – Rush Family

(E) *Cyperus involucratus* - Nutsedge

(N) *Eleocharis microstachya* – Spike Rush

Iridaceae – Iris Family

(N) *Sisyrinchium bellum* – Blue-eyed Grass

Juncaceae – Rush Family

(N) *Juncus balticus* - Baltic Rush 4-5

(N) *Juncus bufonius* – Toad Rush

(N) *Juncus effusus*

(N) *Luzula comosa* – Hairy Woodrush

Lilaceae – Lily Family

(N) *Calochortus tolmiei* – Pussy Ears 3

(N) *Fritillaria recurva* – Scarlet Fritillary 3

(N) *Triteleia hyacinthine* – White Brodiaea

Orchidaceae – Orchid Family

(N) *Spiranthes porrifolia* – Ladies Tresses 5

Poaceae – Grass Family

(N) *Achnatherum lemmonii* – Lemmons Needlegrass

(E) *Aegilops triuncialis* – Barbed Goatgrass NOXIOUS WEED

(E) *Agrostis capillaries* – Colonial Bent

(N) *Agrostis exerata* – Spike Bent

(N) *Agrostis pallens* - Thingrass

(E) *Aira caryophyllea* – Silver European Hairgrass

(E) *Anthoxanthum aristatum* – Vernal Grass

(N) *Aristida oligantha* – Oldfield Three-awn

(E) *Avena fatua* – Wild Oatgrass

(E) *Briza maxima* – Quaking Grass, Rattlesnake Grass

(E) *Briza minor* – Little Rattlesnake Grass

(N) *Bromus carinatus* – California Brome

(E) *Bromus diandrus* – Rip-gut Brome

(E) *Bromus hordeaceus (mollis)* – Soft Chess

(E) *Bromus leavipes* – Woodland Brome

(E) *Bromus madrintensis* – Foxtail Chess

(E) *Bromus rubens* – Red Brome 5

(E) *Cynodon dactylon* – Bermuda Grass

(E) *Cynosurus echinatus* – Hedgehod Dogtail

(N) *Elymus elymoides* - Squirltail

(N) *Elymus glaucus* – Blue Wild Rye

(E) *Festuca arundinacea* – Tall Fescue

(N) *Hordeum brachyantherum* – Meadow Barley

(E) *Lolium multiflorum* – Italian Ryegrass

(N) *Melica Californica* – Calif. Melic 5

(N) *Melica torreyana* – Torreys Melic 5
(E) *Panicum capillare* – Witch Grass
(E) *Paspalum dilatatum* – Dallas Grass
(E) *Paspalum distichum* - Knotgrass
(E) *Poa bulbosa* – 3-4
(N) *Poa secunda* – Pine Bluegrass L4-5
(E) *Polypogon maritimus* – Mediterranean Beard Grass
(E) *Sorgum halepense* - Johnsongrass
(E) *Taeniatherum caput-medusa* – Medusahead Grass NOXIOUS WEED
(E) *Vulpia bromides* -
(E) *Vulpia myuros* – Annual Fescue

Tecophilaeaceae – Family (*Liliaceae)*

(N) *Odontosomum hartwegii* – Hartwigs Odontostomum L4-5

Themidaceae – Family (*Liliaceae)*

(N) *Brodiaea californica* – California Brodiaea
(N) *Brodiaea coronaria* – Harvest Brodiaea
(N) *Dichelostemma capitatum* – Bluedicks 2-4
(N) *Dichelostemma congestum* – Forked toothed Ookow 4-5
(N) *Dichelostemma multiflorum* – Wild Hyacinth 4-5
(N) *Dichelostemma ida-maia* – Firecracker Lily 3-5
(N) *Triteleia hyacinthine* – White Brodiaea

Thyphaceae – Cattail Family

(N) *Typha angustifolia* – Narrowleaf Cattail

FISH & WILDLIFE
SECTION 6

Section 6
FISH AND WILDLIFE RESOURCES

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Section 6
FISH AND WILDLIFE RESOURCES

INTRODUCTION

Wildlife resources within the Shasta West Watershed are of special interest for several reasons. The west Redding area is uniquely situated in the foothills at the intersection of three distinct ecological regions: the Sacramento Valley, the Klamath Mountains, and southern extent of the Cascade Range. Valley grassland and blue oaks mix with montane conifer and chaparral habitats to support a diversity of mammals, birds, reptiles, amphibians and insects. Oak woodlands that make up the largest vegetative community in the watershed are among the most diverse habitats in California.

The overlapping ranges of valley, mountain, and coast-associated species make the Shasta West Watershed a naturally rich place in terms of the number of wildlife species (Figure 6-1). The watershed may support 200 to 300 species of terrestrial vertebrates, as many as 50 species of fishes and thousands of species of insects and other invertebrates. Neo-tropical songbirds, such as vireos, particularly favor oak woodlands and associated riparian habitats for nesting when they return to the watershed in summer. Shrubs found in the oak and the chaparral habitats provide a crucial source of food for a resident population of mule deer.

The Keswick dam just north of Redding is a barrier to anadromous fish returning from the Pacific Ocean to spawn. Consequently, the main stem of the Sacramento River that forms a watershed boundary is the northernmost stretch of remaining habitat for threatened and endangered steelhead trout and Chinook salmon. An unknown level of salmonid spawning occurs in individual streams such as Salt, Middle, Canyon and Olney Creeks but the cumulative contribution of the watershed's streams, to overall spawning and rearing habitat for salmonids in the northern Sacramento River system is believed to be significant.

In the remainder of this section, the themes introduced above are discussed in greater detail. Sources of local information are evaluated. The location and condition of habitat types (e.g., blue oak–foothill pine, riverine, etc.) are analyzed and assessed. The species potentially occurring in these habitats are identified and discussed, with special attention paid to endangered, threatened and other special status species, as well as animals of special interest (e.g., mountain lion). Issues of urbanization, habitat connectivity, and wildfire exclusion are explored. Finally, observations are summarized, data gaps identified and action items suggested.

SOURCES OF DATA

Little specific information or research about wildlife populations in the watershed was available for incorporation into this watershed assessment. However, much information was found about habitats and species at the statewide level. Vegetation mapping based on satellite imagery and predictive species modeling provided coarse scale data on the distribution of habitat types in the watershed and the animals likely to occur in them. The conclusions of several scientific studies (e.g., non natal fish rearing, neotropical songbird use of riparian corridors) from nearby watersheds may be transferable to the Shasta West Watershed context. The California Natural Diversity database was checked for known occurrences of special status species in the watershed. Various experts and persons with local knowledge provided valuable information. These individuals include Steve Baumgartner, Patricia Bratcher, Eda Eggeman, Dan Fehr, Pete Figura, Rich Lis, Jack Miller, Teri Moore, John Siperek, and David O. Smith of the California Department of Fish and Game (DFG); retired DFG biologist Terry Healey; Irwin Fernandez and Eric Ritter of the Bureau of Land Management; Jack Williamson, Ron Clementsen and Bob Null of the US Fish and Wildlife Service; Ryan Burnett of the Point Reyes Bird Observatory; wildlife biologist Mike Grifantini, Susan Weale of Friends of Canyon Creek and Leslie Bryan of the Western Shasta Resource Conservation District.

Some of the information included in this section about species and habitats in the watershed is anecdotal. This information is qualified when cited.

TERRESTRIAL HABITATS AND WILDLIFE SPECIES

Satellite imagery was used to estimate the amounts of vegetative "lifeforms" in the watershed (Table 6-1). Technical issues pertaining to the accuracy of the imagery and the rational for grouping some mapping categories into more general lifeforms is discussed in Section 5, "Botanical Resources." For the purposes of wildlife habitat assessment within the watershed, each lifeform has been cross-walked to the California Wildlife Habitat Relationships (CWHR) habitat type that best describes on-the-ground conditions across the majority of the lifeform. The CWHR system is described in greater detail in section 5.

Table 6-1
WILDLIFE HABITATS IN THE SHASTA WEST WATERSHED

Most Representative CWHR Habitat	Dominant Vegetation Lifeform	Estimated Percent Area (acres) from 2001 LCMMP imagery
Blue Oak-Foothill Pine (BOP)	Blue Oak and Foothill Pine	**34 % (10,150)**
Mixed Chaparral (MCP)	Chaparral	**25 % (7,500)**
Annual Grassland (AGS)	Herbaceous Plants	**4 % (1,200)**
Valley Foothill Riparian (VRI)	Riparian *	**1 % (300)**
Fresh Emergent Wetland (FEW)	Wetlands *	**< 1 % (50-150)**
Closed-Cone Pine Cypress (CPC)	Knobcone Pine	**6 % (1,750)**
Ponderosa Pine (PPN)	Ponderosa Pine	**2 % (550)**
Urban (URB)	Urban	**21 % (6,250)**

*Notes: Most estimates are based on 2001 LCMMP imagery. The estimated amounts of riparian and wetland lifeforms were not based solely on the LCMMP data. The amount of riparian lifeform was coarsely estimated by buffering rivers and intermittent streams in the watershed by six meters on each side in areas where LCMMP imagery showed forest vegetation. The amount of wetlands was based on water bodies shown on topographic maps.

The CWHR system includes habitat suitability models (i.e., CWHR 8.0). They are part of a computer software package developed by the DFG and other agencies that provides information on 675 species of amphibians, reptiles, birds, and mammals known to occur in the state. The model predicts the occurrence of individual species based on county, habitat type and habitat structure. Habitats types and structural stages are described in Table 5-2. They are used to model the suitability of reproductive, cover and feeding habitat as high, medium, or low. An example of a CWHR habitat suitability model (e.g., Cooper's hawk in blue oak-foothill pine) is featured in Figure 6-2.

The suitability models can be queried to list all species that occur in Shasta County and are predicted to occur in the suite of habitats and structural stages found in the Shasta West Watershed. The model user is prompted to set thresholds for habitat suitability (e.g., H-high, M-moderate, or L-low). A Visual Basic "macro" for Excel was written and used in lieu of the CWHR 8.0 single condition querying mechanism. The macro allows *and* logic to be used in cases when habitat suitability filters are set above "low – L" for reproduction, cover, and feeding. The species lists for the various habitats discussed in this Section are those predicted to find reproduction *and* cover *and* feeding habitat of at least moderate or high suitability. For more detailed information on CWHR 8.0, or to download the software, go online to www.dfg.ca.gov/whdab/html/cwhr.html.

Table 6-2 shows the list of 222 species that potentially occur in the watershed and find habitat quality of at least moderate quality for reproduction, cover, and feeding in at least one of the major CWHR habitats. These habitats include all those listed in Table 6-1, except urban and fresh emergent wetland habitats. One third of the species listed in Table 6-2 meet the moderate quality criterion for only one of the major CWHR habitat types. The other two thirds find "good" habitat in more than one vegetation type (e.g., both oak woodland and chaparral).

An additional 108 species not listed in Table 6-2 may potentially occur in the watershed, but these species would only find habitat of low quality for at least one of their life cycle requirements (e.g., reproduction, cover, and feeding).

Blue Oak-Foothill Pine

Oak woodland is the most common habitat type in the watershed, accounting for 30 to 40 percent of the area. Oak forests are rich in wildlife value, supporting the life cycle needs of as many as 330 species across California (CalPIF, 2002). The majority of oak woodlands in the Shasta West Watershed can be categorized as the blue oak-foothill pine CWHR type. The botanical aspects of this vegetative community are described in greater detail in Section 5 "Botanical Resources."

Despite the effects of fire suppression, blue oak-foothill pine habitat in the watershed remains relatively variable. Dense clumps of oaks are frequently broken up by small to medium size openings containing grasses and shrubs. The structural complexity of the blue oak-foothill pine forest makes it excellent wildlife habitat. Patches of closed canopy oaks provide thermal cover for mammals such as bobcat and coyote on hot summer days (Barrett, 1979). Cooper's hawks for concealing their nests and ambushing prey also prefer dense cover. On the other hand, the interspersion of grasses and shrubs within the oaks and pines provides suitable conditions for the western meadowlark, gray fox, and other species that are more commonly found in annual grassland and chaparral habitats.

A variety of habitat elements found in blue oak-foothill pine are important for supporting the reproductive, cover, and feeding requirements of wildlife. Dead trees (i.e., snags) and large dead limbs on live trees provide opportunities for woodpeckers and red-breasted nuthatches to excavate cavities for nesting. A guild of species known as "secondary cavity nesters" (e.g., northern pygmy owls, purple martins, etc.) utilizes abandoned holes originally dug out by other birds called "primary cavity nesters." The western rattlesnake and other reptiles use downed logs for cover. Acorns provide a key food source for large numbers of animals including mule deer, wild pigs, acorn woodpeckers, and squirrels. Rock wrens and California ground squirrels are examples of animals

associated with rock outcroppings within a variety of habitats. A source of water is of critical importance to the survival of all animals.
The CWHR models predict that the 10,000 acres of blue oak-foothill pine within the watershed may provide habitat of at least moderate quality to 152 species of wildlife. Table 6-3 lists the subset of 91 species that may find high quality habitat in this type, including 62 birds, 20 mammals, and 9 reptiles. Not all of these species are year round residents. Many of them return from Central and South America in spring or summer to breed. The total density of male birds defending territories during the early summer breeding months has been estimated on the order of 1,300 per square mile in California oak woodlands (Verner, 1979). In general, the less dense stages of oak habitats support higher numbers of species (IHRMP, 1996). According to the CWHR models, 92 percent of the species listed in Table 6-3 find high quality habitat in open woodlands (e.g., less than 40 percent canopy cover), whereas only 47 percent find similar quality habitat in dense woodlands (e.g., greater than 40 percent canopy closure).

In excess of 5,000 species of insects and arachnids (e.g., spiders, ticks, mites and scorpions) may inhabit California oak woodlands (Little et. al., 2001). Even though most of these invertebrates (i.e., animals that lack a backbone) measure less than one inch in length, they are an important source of food for bat, birds, reptiles, and amphibians. Most insects found in oak woodlands are specialized to feed on oak root, trunk, bark, branches, leaves, and acorns (Little et. al., 2001).

The oak gall, or 'oak apple' is a notable sign of insect life in the watershed. More than 130 species of cynipid wasps develop through the larval stage in galls on California oaks. Each species of gall wasp's larvae secretes a different chemical causing an overgrowth of plant tissues and a unique type of gall to form on the leaf, twig, catkin or acorn of an oak tree. Most galls cause little or no lasting damage to oak trees (Little et. al., 2001).

Mixed Chaparral

This mixed chaparral CWHR type covers approximately one-quarter of the watershed. Discussion in Section 5, "Botanical Resources" notes that most of the chaparral habitat in the watershed has reached an overly dense and decadent condition largely due to the exclusion of fire. Some animals such as California thrashers, wrentits, brush mice, and mountain lions prefer the cover of dense thickets. Other animals such as mule deer find higher quality browse from young growth shrubs. Overall species diversity in the chaparral habitat type is significantly lower than in the blue oak-foothill pine community. The CWHR models predict that mixed chaparral within the watershed may provide habitat of at least moderate quality to 87 species of wildlife. Table 6-4 lists the subset of 39 species that may find high quality habitat in this type including 18 mammals, 12 birds, and 9 reptiles.

The distribution of chaparral in the watershed is concentrated in the northeast region of the watershed. The lack of recurring fire in this chaparral has allowed "old growth" manzanita with few new shoots to crowd out younger plants and other types of shrubs (e.g., buckbrush) and herbaceous plants that would provide a more palatable food source for mule deer and other animals. The common king snake and spotted towhee are two such animals that prefer younger, less dense chaparral. The CHWR models predict that only 19 of the species listed in Table 6-4 find high quality habitat in decadent dense shrubs.

Table 6-2
222 WILDLIFE SPECIES PREDICTED BY THE CWHR MODELS TO POTENTIALLY OCCUR IN THE WATERSHED AND FIND MEDIUM OR HIGH QUALITY HABITAT WITHIN THE MAJOR TERRESTRIAL HABITATS

Acorn Woodpecker	Cassin's Vireo	Long-Eared Owl	Striped Racer
Allen's Chipmunk	Cedar Waxwing	Long-Legged Myotis	Striped Skunk
American Badger	Chestnut-Backed Chickadee	Long-Tailed Vole	Swainson's Hawk
American Beaver	Chipping Sparrow	Long-Tailed Weasel	Swainson's Thrush
American Crow	Cliff Swallow	Macgillivray's Warbler	Townsend's Big-Eared Bat
American Goldfinch	Common Garter Snake	Phainopepla	White-Headed Woodpecker
American Kestrel	Common Kingsnake	Mallard	Townsend's Solitaire
American Mink	Common Merganser	Mountain Bluebird	Tree Swallow
American Robin	Common Muskrat	Mountain Chickadee	Trowbridge's Shrew
American Wigeon	Common Nighthawk	Mountain Lion	Turkey Vulture
Anna's Hummingbird	Common Poorwill	Mountain Quail	Violet-Green Swallow
Ash-Throated Flycatcher	Common Porcupine	Mourning Dove	Virginia Opossum
Band-Tailed Pigeon	Common Raven	Mule Deer	Warbling Vireo
Bank Swallow	Common Yellowthroat	Nashville Warbler	Western Aquatic Garter
Barn Owl	Cooper's Hawk	Night Snake	Snake
Barn Swallow	Coyote	Northern Alligator Lizard	Western Bluebird
Barred Owl	Dark-Eyed Junco	Northern Flicker	Western Fence Lizard
Belted Kingfisher	Deer Mouse	Northern Flying Squirrel	Western Gray Squirrel
Bewick's Wren	Downy Woodpecker	Northern Harrier	Western Harvest Mouse
Big Brown Bat	Dusky Flycatcher	Northern Mockingbird	Western Kingbird
Black Bear	Dusky-Footed Woodrat	Northern Pintail	Western Mastiff Bat
Black Phoebe	Ensatina	Northern Pygmy Owl	Western Meadowlark
Black Rat	Ermine	Northern River Otter	Western Pond Turtle
Black-Chinned	European Starling	Northern Rough-Winged	Western Rattlesnake
Hummingbird	Flammulated Owl	Swallow	Western Red Bat
Black-Crowned Night	Foothill Yellow-Legged	Northern Saw-Whet Owl	Western Screech Owl
Heron	Frog	Nuttall's Woodpecker	Western Scrub-Jay
Black-Headed Grosbeak	Fox Sparrow	Oak Titmouse	Western Skink
Black-Tailed Jackrabbit	Fringed Myotis	Orange-Crowned Warbler	Western Spadefoot
Black-Throated Gray	Golden Eagle	Osprey	Western Spotted Skunk
Warbler	Gopher Snake	Pacific Chorus Frog	Western Tanager
Blue Grosbeak	Gray Fox	Pacific Coast Aquatic Garter	Western Terrestrial Garter
Blue-Gray Gnatcatcher	Great Blue Heron	Snake	Snake
Bobcat	Great Egret	Pacific Giant Salamander	Western Toad
Botta's Pocket Gopher	Great Horned Owl	Pacific-Slope Flycatcher	Western Whiptail
Brazilian Free-Tailed Bat	Green Heron	Pallid Bat	Western Wood-Pewee
Brewer's Blackbird	Green-Tailed Towhee	Pine Siskin	White-Tailed Kite
Broad-Footed Mole	Green-Winged Teal	Pinon Mouse	Wild Pig
Brown Creeper	Hairy Woodpecker	Prairie Falcon	Wild Turkey
Brown-Headed Cowbird	Hermit Warbler	Purple Finch	Willow Flycatcher
Brush Mouse	Hoary Bat	Purple Martin	Wilson's Warbler
Brush Rabbit	Horned Lark	Raccoon	Winter Wren
Bullfrog	House Finch	Racer	Wood Duck
Bullock's Oriole	House Mouse	Red-Breasted Nuthatch	Wrentit
Bushtit	House Sparrow	Red-Legged Frog	Yellow Warbler
Bushy-Tailed Woodrat	House Wren	Red-Shouldered Hawk	Yellow-Billed Magpie
California Ground Squirrel	Hutton's Vireo	Red-Tailed Hawk	Yellow-Breasted Chat
California Kangaroo Rat	Killdeer	Red-Winged Blackbird	Yellow-Rumped Warbler
California Mountain	Lark Sparrow	Ringneck Snake	Yuma Myotis
Kingsnake	Lawrence's Goldfinch	Ring-Necked Pheasant	Say's Phoebe
California Myotis	Lazuli Bunting	Ringtail	Sharp-Tailed Snake
California Quail	Lesser Goldfinch	Rough-Skinned Newt	Silver-Haired Bat
California Thrasher	Lesser Nighthawk	Rubber Boa	Song Sparrow
California Towhee	Lewis' Woodpecker	Ruby-Crowned Kinglet	Sonoma Chipmunk
California Vole	Loggerhead Shrike	Sagebrush Lizard	Southern Alligator Lizard
Calliope Hummingbird	Long-Eared Myotis	Savannah Sparrow	Spotted Sandpiper
Canyon Wren	Peregrine Falcon	White-Breasted Nuthatch	Spotted Towhee
Greater Roadrunner		White-Crowned Sparrow	Steller's Jay

Notes: Based on the vegetation assessment discussed in Section 7, the following habitat types and stages are included in the query: AGS all stages; BOP all stages except 1 & 5; CPC all stages except 1 & 5; MCH all stages except 1; PPN 2S, 2P, 3S, 3P, 4S, 4P; VRI all stages. AND logic used such that Reproduction, Cover, and Feeding must be of medium (M) or high (H) quality for at least one of queried habitat stages. A CWHR 8.0 single condition species detail report was generated. Other parameters of the detail report were: Shasta County, no elements excluded, all species, no special status species limitations, all season categories. A supplemental spreadsheet model was used to convert from OR to AND logic.

Table 6-3 BLUE OAK FOOTHILL PINE: 91 WILDLIFE SPECIES PREDICTED BY THE CWHR MODELS TO POTENTIALLY OCCUR IN THE WATERSHED AND FIND HIGH QUALITY HABITAT IN THIS CWHR TYPE			
Acorn Woodpecker	California Quail	Lazuli Bunting	Spotted Towhee
American Crow	California Towhee	Lesser Goldfinch	Striped Skunk
Anna's Hummingbird	Chipping Sparrow	Loggerhead Shrike	Turkey Vulture
Ash-Throated Flycatcher	Cliff Swallow	Long-Eared Owl	Violet-Green Swallow
Barn Owl	Common Poorwill	Long-Tailed Weasel	Warbling Vireo
Barn Swallow	Common Raven	Mourning Dove	Western Bluebird
Bewick's Wren	Cooper's Hawk	Mule Deer	Western Fence Lizard
Big Brown Bat	Coyote	Northern Pygmy Owl	Western Gray Squirrel
Black Bear	Dark-Eyed Junco	Northern Rough-Winged Swallow	Western Kingbird
Black Rat	Dusky-Footed Woodrat	Northern Saw-Whet Owl	Western Meadowlark
Black-Chinned Hummingbird	European Starling	Nuttall's Woodpecker	Western Pond Turtle
Black-Headed Grosbeak	Golden Eagle	Oak Titmouse	Western Rattlesnake
Black-Tailed Jackrabbit	Gopher Snake	Orange-Crowned Warbler	Western Screech Owl
Black-Throated Gray Warbler	Gray Fox	Pacific-Slope Flycatcher	Western Scrub-Jay
Blue-Gray Gnatcatcher	Great Horned Owl	**Phainopepla**	Western Skink
Bobcat	**Greater Roadrunner**	Prairie Falcon	Western Spotted Skunk
Brown-Headed Cowbird	Hoary Bat	Red-Tailed Hawk	Western Terrestrial Garter Snake
Brush Mouse	Horned Lark	Ringneck Snake	Western Wood-Pewee
Brush Rabbit	House Finch	Ringtail	White-Breasted Nuthatch
Bullock's Oriole	House Mouse	**Say's Phoebe**	White-Tailed Kite
Bushtit	House Wren	Sharp-Tailed Snake	Wild Pig
California Ground Squirrel	Hutton's Vireo	Sonoma Chipmunk	Wild Turkey
	Lark Sparrow	Southern Alligator Lizard	
	Lawrence's Goldfinch		
Notes: Bold font denotes species that can only find habitat of at least medium quality for reproduction and cover in Blue Oak-Foothill Pine and not in other habitats available in the watershed.			

Table 6-4 MIXED CHAPARRAL: 39 WILDLIFE SPECIES PREDICTED BY THE CWHR MODELS TO POTENTIALLY OCCUR IN THE WATERSHED AND FIND HIGH QUALITY HABITAT IN THIS CWHR TYPE			
American Badger	Common Garter Snake	Mule Deer	Striped Racer
Anna's Hummingbird	Common Kingsnake	Northern Mockingbird	Striped Skunk
Bewick's Wren	Common Poorwill	Orange-Crowned Warbler	Turkey Vulture
Black-Tailed Jackrabbit	Coyote	Pinon Mouse	Western Fence Lizard
Bobcat	Deer Mouse	Ringneck Snake	Western Rattlesnake
Brush Mouse	Dusky-Footed Woodrat	Ringtail	Western Scrub-Jay
Brush Rabbit	Gopher Snake	Sharp-Tailed Snake	Western Spotted Skunk
California Kangaroo Rat	Gray Fox	Sonoma Chipmunk	Wild Pig
California Quail	House Wren	Southern Alligator Lizard	Wrentit
California Thrasher	Mountain Lion	Spotted Towhee	
Notes: Bold font denotes species that can only find habitat of at least medium quality for reproduction and cover in Mixed Chaparral and not in other habitats available in the watershed.			

Valley Foothill Riparian

Structural complexity, lush vegetation, and edges with other habitats are features that make riparian forests particularly rich for wildlife. The CWHR models predict that valley foothill riparian habitat within the Shasta West Watershed may provide habitat of at least moderate quality for 172 species of wildlife. Table 6-5 lists the subset of 105 species that may find high quality habitat in this type including 60 birds, 27 mammals, 14 reptiles, and 4 amphibians. Riparian areas provide nesting habitat for numerous species of neo-tropical birds returning to California in the summer to breed. Riparian areas provide a source of water. They attract insects that are a key source of food for many birds, amphibians, and reptiles. Riparian areas also provide cover habitat and movement corridors for numerous animals.

Valley foothill riparian is potentially the most diverse habitat in the watershed. However, it covers less than one percent of the watershed. Remnants of dense, multistory riparian forest occur along the Sacramento River and the lower portions of Olney Creek. This forest contains valley oak and a gallery of smaller trees, shrubs, and vines. Multi-story riparian forest habitat also exists along Clear Creek immediately to the south of the watershed. Complex valley foothill riparian forest found along the Sacramento River, Clear Creek, and Olney Creek provide nesting habitat for species like yellow-breasted chat and song sparrow. The conservation and restoration of high quality riparian habitat may also assist in the recovery of state and federally endangered birds including Bell's vireo and the yellow-billed cuckoo that have been extirpated from Clear Creek, Shasta West Watershed, and many other parts of the state (RHJV, 2000).

Research conducted along Clear Creek (Burnett and DeStaebler, 2001 & 2002) provides valuable information on the local value of structurally complex valley foothill riparian forest. The forest along Clear Creek is high quality and supports a diverse community of songbirds including three species (e.g., song sparrow, yellow warbler, yellow-breasted chat) that have been extirpated from nearby valley sites, possibly including the Shasta West Watershed. The research confirmed a positive correlation between bird species richness and shrub species richness versus a negative correlation with bare ground. Some of the understory plant species associated with higher levels of bird diversity were mugwort, pipevine, California grape, and black mustard.

Structurally simpler valley foothill riparian habitat occurs along intermittent watershed creeks including Canyon Creek and Salt Creek. This form of valley foothill riparian exists in patches and narrow bands. Scattered cottonwoods and willows replace dense galleries dominated by valley oak. In some places, stringers of willow bushes may provide nesting habitat for willow flycatcher. In other areas, elderberry plants may provide a home for valley longhorn elderberry beetles. Perennial streams may provide habitat to foothill yellow legged frog and western pond turtle. Red-shouldered hawks frequently nests in riparian habitats and hunt along their edges.

Section 5 provides more information on botanical conditions in Shasta West Watershed riparian habitats.

Fresh Emergent Wetland

Little information was readily available for assessing the distribution of wetland habitats in the watershed. In general, the fresh emergent wetland CWHR type exists in the Shasta West Watershed as a narrow band of transition between valley foothill riparian or wet meadow CWHR habitats and riverine or lacustrine CWHR habitats. It was estimated from topographical maps that the watershed contains approximately 49 acres of small lakes and upland ponds, and 104 acres of backwater pools and ponds associated with the Sacramento River. The edges of these water bodies provide habitat to variety of wetland-associated wildlife species. Figure 6-3 shows the connectivity between these wetlands and streams and the Sacramento River.

Table 6-5 VALLEY FOOTHILL RIPARIAN: 105 WILDLIFE SPECIES PREDICTED BY THE CWHR MODELS TO POTENTIALLY OCCUR IN THE WATERSHED AND FIND HIGH QUALITY HABITAT IN THIS CWHR TYPE			
Acorn Woodpecker	Common Garter Snake	Mourning Dove	Tree Swallow
American Goldfinch	Common Kingsnake	Mule Deer	Turkey Vulture
American Mink	**Common Merganser**	Northern Flicker	Violet-Green Swallow
American Robin	**Common Muskrat**	Northern Flying Squirrel	Virginia Opossum
Anna's Hummingbird	Common Yellowthroat	Northern Pygmy Owl	Warbling Vireo
Ash-Throated Flycatcher	Coyote	Northern Rough-Winged Swallow	**Western Aquatic Garter Snake**
Bank Swallow	Dark-Eyed Junco	Northern Saw-Whet Owl	Western Fence Lizard
Belted Kingfisher	Deer Mouse	Nuttall's Woodpecker	Western Gray Squirrel
Bewick's Wren	**Downy Woodpecker**	Orange-Crowned Warbler	Western Harvest Mouse
Big Brown Bat	Ensatina	Osprey	Western Kingbird
Black Bear	**Foothill Yellow-Legged Frog**	Pacific Chorus Frog	Western Pond Turtle
Black Phoebe	Gopher Snake	**Pacific Coast Aquatic Garter Snake**	Western Rattlesnake
Black Rat	Great Horned Owl	**Pacific Giant Salamander**	Western Screech Owl
Black-Chinned Hummingbird	**Green Heron**	Pacific-Slope Flycatcher	Western Scrub-Jay
Black-Headed Grosbeak	Hairy Woodpecker	Raccoon	Western Skink
Blue Grosbeak	Hoary Bat	Red-Shouldered Hawk	Western Spotted Skunk
Bobcat	House Finch	Ringneck Snake	Western Terrestrial Garter Snake
Broad-Footed Mole	House Wren	Ringtail	Western Wood-Pewee
Brush Mouse	Hutton's Vireo	**Rough-Skinned Newt**	White-Breasted Nuthatch
Brush Rabbit	Lawrence's Goldfinch	Sharp-Tailed Snake	Wild Pig
Bullock's Oriole	Lazuli Bunting	Song Sparrow	**Willow Flycatcher**
Bushtit	Lesser Goldfinch	Sonoma Chipmunk	**Wilson's Warbler**
Bushy-Tailed Woodrat	Lewis' Woodpecker	Southern Alligator Lizard	Winter Wren
California Quail	Long-Eared Myotis	Spotted Towhee	**Wood Duck**
California Towhee	Long-Eared Owl	Striped Skunk	Yellow Warbler
Canyon Wren	Long-Tailed Weasel	**Swainson's Thrush**	**Yellow-Breasted Chat**
Cliff Swallow			

Notes: Bold font denotes species that can only find habitat of at least medium quality for reproduction and cover in Valley Foothill Riparian and not in other habitats available in the watershed.

The CWHR models have not been used to predict species potentially occurring in fresh emergent wetlands, because of the lack of information about habitat conditions. However, the non-fish animals that use wetlands and associated aquatic habitats include pacific chorus frog, western pond turtle, river otter, red-winged blackbird, grey heron, snowy egret, great blue heron, red-shouldered hawk, as well as a variety of waterfowl.

Vernal pools are seasonally flooded depressions in the land underlain by a hardpan soil layer that limits drainage. They fill with water in the winter, flourish with life in the spring and dry out in the summer. These pools occur singly or in complexes. They differ from other ephemeral wetlands in that they often support a specialized set of plants and animals including a relatively large number of threatened and endangered species. There are no vernal pools or associated threatened or endangered species known to occur in the watershed, although vernal pools are present to the east of the Sacramento River (Eggeman, pers. comm., 2003). However, it is possible that stock ponds and other small pools of water may support vernal pool associated species (Lis, 2004). Information collected as part of an environmental assessment for the proposed West Ridge Master Plan Project (NSR, 2003) identified 0.11 acre of intermittent pools, 0.15 acre of vernal pools and 0.02 acre of backhoe pits within a 400-acre study in the vicinity of upper reaches of Canyon Creek. The draft report states these seasonal habitats are potentially suitable to the federally listed vernal pool fairy shrimp (*Branchinecta lynchi*) and vernal pool tadpole shrimp (*Lepidurus packardi*).

Annual Grassland

Grasslands provide excellent foraging habitat for many species of wildlife. Grasses and forbs produce seeds and attract insects that in turn are food for bluebirds, meadowlarks, mice and voles. Red-tailed hawks, American kestrels and white-tailed kites hunt in grasslands. Some birds including the killdeer and horned lark nest in grasslands. Numerous rodents dig underground burrows where they give birth to and raise their young. Snakes seek prey in these burrows and often lay their eggs there too.

It is unlikely that the ranges of some species (e.g., Swainson's hawk, burrowing owl) associated with Central Valley grasslands extend as far north as the Shasta West Watershed. This is one reason why the watershed's grasslands support less wildlife species by themselves than do other habitats. The CWHR models predict that the annual grassland habitat type within the watershed may provide habitat of at least moderate quality for 61 species of wildlife. Table 6-6 lists the subset of 32 species that may find high quality habitat in this type including 18 birds 9 mammals, 4 reptiles, and one amphibian.

Table 6-6
ANNUAL GRASSLAND:
32 WILDLIFE SPECIES PREDICTED BY THE CWHR MODELS TO POTENTIALLY OCCUR IN THE WATERSHED AND FIND HIGH QUALITY HABITAT IN THIS CWHR TYPE

American Badger	California Vole	Long-Tailed Vole	Red-Winged Blackbird
American Wigeon	Common Garter Snake	Mallard	Ring-Necked Pheasant
Bank Swallow	Gopher Snake	**Northern Harrier**	**Savannah Sparrow**
Barn Swallow	Green-Winged Teal	Northern Pintail	Turkey Vulture
Botta's Pocket Gopher	Horned Lark	Pacific Chorus Frog	Western Harvest Mouse
Broad-Footed Mole	House Mouse	Peregrine Falcon	Western Meadowlark
California Ground Squirrel	Killdeer	Prairie Falcon	**Western Spadefoot**
California Kangaroo Rat	Lark Sparrow	Racer	Wild Turkey

Notes: Bold font denotes species that can only find habitat of at least medium quality for reproduction and cover in Annual Grassland and not in other habitats available in the watershed.

Grasslands account for less than five percent of the watershed. Very few patches of grassland within the watershed are larger than 20 acres. The quality of grassland habitat has been degraded by the invasion of non-native grasses. Exotic grasses and noxious weeds have largely replaced native bunch grasses thereby reducing vegetation habitat complexity. Fire suppression has allowed dense chaparral and woodlands to encroach and fill in more of the watershed than was the case historically. All of these factors have marginalized the importance of grasslands as a unique habitat within the watershed. In past centuries, higher quality grasslands probably supported elk herds in the watershed. Section 5 provides more information on botanical conditions in the watershed's grasslands.

A large number of wildlife species rely on patches of grasses within other habitats. Many animals use edges between wooded and grassy habitats to forage and hunt. Rabbits and hares eat grasses, but require shrubs for cover. Hawks and kites hunt for rodents in open grasslands, but often nest in dense clumps of oaks. Consequently, the persistence of small patches (e.g., less than 1 acre) of grassland with the watershed's blue oak-foothill pine greatly enhances wildlife diversity within the watershed.

Closed-Cone Pine Cypress / Ponderosa Pine

Both of these CHWR vegetative communities are described in Section 5 "Botanical Resources." Together, they make up less than 10 percent of the watershed. However, they are connected to larger areas of closed-cone pine cypress, ponderosa pine and other montane conifer habitats immediately west of the watershed in the Whiskeytown National Recreation Area.

Knobcone pine forests define the closed-cone pine cypress vegetative community in the watershed. Because of its dense and monotypic structure (i.e., one species of tree), knobcone pine stands are the least diverse type of wildlife habitat in the watershed. The CWHR models predict that closed-cone pine cypress habitat within the watershed may provide habitat of at least moderate quality for 72 species of wildlife. Table 6-7 lists the subset of 23 species that may find high quality habitat in this type including 13 birds, 7 mammals, and 3 reptiles. The chestnut–backed chickadee is one of the few species that prefers dense closed-cone pine cypress to other habitats available in the watershed.

The 800 acres of ponderosa pine CWHR type found in the watershed exist in an open condition (see Section 5 "Botanical Resources" for discussion on this topic). Therefore, CWHR predictive modeling was limited to the open canopy classes. Table 6-7 lists the 48 species predicted to occur in the watershed and find high quality habitat in this type including 12 birds, 7 mammals, and 4 reptiles.

Urban

Over 20 percent of the watershed is urbanized. Some wildlife species such as raccoons, opossums, and crows are attracted to urban areas where they scavenge for food. Street trees and urban structures provide nesting substrates for a variety of birds including scrub jays, mockingbirds, and woodpeckers. No specific information on urban habitats was available for this watershed assessment.

AQUATIC SPECIES AND HABITATS

The Sacramento River forms the eastern boundary of the Shasta West Watershed and together with many of the tributaries in Shasta West, the area provides spawning and rearing habitat for numerous species of fish, including the threatened and endangered Chinook salmon and Central Valley steelhead and resident rainbow trout. Historically, utilized hundreds of miles of spawning habitat above the Shasta West Watershed, but the construction of Keswick and Shasta Dams are barriers to migration, leaving the smaller, valuable streams in the watershed as the northernmost spawning area of the Great Central Valley. Not all tributaries in the Shasta West Watershed provide spawning habitat, but the cumulative contribution of these streams is significant for supporting anadromous and resident salmonids (Willamson, pers. Comm., 2004, Baumgartner pers. Comm., 2003) and there is evidence that lower stretches of the streams provide rearing habitat for juvenile salmonids.

Table 6-7
CLOSED-CONE PINE CYPRESS/PONDEROSA PINE:
WILDLIFE SPECIES PREDICTED BY THE CWHR MODELS
TO POTENTIALLY OCCUR IN THE WATERSHED
AND FIND HIGH QUALITY HABITAT IN THESE 2 CWHR TYPES

Ponderosa Pine		Closed-Cone Pine Cypress	
Allen's Chipmunk	Mourning Dove	Bobcat	Orange-Crowned Warbler
American Robin	Mule Deer	California Towhee	Pacific-Slope Flycatcher
Barn Swallow	**Nashville Warbler**	**Chestnut-Backed Chickadee**	**Pine Siskin**
Black-Throated Gray Warbler	Northern Pygmy Owl	Common Raven	Red-Tailed Hawk
Bobcat	Northern Rough-Winged Swallow	Coyote	Striped Skunk
Cassin's Vireo	Pinon Mouse	Dark-Eyed Junco	Turkey Vulture
Chipping Sparrow	Prairie Falcon	Gopher Snake	Western Meadowlark
Common Raven	Red-Tailed Hawk	Great Horned Owl	Western Rattlesnake
Coyote	**Rubber Boa**	Hutton's Vireo	Western Skink
Dark-Eyed Junco	Silver-Haired Bat	Long-Tailed Weasel	Western Spotted Skunk
Deer Mouse	Sonoma Chipmunk	Mountain Lion	Western Terrestrial Garter Snake
Dusky Flycatcher	Striped Skunk	Mule Deer	
Dusky-Footed Woodrat	**Townsend's Solitaire**		
Flammulated Owl	Turkey Vulture		
Golden Eagle	Violet-Green Swallow		
Great Horned Owl	Western Fence Lizard		
Hairy Woodpecker	Western Rattlesnake		
Hermit Warbler	Western Spotted Skunk		
Hoary Bat	**Western Tanager**		
Lewis' Woodpecker	Western Wood-Pewee		
Long-Eared Myotis	**White-Headed Woodpecker**		
Long-Legged Myotis	Wild Turkey		
Long-Tailed Weasel	**Yellow-Rumped Warbler**		
Mountain Chickadee			
Mountain Quail			

Notes: Bold font denotes species that can only find habitat of at least medium quality for reproduction and cover in Ponderosa Pine or Closed-Cone Pine Cypress and not in other habitats available in the watershed.

Anadromous fish spend most of their lives in saltwater, but return up rivers to spawn (i.e., lay eggs). The anadromous salmonids of the watershed are Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Oncorhynchus mykiss*). These salmonids hatch from eggs deposited in gravels in cold-water rivers and streams. Steelhead trout typically remain in fresh water for one to three years before migrating seaward. Juvenile Chinook salmon called "fry" usually rear for only a few weeks or months in the waters near where they are born before emigrating to the ocean. As part of this migration, Chinook "smolts" linger in estuaries where they physically change to adapt to saltwater conditions. Most Sacramento River system Chinook salmon and steelhead trout return upstream at 3 to 5 years of age to spawn. They find suitable habitat in waters below 56°F. The optimal spawning and egg incubation temperature is about 52°F. Adult salmonids build nests called "redds" for laying their eggs in gravels 2.0 to 4.0 inches in diameter. This size gravel and an adequate flow of well-oxygenated cold water are necessary for successful incubation of the eggs. After the male fertilizes the eggs, the female remains nearby guarding the nest for about two weeks before she dies. The carcasses of these fish litter rivers and streams providing a valuable seasonal source of nutrients for the aquatic food web, as well as for terrestrial wildlife, including black bear. After 30 to 60 days the eggs hatch and the life cycle of Chinook salmon and steelhead trout begins again.

Rainbow trout are actually the same species as steelhead trout (i.e.., Oncorhynchus mykiss) except rainbow trout generally remain resident. Large, football-shaped rainbow trout resident to the Sacramento River use watershed streams for spawning during winter months when flows are high. However, it is often difficult to distinguish between rainbow trout and steelhead trout based on outward appearance. Close examination of a rainbow trout/steelhead's scales is one method that can identify whether the fish is a resident rainbow trout or a steelhead trout that has been to the ocean.

There is some indication that two separate runs (winter and summer) of steelhead trout were present in the Sacramento River system prior to the construction of large dams, but it seems unlikely that summer temperatures were historically conducive to keep the summer run steelhead trout in the local area. This run of steelhead, currently present in other river systems, re-enters freshwater before sexual maturation and returns to headwater streams, holding over in deep pools until mature, and spawning in the winter (McEwan, 1997). The only run of steelhead currently in the Sacramento River, winter run, matures in the ocean before returning homeward to spawn and is federally listed as a threatened species.

The four runs of Chinook salmon are fall run, late-fall run, winter run, and spring run. Fall and late-fall runs are the most abundant Chinook salmon runs in the Sacramento River below Keswick Dam. Spring run Chinook salmon are a federally and State-listed threatened species. Winter run is a federally and State-listed endangered species. These designations are discussed further in the Special Status Wildlife Species sub-section. Figure 6-4 depicts the reproductive timelines of the different runs of Chinook salmon and steelhead trout.

Historically, all of the Chinook salmon runs were spread out spatially so that overlaps in timing were less likely to result in cross-hybridization. In recent times, the construction of Keswick Dam forced fall, late-fall, and spring runs to share the same spawning areas at similar times of the year. This may hasten genetic absorption of the threatened spring run into the larger fall and late-fall runs (Moore and Baumgartner, pers. comms., 2003). Furthermore, the spring run has adapted more than other runs to spawning in upper tributaries, but it over-summers before spawning and requires cold-water pools (Baumgartner, pers. comm., 2003). Consequently, few spring run Chinook spawn in the watershed. The endangered winter run Chinook salmon is temporally distinct from the other three Chinook runs. Along the Sacramento River through Redding the numbers are estimated to be low at about 6,000 per year (Baumgartner, pers. comm., 2003). Winter run also appears to use intermittent streams for rearing proportionally more than the other runs (Maslin et. al., 1998).

The Shasta West watershed streams are quite important to anadromous fish in terms of non-natal rearing habitat. Due to bottom drainage from Shasta and Keswick Dams, the Sacramento River along the watershed is colder than optimal for rearing habitat. Juvenile Chinook salmon may historically have found favorable rearing conditions in shallow, protected backwaters and side channels that are now less common in the Sacramento River itself due to development (Maslin et al., 1998). Presently, there is evidence that Chinook fry use various small tributaries, as refugia from predators and the colder more turbid waters of the larger Sacramento River. Juvenile Chinook salmon have been recorded using tributaries near Red Bluff for periods up to five weeks during which they eat and grow (Moore, 1997). Within the watershed, Chinook salmon rearing has been recorded on Olney Creek (Maslin et. al., 1998). It has also been observed on tiny Calaboose Creek immediately east of Cypress Avenue behind the California Department of Fish and Game offices (Moore, pers. comm., 2003). This suggests that all Shasta West tributaries of the Sacramento River offer non-natal rearing habitat.

Besides salmonids, native fish species of the Cypriniformes order including suckers, minnows and Sacramento pike minnows use Shasta West tributaries. California roach (*Hesperoleucus symmetricus*) is a minnow species that can tolerate the especially high temperatures and low oxygen levels associated with these streams during the summer months. This fish often remains in isolated pools that retain water year round.

The following is a stream-by-stream summary of the occurrences of salmonids, the locations of known spawning and rearing activity, the distribution and quality of habitat, and status of natural and artificial barriers to fish passage. Much of this information is based on an interview with retired DFG biologist Terry Healey, based on over 40 years of field experience with the DFG in Redding. Other information sources drawn on in this section are anecdotal or inferential and have been corroborated by other sources when possible. Most of the fish occurrence information is for positive occurrences. Information from opportunistic sightings does not necessarily mean that the species, not observed, do not also exist in a stream.

Overall, Mr. Healey ranked the current productivity of Shasta West watershed streams for salmonids is led by Olney Creek, followed by Salt Creek then Middle Creek (Healey, pers. comm., 2004). Plans for alleviating a fish passage barrier below Highway 273 may increase access to salmonid spawning habitat on Canyon Creek. Appendix A contains additional information about the fish passage barriers on Olney Creek.

Sacramento River

The Sacramento River flowing through Redding provides habitat for at least 50 species of fish, which are listed and categorized in Table 6-8 as either native or non-native. The Pacific lamprey (*Lampetra tridentata*) is a jawless, anadromous fish that resembles an eel and becomes parasitic of other fishes once it reaches the ocean. It spawns in the Sacramento River, but the annul return of this species has decreased since the 1970s. There is little hard data about its life history and distribution.

Most spawning of anadromous salmonids in the Shasta West Watershed occurs along the Sacramento River in places where suitable gravel is available, such as above Diestlehorst Bridge. Upstream dams and constriction of the natural meander of the river has limited the sources of potential gravel recruitment. However, bottom drainage from Shasta and Keswick dams keeps the water in the mainstem cold enough for proper egg incubation.

In order to facilitate the recovery of the endangered winter-run Chinook salmon, migrating adults are captured below Keswick Dam and transported to an upstream federal fish hatchery where the eggs are removed and fertilized artificially. Where they imprint on the characteristics of the water upstream, and instinctively return towards these waters when they are ready to spawn. The fry are returned to the Caldwell Park stretch of the river where they rear on their own before emigrating to the ocean. Consequently, non-natal rearing habitat provided by the lower stretches of watershed streams may be important to the survival of these hatchery-propagated, endangered fish.

Rock Creek

Rock Creek is the northern-most stream in the watershed. Mr. Healey (pers. comm., 2004) described a natural waterfall barrier just beyond the mouth of the stream, which fish can likely only pass during high flows. He has never seen salmonids above this point and noted that the quality of potential spawning habitat is poor as one continues upstream about one-eighth mile to a second natural barrier, a series of steep cascades. Mr. Healey has observed California roach in year-round pools on this creek.

Table 6-8
SPECIES OF SACRAMENTO RIVER FISHES

Sturgeon	Minnow	Temperate Bass
Green Sturgeon	Blackfish	Striped Bass*
White Sturgeon	California Roach	
	Carp*	Sunfish
Lamprey	Fathead Minnow*	Black Crappie*
Pacific Brook Lamprey	Golden Shiner*	Bluegill*
Pacific Lamprey	Goldfish*	Green Sunfish*
River Lamprey	Hardhead	Largemouth Bass*
	Hitch	Pumpkinseed
Herring	Lahontan Redside*	Redear Sunfish
American Shad*	Sacramento Splittail	Sacramento Perch
Threadfin Shad*	Sacramento Pike Minnow	Smallmouth Bass*
	Speckled Dace	Warmouth*
Salmon and Trout	Thicktail Chub	White Crappie*
Brown Trout*	Tui Chub	
Chinook Salmon		Perch
Pink Salmon**	Sucker	Bigscale Logperch*
Sockeye Salmon**	Sacramento Sucker	
Steelhead/Rainbow Trout		Surfperch
	Livebearer	Tule Perch
Catfish	Mosquitofish*	
Black Bullhead*		Sculpin
Brown Bullhead*	Silverside	Prickly Sculpin
Channel Catfish*	Mississippi Silverside*	Riffle Sculpin
White Catfish*		Staghorn Sculpin
Yellow Bullhead*	Stickleback	
	Threespine Stickleback	

* Denotes exotic species **uncommon or rare occurrences of species in Sacramento River

Middle Creek

According to Mr. Healey (pers. comm., 2004), there is a natural barrier halfway between the County dumpsite and Iron Mountain Road. He believes it unlikely that salmonids can pass this barrier, even during high flows. The existence of this barrier was confirmed by another source as 1-1 ½ miles upstream from the mouth (Souza, pers. comm., 2003). Mr. Healey has observed rainbow trout/steelhead in the pool below the barrier as well as spawning by Chinook salmon and rainbow trout/steelhead in stretches below. He has not observed any identifiable steelhead trout in Middle Creek. He described pockets of suitable spawning gravels along the creek with the best habitat between "the old County bridge and the historic town of Naugh." During a January 1995 survey conducted by Mr. Healey (1995a) after several days of heavy rain, he observed 33 live and 2 dead Chinook salmon and 114 live and 1 dead rainbow trout/steelhead. All but one of the Chinook salmon were observed downstream of Iron Mountain Road.

Housing development and road-related erosion problems led to elevated sediment levels on Middle Creek in the early 1990s (various documents from CRWQB files, 1991-1998). Mr. Healey (pers. comm., 2004) noted that this sediment negatively affected the quality and amount of spawning habitat available on the creek. However, in October 1998, a cooperative project between the Western Shasta Resource Conservation District, Cantara Trustee Council, NORCAL Guides and Sportsman's Association and the DFG led to a restoration project in which 250 tons of clean spawning gravel were placed in the channel using an injection method. By December, the leading edge of the gravels had already moved 800 feet downstream and Chinook salmon carcasses were observed in the newly restored reaches (WSRCD, 1998). Additionally, sediment levels were monitored as closer to background levels in the late 1990s (various documents from CRWQB files, 1991-1998).

Salt Creek

Extensive spawning by Chinook salmon and large rainbow trout/steelhead has been noted on Salt Creek below Highway 299. A January survey (Healey, 1995b) following several days of heavy rain noted a total of 24 live and 3 dead Chinook salmon and 24 live rainbow trout/steelhead. Most of the salmon (19) were seen between Highway 299 and a gorge about 1/4-mile downstream. Two rainbow trout/steelhead were seen spawning immediately upstream of the highway. Mr. Healey (pers. comm., 2004) estimated about 30 percent of the stream length between the highway and the mouth contains suitable spawning gravels. Unfortunately, there is no evidence of identified steelhead trout using the stream. After an earlier survey (Hinton, 1985), biologists noted that, based on body color, shape, and spotting, the trout in the creek were resident rainbow trout rather than migratory steelhead trout.

The bottom end of the culvert under Highway 299 is elevated above a stream pool. This culvert presents a partial barrier except for a limited time after storm events when as the flow abates conditions become favorable for passage. Large rainbow trout/steelhead have been observed jumping and successfully passing through the culvert at a rate of one every few seconds (Baumgartner, pers. comm., 2003; Furnas, pers. obs., 2003).

Mr. Healey (pers. comm., 2004) reported that rainbow trout/steelhead regularly use the short stretch of gravels upstream of Highway 299 to the old bridge. Lack of data raises the concern about the viability of spawning and rearing habitat further upstream (Baumgartner and Healey, pers. comm., 2004). The stream quickly branches out with more areas of exposed bedrock and less water. The concern is about whether newly hatched salmonids survive long enough in the higher temperature waters to migrate downstream. On the other hand, there are confirmed reports of rainbow trout/steelhead as large as 20 inches and redds in the upper reaches of Salt Creek almost as far up as Swasey Drive (Weale, 2004, Baumgartner, pers. comm., 2004). There are also confirmed sightings of one Chinook salmon carcasses on upper Salt Creek (Healey and Fehr, pers. comms., 2004). To further assess the viability of spawning and rearing habitat above Highway 299, the DFG planned to place temperature recorders in-stream in 2004 (Baumgartner, pers. comm., 2004).

In 2002, the Western Shasta Resource Conservation District removed a small concrete dam from the bottom of Salt Creek. It was a 3-foot high partial barrier, and its removal has likely expanded the availability of non-natal rearing habitat (Souza, pers. comm., 2003).

Jenny Creek

Mr. Healey (pers. comm., 2004) described poor quality spawning habitat along Jenny Creek and has not observed salmonids using this creek. Historical data supports spawning habitat in Jenny Creek and newspaper reports of rainbow trout/steelhead in the creek appears 30 years ago. Based on recent observations on nearby Calaboose Creek (Moore, pers. comm., 2003), it is possible that the lower reaches of Jenny Creek below Shasta High School do provide non-natal rearing habitat.

Calaboose Creek

This small creek runs from the headwaters near the Benton Airport through downtown Redding to the river at the Cypress Avenue Bridge. Much of the creek has been channeled through artificial drainage structures to accommodate urban development. Much of the remaining stream is littered with rubbish. In the past, it is likely that the creek supported Chinook salmon spawning as far as what is now the west end of downtown near Court Street. There are newspaper reports of local residents recalling how salmon were caught there with pitchforks. (Figura, 2004). Pitchforking salmon in Calaboose Creek probably occurred from 1890 until the early 1900's and may have happened as late as the 1930's (Smith, pers. Comm., 2005).

In 2003, non-natal rearing by juvenile Chinook salmon has been observed in the stretch of stream behind the DFG lot in the vicinity of Cypress and Athens avenues (Moore, pers. comm., 2003)

Canyon Creek (Canyon Hollow Creek)

An A.C.I.D. canal conduit pipe between Highway 273 and the confluence with the Sacramento River presents a 7-foot fish passage barrier to Canyon Creek and its tributaries (Baumgartner, pers. comm., 2004, Smith 2003). This barrier is surmountable during high flows. Numerous large rainbow trout/steelhead, but no Chinook salmon or identifiable steelhead have been observed above the barrier. Rainbow trout/steelhead have been observed as far up as Teton Drive on the Buenaventura fork and as far as Blazingwood Drive on the Canyon Hollow fork (Healey and Baumgartner, pers. comm., 2004). Additionally, two redds were documented about 1/8-mile upstream of Blazingwood Drive on the Canyon Hollow fork (Harral, 2001).

Pockets of suitable spawning gravel occur for at least one mile on both Buenaventura and Canyon Hollow forks above the intersection of Buenaventura Boulevard and Canyon Creek Road, though this habitat could be improved by the addition of gravel (Baumgartner, pers. comm., 2004). Furthermore, the invasive weed species, giant reed (*Arundo donax*) clogs the channel zone in many places on Canyon Creek (Furnas pers. obs., 2004).

Planning is underway for alleviating the A.C.I.D pipe barrier below Highway 273 (Baumgartner, pers. comm., 2004; Smith 2003). Construction of a step weir will increase access for rainbow trout and may open upstream spawning habitat to Chinook salmon. It is unclear to what extent the culvert below Buenaventura Boulevard at Teton Drive, or the culvert and steeper terrain just above Blazingwood Drive on the middle fork of Canyon Creek, are barriers to fish passage. The arched culvert with natural stream bottom at Blazingwood Drive is not a barrier to the Canyon Hollow fork. However, DFG biologists have the same concerns regarding the viability of the upper reaches of Canyon Creek tributaries for supporting newly hatched salmonids (Baumgartner, pers. comm., 2004). Additional data may help determine the viability of the upper reaches of Canyon Creek tributaries.

UPDATE: In August of 2004 Redding Rotary removed the 7-foot barrier to fish passage along Canyon Creek. 700 cubic yards of local and imported large rock was used to create gradually tapering rapids on the face of the once almost insurmountable 7 foot diameter pipe. (Smith, pers. Comm., 2005)

Oregon Gulch

Mr. Healey (pers. comm., 2004) reported suitable spawning gravel for salmonids on the lower stretches of Oregon Gulch. He believes that survivability of newly hatched salmonids may be an issue upstream. A DFG warden who patrols Oregon Gulch has spotted Chinook salmon as recently as 2003 just past the fifth bridge, about 3/4-mile beyond Highway 273 (Fehr, 2004). There is suitable gravel from this bridge down to the highway, but the creek has been heavily impacted by garbage dumping and sedimentation caused by off-road vehicle activity. It has been estimated that 30 acres of slopes 30 percent or greater have been disturbed by off-road vehicles. Plans are underway to install gates to prevent access to motor vehicles starting one mile above Highway 273, and also to remove rubbish and abandoned vehicles from the stream channel. Mr. Fehr (2004) believes that the quality of salmonid spawning habitat improves above where the first gate will be installed. The channel has natural meander and shade from mature trees above this point. He has also seen rainbow trout in the creek.

UPDATE: In 2004 the Western Shasta Resource Conservation District, with funding provided by the Cantara Trustee Counsel, installed gates and access barriers to Oregon Gulch. The City of Redding is currently removing rubbish and abandoned cars from the area.

Olney Creek

Chinook salmon, steelhead and rainbow trout have been documented spawning in Olney Creek (Maslin et. al., 1998; Baumgartner, pers. comm., 2003; Healey, pers. comm., 2004). In 1998, juvenile Chinnok salmon were observed using Olney Creek for rearing as far as one mile from the mouth, and the population of juveniles was estimated at 2,175 (Maslin, 1998). In 1962, DFG staff "rescued" an average of 540 fingerling-sized juvenile Chinook salmon and 289 fingerling-sized rainbow trout per day from the creek over a period of days in May (Healey, undated).

Mr. Healey (pers. comm., 2004) has observed stretches of suitable spawning gravel on the creek as far up as the Texas Springs Road bridge near the confluence with Tadpole Creek, approximately four miles up from the mouth of Olney Creek. In 2003, the Western Shasta Resource Conservation District removed a abandoned slat dam barrier 200 feet upstream of the Tadpole Creek confluence on the main stem of Olney Creek. It is anticipated that this action will provide access to additional upstream spawning habitat. A natural cascade barrier remains on the Tadpole Creek 1/4-mile beyond the Texas Springs Road bridge (Healey, pers. comm., 2004). Mr. Healey has observed rainbow trout in the pool below this barrier.

A number of other fish species besides salmonids have been documented using Olney Creek (Maslin et. al., 1998) and are listed in Table 6-9. There are reports of an Olney Creek resident keeping records of spawning run dates for a variety of species including salmonids and Sacramento pike minnow (Grifantini, pers. comm., 2004).

Table 6-9
FISH SPECIES OBSERVED USING OLNEY CREEK

Common Name	Scientific Name	Family
Chinook Salmon	*Oncorhynchus tshawytscha*	Salmon/Trout
Steelhead & Rainbow Trout	*Oncorhynchus mykiss*	Salmon/Trout
Sacramento Sucker	*Catostomus occiedentalis*	Sucker
Threespined Stickleback	*Gasterosteus aculeatus*	Stickleback
Tule Perch	*Hysterocarpus traski*	Surfperch
Sacramento Pike Minnow	*Ptychocheilus grandis*	Minnow
California Roach	*Hesperoleucus symmetricus*	Minnow
Golden Shiner	*Notemigonus crysoleucas*	Minnow
Hardhead	*Mylopharodon conocephalus*	Minnow
Green Sunfish	*Lepomis cyanellus*	Sunfish

Source: Maslin et. al., 1998, page 28

SPECIAL STATUS WILDLIFE SPECIES

A wildlife species may be "listed" as threatened or endangered under the federal and California Endangered Species Acts (ESA). Although there are differences between these two sets of law, both ESAs prohibit "take," generally defined as harassing, harming, pursuing, hunting, shooting, killing, trapping, capturing or collecting listed animals or an attempt to achieve any of these proscribed activities. The federal law also requires the identification of "critical habitat" important for the recovery of a species. In addition to formal listing, there are a variety of other designations used by federal and state agencies for prioritizing the protection of other species of Special Concern.

All terrestrial vertebrate species contained in Table 6-2 were checked for special status. Special status species that may potentially occur in Shasta West Watershed habitats are shown in Table 6-10. Per the California Natural Diversity Database (www.dfg.ca.gov/whdab/html/cnddb.html), only two potentially occurring special status terrestrial vertebrate species are reported to occur inside, or within one mile of, the watershed. These species are bank swallow (*Riparia riparia*) and valley elderberry long horn beetle (*Desmocerus californicus dimorphus*).

The bank swallow is listed as a threatened species in the State of California. This bird is the smallest North American swallow with a body length of 4.75 inches. Most of the State's remaining populations of bank swallow nest along the upper Sacramento River. The birds burrow into vertical riverbanks consisting of fine-textured soils. It is believed that riprapping of natural stream banks for flood control purposes is the single most serious, human-caused threat to the long-term survival of the bank swallow in California (DFG, 2000a).

The valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) is listed by the federal government as a threatened species (Figure 6-5). This insect is dependent on elderberry (*Sambucus spp.*), a common plant found in valley foothill riparian habitat. Adults bore into elderberry stems to lay eggs. The life cycle takes one or two years during most of which the larval stage of this species lives within the stems of elderberry plant. The US Fish and Wildlife Service (1999) have written conservation guidelines for protection of the species. All elderberry shrubs with one or more stems measuring 1.0 inch or greater in diameter at ground level are considered potential habitat. Elderberry is found along the Sacramento River and its tributaries in the watershed.

The bald eagle (*Haliaeetus leucocephalus*) is a federally listed threatened and a State-listed endangered species. It is also designated as a fully protected species and a Board of Forestry sensitive species by the State of California. Bald eagles have been observed along the Sacramento River. They may use some watershed wetlands for hunting (Furnas pers. obs., 2003). However, there are no known bald eagle nests in the watershed, and the CWHR models suggest that watershed habitats provide only low quality reproductive habitat for these birds. It more likely that bald eagles that hunt for fish in the Sacramento River nest in montane conifer habitats to the west of the watershed.

The western pond turtle (*Clemmys marmorata*) is a California Species of Special Concern. This reptile lives in ponds and slow flowing streams. Pond turtles have been observed in Mary Lake in the watershed (Furnas, pers. obs., 2003). Pond turtles have also been seen using intermittent tributaries of the Sacramento River in Shasta and Tehama Counties (Moore, pers. con. 2003). In interior California where winter temperatures get cold, this species often over-winters in upland habitat away from ponds and streams. However, turtles that remain in ponds during the winter may hibernate in mud at the bottom. The turtles also leave aquatic habitat to lay eggs, generally during May and June.

Incubation takes 70 to 80 days. Nesting sites have been documented as far as a quarter mile away from aquatic sites, but distances traveled vary considerably and depend on the availability of suitable nesting sites. Nesting often occurs in clay or silt soils on exposed aspects. Excessively moist nests often fail, whereas there is danger of hatchling mortality in hot, dry conditions. Pond turtles are long lived, the youngest individual found in one Trinity County study was 42 years old. Unfortunately, it is believed that the level of recruitment of new turtles in California may be too low. Drought, habitat alteration, and roads may be factors. The predation of hatchling and juvenile turtles by bullfrogs is also a problem (Jennings and Hayes, 1994; DFG, 2002).

The Shasta West Watershed is within the range of the California red-legged frog, a federally listed threatened species. However, the watershed does not include any legally designated critical habitat. The DFG's predictive model for willow flycatcher identifies several patches of potential habitat in the watershed for this State-listed endangered bird. It breeds in extensive willow thickets, but is typically found in wet meadow complexes not found in the watershed (DFG, 2000b).

Winter-run chinook salmon (*Oncorhynchus tshawytscha* – state and federally endangered) and steelhead trout (*Oncorhynchus mykiss* – State and federally threatened) are found in the Sacramento River and its tributaries in the watershed. Spring-run chinook salmon (*Oncorhynchus tshawytscha* – State and federal threatened) are found in the Sacramento River, but it is unlikely that this fish uses the watershed's intermittent streams for spawning and rearing. Sacramento splittail (*Pogonichthys macrolepidotus*) and green sturgeon (*Acipenser medirostris*) are two river fishes with special status designations. No information on watershed occurrences of these two fishes was discovered during this watershed assessment.

BREEDING BIRD SURVEY TREND INFORMATION

The Breeding Bird Survey is a network of roadside bird surveying that has occurred annually across North America since 1966. The power of this monitoring program is the information it provides about long-term population trends for multiple species of avifauna. The surveys occur at dawn during the height of the breeding season in June. Although expert birders record all birds they hear or see during a three-minute period, or point count, the system is primarily designed to detect songbirds. Waterfowl and raptors are less likely to be noticed than neotropical migrants calling for a mate or defending a territory. Each 24.5-mile "route" has a total of 50 stops, each at 0.5-mile intervals (Sauer, 1997).

The US Geological Survey maintains a website posting survey results. California trend information for birds potentially occurring in Shasta West Watershed is featured in Table 6-11 (Sauer, 2003). Numerical trend information was reported as percent annual change in the frequency of species being spotted along routes. P was the measure of statistical significance. For the purposes of this watershed assessment, a trend was deemed significant (instead of random or undetermined) when P was less than 0.1. The breeding bird survey website provides trend information over the last 40 years and over the last 20 years. Only those species with significant trends were listed in Table 6-11. A pattern was identified as increasing, decreasing, or flat as defined by the significant trend for either of the two time periods. A percent annual change of more than one percent was considered to be an increase or decrease. 35 species were identified as decreasing in California, 26 were increasing, and 4 were flat.

Table 6-10
SPECIAL STATUS WILDLIFE POTENTIALLY OCCURING IN THE SHASTA WEST WATERSHED

Common Name	Scientific Name	Endangered, Threatened or Protected	Other Status
Birds			
Bald Eagle	*Haliaeetus leucocephalus*	FT, CE	BOF
Bank Swallow	*Riparia Riparia*	CT	CSSC
Golden Eagle	*Aquila chrysaetos*	CFP	CSSC
American Peregrine Falcon	*Falco peregrinus anatum*	CE, CFP	
White-Tailed Kite	*Elanus leucurus*	CFP	
Willow Flycatcher	*Empidonax traillii*	CE	CSSC, USFS, BOF
Blue Grosbeak	*Geothlypis trichas*		CSSC
Common Yellowthroat	*Guiraca caerulae*		CSSC
Cooper's Hawk	*Accipiter cooperii*		CSSC
Great Blue Heron	*Ardea herodias*		BOF
Long-Eared Owl	*Asio otus*		CSSC
Osprey	*Pandion haliaetus*		CSSC, BOF
Prairie Falcon	*Falco mexicanus*		CSSC
Purple Martin	*Progne subis*		CSSC
Yellow Warbler	*Dendroica petechia*		CSSC
Yellow-Breasted Chat	*Icteria virens*		CSSC
Mammals			
Ringtail	*Bassariscus astutus*	CFP	
California Kangaroo Rat	*Dipodomys californicus*		CSSC, BLM
Northern Flying Squirrel	*Glaucomys sabrinus*		CSSC, USFS
Townsend's Big-Eared Bat	*Corynorhinus townsendii*		CSSC, BLM, USFS
Western Mastiff Bat	*Eumops perotis*		CSSC
Reptile			
Western Pond Turtle	*Clemmys marmorata*		CSSC, USFS
Amphibians			
California Red-Legged Frog	*Rana aurora*	FT	CSSC
Foothill Yellow-Legged Frog	*Rana boylii*		CSSC
Ensatina*	*Ensatina eschscholtzi*		CSSC, BLM, USFS
Western Spadefoot	*Spea hammondii*		CSSC
Fishes			
Chinook Salmon – winter run	*Oncorhynchus tshawytscha*	FE, CE	
Chinook Salmon – spring run	*Oncorhynchus tshawytscha*	FT, ST	
Steelhead – northern California ESU	*Onchorynchus mykiss*	FT	CSSC
Sacramento Splittail	*Pogonichthys macrolepidotus*	FT	
Green Sturgeon	*Acipenser medirostris*		CSSC,
Insect			
Valley Longhorn Elderberry Beatle	*Desmocerus californicus dimorphus*	FT	

<u>Key to Special Statuses</u>:

CE	California Endangered	CT	California Threatened
FE	Federally Endangered	FT	Federally Threatened
CFP	California Fully Protected	CSSC	California Species of Special Concern
USFS	US Forest Service Sensitive	BLM	Bureau of Land Management Sensitive
BOF	Board of Forestry Sensitive		

FRAGMENTATION AND CONNECTIVITY OF WILDLIFE HABITATS

Movement is important for wildlife for a number of reasons. Many animals regularly travel to sources of water. Although small animals such as rodents and amphibians may have home ranges less than an acre in size, the dispersal of individuals between isolated populations helps to maintain genetic "bandwidth." Larger animals, like deer and mountain lion, range over greater areas in search of sufficient amounts of nutritious forage or prey. Many species of wildlife use riparian corridors for movement. On a larger scale, many birds migrate thousands of miles with the seasons.

The roads in the Shasta West Watershed may act as a barrier to the movement of some animals. Road kill is a serious problem Statewide. Incidents involving deer are of particular interest, because they can cause vehicle damage and sometimes result in injury or death for people. Two Statewide databases track reported vehicle collisions with wildlife (primarily deer) on state highways. They are the Caltrans Traffic and Surveillance System (TASAS) and the California Highway Patrol-Administered Statewide Integrated Traffic Records System (SWITRS). Local data relating to roads within the watershed have not been analyzed for this watershed assessment. Some researchers believe that road kill of numerous mammals, birds, reptiles, and amphibians may be a serious threat to population levels for some species (Forman et. al., 2003). Other scientists suspect that the regulation of population levels through road mortality may actually increase reproductive rates among deer and other animals (Smith, pers. comm., 2003).

Highways 273 and 299 are probably significant barriers to wildlife movement in the watershed. They both interrupt movement and fragment habitats along riparian corridors. The extent to which the four lanes of Highway 273 and parallel rail track and Eastside Road are barriers to wildlife movement is unclear. Inspections of Olney Creek, Oregon Gulch, and Canyon Creek intersections with Highway 273 reveal that road and rail track overpasses may be sufficient to allow safe passage of mid-sized mammals and other animals such as the western pond turtle (Furnas, pers. obs., 2003). Narrow strips of valley foothill riparian forest on Olney Creek provide cover to animals on either side of the highway. Figure 6-6 shows pictures of habitat conditions and an overpass at this intersection.

Table 6-11
CALIFORNIA BREEDING BIRD SURVEY TREND INFORMATION FOR SHASTA WEST WATERSHED SPECIES

Species	Pattern	1966-2002			1980 - 2002		
		Trend	**P**	**N**	**Trend**	**P**	**N**
American Kestrel	Decrease	-1.4	0.04	165	-0.5	0.68	146
Belted Kingfisher	Decrease	-3.9	0.01	64	-4.8	0.01	52
Bewick's Wren	Decrease	-1.9	0.02	153	-3	0.03	139
Brewer's Blackbird	Decrease	-1.8	0	182	-2.1	0	168
Brown Creeper	Decrease	-2.2	0.03	93	-3.1	0.02	87
Bullock's Oriole	Decrease	-1.8	0	163	-1.9	0	146
Bushtit	Decrease	-2.8	0.07	134	-4.5	0.01	119
California Thrasher	Decrease	-1.7	0.11	75	-2.4	0.07	61
Canyon Wren	Decrease	-3.8	0.37	48	-6.1	0.01	45
Chestnut-Backed Chickadee	Decrease	-2.9	0	48	-3.7	0	43
Chipping Sparrow	Decrease	-5.2	0	121	-4	0	109
Cooper's Hawk	Decrease	-0.4	0.93	43	-6.2	0.02	32
Dark-Eyed Junco	Decrease	-1.3	0.04	127	-0.9	0.19	122
Greater Roadrunner	Decrease	-3.8	0.03	45	-5.9	0.07	34
Horned Lark	Decrease	-3.5	0	111	-4.9	0	97
House Finch	Decrease	-1.7	0.03	188	-0.8	0.31	172
House Sparrow	Decrease	-0.7	0.12	154	-1.6	0	137
Killdeer	Decrease	-2	0	146	-1.9	0.01	127
Lesser Goldfinch	Decrease	-0.8	0.42	155	-1.3	0.05	141
Loggerhead Shrike	Decrease	-2.2	0.01	108	-0.3	0.71	93
Mountain Chickadee	Decrease	-1.9	0	83	-2.6	0	79
Nashville Warbler	Decrease	-2	0.01	71	-2.5	0.03	66
Northern Flicker	Decrease	-1.2	0	171	-1.1	0.04	157
Northern Pintail	Decrease	-6.8	0	26	-11	0.08	21
Oak Titmouse	Decrease	-1.2	0.09	103	-1.7	0.01	98
Pine Siskin	Decrease	-6.7	0.02	64	-10.4	0	54
Purple Finch	Decrease	-1.7	0.05	106	-2.8	0	93
Violet-Green Swallow	Decrease	-2.1	0.02	124	-3.7	0.02	112
Warbling Vireo	Decrease	-1.3	0.01	117	-2.7	0	107
Western Bluebird	Decrease	-0.9	0.11	119	-1.1	0.05	109
Western Meadowlark	Decrease	-1.4	0.01	164	-1.8	0	145
Western Wood-Pewee	Decrease	-2.2	0	162	-1.7	0.03	146
White-Crowned Sparrow	Decrease	-3.6	0	25	-2.6	0.1	23
Wilson's Warbler	Decrease	-1.5	0.03	92	-1.7	0.04	71
Yellow Warbler	Decrease	-1.8	0.1	122	-2.3	0.08	105
American Robin	Flat	-0.9	0.07	175	-1	0.06	166
Mourning Dove	Flat	-1	0.01	213	-0.9	0.1	200
Steller's Jay	Flat	0.1	0.73	124	0.9	0.03	119
Western Scrub-Jay	Flat	0.9	0	160	0.5	0.14	150
Acorn Woodpecker	Increase	0.9	0.01	116	1.3	0.01	103
American Crow	Increase	2.3	0.01	112	1.8	0.03	96
Anna's Hummingbird	Increase	1.5	0.13	131	2.5	0	121
Black Phoebe	Increase	1.9	0.01	119	0.4	0.76	112
Black-Crowned Night Heron	Increase	8.4	0.01	32	4	0.06	27
Blue Grosbeak	Increase	4.3	0.08	36	0.6	0.87	31
California Quail	Increase	1.2	0.05	162	1	0.06	147
Cassin's Vireo	Increase	1.5	0.16	96	1.8	0	90
Common Merganser	Increase	3.2	0	30	2.1	0.19	30
Common Raven	Increase	4.3	0	181	3	0	175
Common Yellowthroat	Increase	5.7	0	52	2.3	0.38	45
Green Heron	Increase	6.5	0	38	2.9	0.1	37
Mallard	Increase	6.3	0	125	6.2	0	112
Northern Mockingbird	Increase	1.7	0	128	1.6	0	109
Northern Pygmy Owl	Increase	2.8	0.05	34	-2.9	0.18	29
Osprey	Increase	6.4	0.01	27	6.7	0	25
Red-Shouldered Hawk	Increase	11.2	0	62	9	0.03	59

Table 6-11 (cont.)
CALIFORNIA BREEDING BIRD SURVEY TREND INFORMATION FOR SHASTA WEST WATERSHED SPECIES

Species	Pattern	1966-2002			1980-2002		
		Trend	P	N	Trend	P	N
Red-Tailed Hawk	Increase	1.4	0	194	1.8	0	176
Swainson's Hawk	Increase	9.1	0.22	16	24	0.03	14
Tree Swallow	Increase	4.3	0	102	4.6	0	94
Turkey Vulture	Increase	2.2	0.04	140	3.4	0	124
White-Breasted Nuthatch	Increase	2.4	0.07	112	-0.6	0.83	98
White-Headed Woodpecker	Increase	1.9	0.07	54	1.1	0.45	48
Wild Turkey	Increase	29.2	0	27	28.8	0	27
Winter Wren	Increase	1.8	0.28	29	2.6	0.05	29
Wood Duck	Increase	8.5	0	28	6.3	0.03	26

Notes: N was the sample size of surveys in California. P was the measure of statistical significance for population trends. Trend was the percent annual change in detections. Increasing or decreasing patterns were identified if the trend was more than 1 percent.

At least 20 percent of the watershed is highly urbanized. As much as an additional 60 percent of the watershed has been fragmented or degraded to some degree by suburban and semi-rural housing development. Residual areas of blue oak-foothill pine and valley foothill riparian may be quite important as refugia habitat within the expanding urban matrix. Less than 20 percent of the watershed is under public ownership managed by the Bureau of Land Management or National Park Service. Within these public lands, blue oak-foothill pine and valley foothill riparian habitats may be especially important because of their potential biodiversity. These lands may also provide fewer disturbed, higher quality habitats than in lands in the privately owned matrix. Figure 6-3 shows the connectivity between Rock, Middle, Salt, and Olney Creek riparian corridors and habitats on Shasta West Watershed public lands. These riparian corridors also provide connectivity with extensive montane conifer habitats to the west of the watershed in the Whiskeytown National Recreation Area.

Although they do not provide connectivity with public lands, hundreds of acres of habitat remain along Canyon Creek and Oregon Gulch west of Highway 273. Due to expanding urbanization, residual habitats along these creeks will become increasingly important as refugia habitat. A large area of blue oak-foothill pine and valley foothill riparian habitats remains along the Canyon Hollow stretch of Canyon Creek, whereas housing development is found on the flat ridges above. Golden eagles, wild turkeys, mule deer, coyote, thrushes, and mockingbirds have been observed using these habitats (Furnas, pers. obs., 2004). Even relatively small patches of blue oak-foothill pine or valley foothill riparian may provide significant refugia habitat benefits. Along the Buenaventura stretch of Canyon Creek, songbird activity occurs in June. A Cooper's hawk has been regularly observed using the area above Teton Road in 2002, 2003 and 2004 (Furnas, pers. obs., 2002-2004). On an even smaller scale, a pair of red-shoulder hawks has been observed nesting in a clump of tall street trees in a residential west-Redding neighborhood adjacent to upper Calaboose Creek (Furnas, pers. obs., 2003-2004). They often hunt in the chaparral-covered City of Redding property across from the Benton Airport, and juveniles have used blue oak-foothill pine habitat along the creek after leaving the nest (see Figure 6-7).

Other factors than the availability of habitat may place wildlife at risk in the urban setting. Besides the issues of movement corridors and habitat fragmentation and degradation, bird nest predation by raccoons and domestic and feral cats may be a serious problem in the watershed (Burnett, pers.

comm., 2003). Research along nearby Clear Creek shows that although the occurrence of song sparrows and yellow warblers is relatively high there, the reproductive success of these species is fairly low (Burnett and DeStaebler, 2001). Research on the effects of residential development on breeding birds in Placer County oak woodlands has shown that some species, such as lark sparrow, are negatively correlated with development, whereas other species such as western scrub jay are positively correlated (Stralberg and Williams, 2002). As discussed in Section 5 "Botanical Resources", year 2000 census data show population densities outside of downtown Redding and the Highway 273 corridor to be highest in the Jenny Creek, Canyon Creek, and lower Olney Creek drainages. Refugia habitats in these areas may be particularly vulnerable to nest predation.

BLACK-TAILED DEER AND MOUNTAIN LION

In contrast to other areas of the State where deer levels have been declining, DFG monitoring data show that black-tailed deer (*Odocoileus hemionus columbianus*) populations in the vicinity of the watershed have stayed relatively stable since the late 1990s. Statewide, typical densities in suitable habitats range from 20 to 60 deer per square mile. There is little or no critical winter range in the watershed for migratory deer. However, there are lots of resident deer using habitats within the watershed. DFG biologists note that there is a fair amount of mostly anecdotal information suggesting that deer populations may be increasing in wildland-urban interface areas across the State (Smith, pers. comm., 2003).

Shrubs are the major food item for deer. They prefer the tender new growth of ceanothus and other shrub species that are rich in protein. They also feed heavily on acorns in the autumn. While open areas are better for foraging habitat, deer utilize moderately dense woodlands and chaparral for cover and reproduction. Consequently, optimal deer habitat is a mosaic of types providing an interspersion of open and dense habitats. In northern California, it is believed that years of fire exclusion have reduced foraging habitat for deer at the landscape level. Denser forests have shaded out the growing space available for the understory shrubs deer eat. In the Shasta West Watershed, fire exclusion has led to the build-up of large areas of unpalatable brush. However, the deer-suitable habitat elements remain in much of the blue oak-foothill pine areas.

The feeding of deer by watershed residents can adversely impact the health of these animals. The practice can lead to artificially high concentrations of deer in too small an area, resulting in increased incidence of lung diseases and intestinal parasites that affect deer. Consumption of unhealthy foods can result in malnourishment. An analogy provided by one DFG biologist likens the feeding of deer by people to eating at a fast food restaurant – "it is not good for you, but it tastes good, so you come back for more." The feeding of deer by humans may also attract a greater number of deer predators such as mountain lion (*Felis concolor*) to the area (Smith, pers. comm., 2003).

Mountain lions use a variety of habitats throughout the State. However, they use chaparral and other brushy stages of habitat for cover and reproduction. They primarily prey on deer, but may also eat rabbits, porcupines, rodents and occasionally domestic animals and livestock. They are mostly nocturnal.

Between 1906 and 1963 the mountain lion was labeled a "bountied predator." During this era at least 12,500 lions were hunted and killed. In 1972, recreational hunting of mountain lion was prohibited. Depredation permits may still be issued for taking lions that kill, injure or threaten livestock or pets. The number of such permits issued Statewide by the DFG increased steadily from 40 in 1980 to 200 in 1990 (DFG 1998).

Mountain lion populations throughout California appear to be increasing. The Statewide numbers of these animals have increased since the mid-1970s. There has been an increased incidence of mountain lion sightings and attacks on humans since 1990. There have only been six attacks and three persons killed Statewide by mountain lions in the last decade.

Mountain lion densities in northwest California may be as high as 7 to 10 individuals per 100 square miles (DFG 1998). This suggests that there are probably no more than 2 or 3 mountain lions using habitats within the watershed at any one time. Besides following the deer they prey on, the competition for territories among an increasing number of mountain lions may be a reason that these animals are becoming more common in the wildland-urban interface. The growth of California urban and suburban development also increases the likelihood of contact between mountain lions and humans (DFG 1998). Within the watershed, DFG wardens shot a mountain lion spotted wandering near upper Calaboose Creek in the vicinity of Manzanita School in 2000 for public safety purposes.

OBSERVATIONS

The following observations, with regard to fish and wildlife resources in the watershed, were summarized from the information discussed in this section.

- Blue Oak-Foothill Pine and Valley Foothill Riparian are the two most potentially diverse wildlife habitats in the watershed in terms of the numbers of species using these habitats. The amounts of both habitat types have been declining across California.

- The cumulative contribution of watershed streams is significant as spawning grounds and rearing habitat for anadromous and resident salmonids in the Sacramento River system below Keswick Dam.

- Olney, Middle and Salt Creek are probably the most productive spawning creeks. Planned barrier removal and restoration projects may improve access and habitat conditions along Canyon Creek and Oregon Gulch. Non-natal rearing habitat for juvenile salmonids is provided by creeks as small as Calaboose Creek.

- Winter-run chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Oncorhynchus mykiss*) are threatened and endangered anadromous fishes known to use the watershed's streams

- The bank swallow (*Riparia riparia*) and valley long horn elderberry beetle (*Desmocerus californicus dimorphus*) are the two non-fish threatened species documented to use habitats within the watershed or along its boundary.

- Riparian habitat corridors along between Rock, Middle, Salt, and Olney Creeks may provide connectivity with protected habitats on public lands within the watershed and to the west of the watershed.

- Residual habitats within the Canyon Creek, Oregon Gulch and Calaboose Creek drainages may become increasingly important refugia as surrounding private land is developed.

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SECTION 6: FISH AND WILDLIFE RESOURCES

Issues Identified

Vegetation typing and LCMMP imagery is insufficient for assessing the quality and quantity of wildlife habitats.

Native habitat is being reduced and fragmented by urban development.

There is a need to review BMP's in providing wildlife habitat parameters and species needs.

Mountain lion occurrences within the watershed can lead to conflicts with residences within the urban-interface habitat of the watershed.

The rate and pattern of urban and semi-rural development and its effects on wildlife habitat and populations have not been fully explored. In particular the impact of wildlife movement barriers, road kill, urban animal predation, on watershed wildlife and populations is unclear.

The viability of the upper reaches of streams for spawning and the successful emigration of newly hatched juvenile salmonids is unclear.

Existing riparian corridors and refugia habitats are under urban development pressures.

Deer population and health are effected by rural development.

Information on wildlife species were based mainly on CWHR modeling. No survey data was collected for the assessment to confirm the actual occurrences of different wildlife species in the watershed.

There is a need for better mapping of the terrestrial habitats and the pattern and rate of urban/semi-rural development.

Data Gaps

There is little data on mountain lion populations occurring in the watershed.

There is incomplete data on the viability of the upper reaches of the streams in the watershed to support spawning and juvenile salmonids.

Lack of data on the effects of the various types of recreation such as, but not limited to, bike riding, OHV use, horseback riding, swimming, fishing and hunting on fish and wildlife populations and habitat.

Lack of quality mapping of urban development, wildland habitat, riparian corridors and refugia habitat to define the urban-interface, rates of fragmentation and opportunities for conservation.

Data is lacking on the impacts and rate of impact on wildlife and birds from urban animal species such as cats, dogs and other domesticated animals.

Data is lacking on the impacts and rate of impact on wildlife and birds from predatory animals such as raccoons, fox, coyotes and other small predatory species.

Action Items

Work with the city and county to review and develop BMP's that retain open spaces areas for the needs of species that require certain stand sizes of habitat.

Work with the city and county to explore the use and/or development of incentive programs for landowners to retain and maintain native habitats.

Use developed educational materials and outreach programs to inform rural residences on the risk of living in Mountain Lion habitat.

Work with agencies to determine the viability of the upper reaches of the streams in the watershed to support juvenile salmonids.

Collaborate with agencies and educate the public on the effects of various forms of recreation on the fish and wildlife populations and habitat. Develop a plan to provide for recreation in a way that minimizes impacts on fish and wildlife species.

Collaborate with the city and county to develop a GIS database that can track urban development and wildlife habitats in the watershed.

Work with agencies and organizations to develop a wildlife monitoring program.

Evaluate habitat using the Guild approach or other comparable scientific method to prioritize habitat restoration and protection efforts. Information gathered could be used to link the habitats of the Shasta West watershed to other adjacent watershed habitat types after the development of a high quality vegetation map of the watershed.
Develop educational materials and outreach programs about the function and importance of fish and wildlife species and the idea of biodiversity for the watershed. Included in the materials should be education on the effects of domestic animals such as cats and dogs and escaped exotic pets on biodiversity and the watershed.

Appendix 6-A

Olney Creek Fish Passage Barrier Removal Project Description

LAND USE
SECTION 7

Section 7
LAND USE AND DEMOGRAPHICS

TABLES

FIGURES

Section 7
LAND USE AND DEMOGRAPHICS

INTRODUCTION

This section examines human use of lands within the Shasta West Watershed including development patterns, growth policies, and population characteristics. More than any other factor, human land use activities may have a profound effect on the physical and biological characteristics of a watershed. As the human population grows and land use activity changes in the Shasta West Watershed, decisions by land use agencies, such as the City of Redding, Shasta County, California Department of Fish and Game, United States Fish and Wildlife Service, Bureau of Land Management, and the Regional Water Quality Control Board, will have a significant influence on the health of the watershed and public sentiment for conservation of natural resources within the watershed. As development intensifies from rural to urban uses, both the challenge and public demand to maintain watershed health becomes a more complex issue.

The purpose of this section is to review available land use and demographic information, characterize the data in relation to the watershed, and highlight any issues of concern. More specifically, this section will evaluate the watershed with respect to the following:

- The distribution and intensity of permitted land use activities
- Growth and development policies by jurisdictions with land use authority
- Infrastructure availability including roads, water service, and sewer service
- Natural growth constraints including slopes, floodways, and habitats
- Basic population characteristics such as densities
- Challenges presented by future growth

SOURCES OF DATA

Land use in the watershed is governed primarily by two local agencies: the City of Redding Development Services Department, Planning Division and the Shasta County Department of Resource Management, Planning Division. Each agency has planning policies and ordinances governing land use in the watershed.

The United States Bureau of Land Management (BLM) owns over 4,000 acres within the 29,000-acre watershed. Figure 7-1 shows the BLM ownership boundaries in the Shasta West Watershed. These lands are exempt from local land use policies; however, federal management plans and policies apply.

Demographic information covering the entire watershed is available through the United States Census. A list of primary information sources for land use and demographic information is provided below:

- City of Redding General Plan, 2000
- City of Redding Zoning Plan, 2003
- City of Redding Planning Division Staff

- Shasta County General Plan, 1998
- Shasta County Zoning Plan, 2003
- Shasta County Planning Division Staff
- BLM, Redding Resource Management Plan, 1993
- BLM Staff
- United States Census Bureau, 1990 and 2000 Census

A detailed list of references is provided at the end of this section.

Other state and federal agencies have limited jurisdiction within the watershed. Figure 7-1 shows all state and federal agency ownership boundaries in the watershed. Approximately 700 acres in the northwest portion of the watershed are within the eastern fringe of the Whiskeytown National Recreation Area (NRA). The National Park Service (NPS) has jurisdiction over these lands based on an NRA Management Plan. The NPS jurisdiction is limited and this area primarily serves as an unused buffer and interface with adjoining private lands. The United States Bureau of Reclamation also has minor holdings within the watershed related to water diversion from Whiskeytown Lake to Keswick Reservoir. These areas have a significant effect on land use activities.

BACKGROUND

Land use is generally characterized by incremental intensities of human use by various types such as residential, commercial, industrial, agricultural, mineral resource, or natural resource. Demographics provide spatial information about population patterns in specific areas for factors such as density, race, age, and income. Demographics are reflective of current land use while land use plans, such as general plans, represent a desired blueprint for future development.

Regulation of Land Use

Land use is controlled directly by local regulations and indirectly by other State and Federal laws intended for public safety, public welfare, or to protect natural resources.

General Plan

All cities and counties are required by State law to prepare and periodically update general plans. General plans are intended to guide growth in light of sensitive resources – both human and natural – and available services. Specifically, Government Code Section 65031.1 provides that growth should be guided by a general plan with goals and policies directed to land use, population growth and distribution, open space, resource preservation and utilization, air and water quality, and other physical, social, and economic factors.

The City of Redding General Plan describes the value of land use policies as follows:

> Land use policies and the General Plan Diagram affect every property in the City. They determine how people can use/develop their land and what they can reasonably expect to develop next door, down the street, or across town. They provide for overall consistency and compatibility between land uses and can be a determining factor on quality of life.

The western half of the Shasta West Watershed (excepting federally owned lands) is subject to the Shasta County General Plan and the remaining incorporated portions are subject to the City of Redding General Plan, as shown in Figure 7-2. The process to update both of these general plans involved extensive public review and environmental review under the California Environmental Quality Act (CEQA). The elected officials on the Redding City Council and Shasta County Board of Supervisors adopted these plans.

The City of Redding and Shasta County General Plans are divided into chapters, known as "Elements," representing various issues associated with land use and growth such as natural resources, housing, circulation, and services. The General Plans have three main components:

- **Baseline and Issues:** Each Element of a General Plan, such as the Land Use Element, is discussed in terms of existing conditions, regulatory environment, issues, and a desired future condition.

- **Goals and Policies:** Each Element includes goals (or objectives) and policies to obtain a future desired outcome. Goals are broad expressions of commonly held community values. Policies are precise statements regarding how public regulatory powers and fiscal resources will be used to achieve a specific goal.

- **Plan Maps:** General plan maps designate areas for various types of uses. The City of Redding and Shasta County General Plan designations are shown on Figure 7-2.

A general plan is not a detailed, parcel-specific policy statement. Instead, it establishes a general pattern for future land use that serves as a basis for more detailed plans such as zoning ordinances. General Plan land use designations within the Shasta West Watershed are summarized in Table 7-1.

Zoning Plan

Zoning plans are local ordinances specifically intended to implement the General Plan. State law requires zoning plans to be consistent with the General Plan. The zoning plan, together with zoning maps, set forth parcel-specific requirements for how lands may be used in the present and near future. Zoning plans include specific listings of the types of land uses allowed in each zoning district. Zoning plans also include detailed development requirements such as building heights and setbacks from property lines.

For purposes of this report, zoning information was not evaluated in detail since the two General Plans better reflect long-term land use on a large scale consistent with this watershed assessment.

Federal Management Plans

Federally owned lands, such as those managed by BLM and the NPS (Whiskeytown) are not subject to local general plans or zoning ordinances. Use of these lands are governed by federal land use polices. Federal policies are more limited in scope since they do not involve private lands. They are limited to activities directly related to the agency's relatively narrow public mandate and authority.

Other Resource Protection Laws
Many other state and federal laws for the protection of resources limit the use of land for development in sensitive areas of the watershed. The most common laws with the greatest effect on land use in the study area are discussed below:

Typical Permit Requirements

The numerous statutory requirements that apply to lands in the watershed generate volumes of regulations to manage how actions occur on both state and federal properties. Although not inclusive an example of the types of permits and administrative actions required to conduct activities, such as restoration projects, in the watershed are summarized below.

A permit is an authorization or other control document issued by a federal, state, or local agency to implement the requirements of a law or regulation. The type of permits that would be required for a project depends on the source of project's funding (private, state, or federal); type of project and resources affected; ownership of land on which the project occurs; and physical location of the project.

Most permits require a fee. The permitting process for *any* project can be complicated and difficult to understand. This section is not intended as a comprehensive guide for project permitting. Because it is the responsibility of the permit applicant to ensure they have applied for all the right permits, the goal of this section is to present enough information to assist project managers in asking the correct questions and searching out appropriate sources of assistance. Some permits apply to specific project types. Others, like CEQA compliance, apply to all projects. There is significant distinction in permit requirements between projects on public and private lands. Most permits are resource use specific. For example, the preparation of a timber harvest plan and submittal of the plan to CDF is required to remove timber. Any project which disrupts a stream channel or waterway requires a 1600 (stream bed alteration) permit from the Department of Fish and Game. Cinder pits require compliance with SMARA. Water re-use projects that may impact water quality will require review by the Regional Water Quality Control Board or the Department of Water Resources. Most all projects will require NEPA or CEQA review as no permit may be issued without the primary agency completing this process.

Brief descriptions of regulatory agencies that may be involved in the project are found in Table 7-2.

A possible project matrix and likely permit requirements for private lands is included as Table 7-3. This table is provided *only* to present areas where permits may be required.

In general, project permitting will take a minimum of 120–180 days. It is important in all project planning and permit operations to

- Prepare a well-defined project description that minimizes disturbance
- Prepare clear and concise plans
- Contact agencies early
- Maintain a positive attitude

Table 7-1
SHASTA WEST GENERAL PLAN LAND USE DESIGNATIONS

General Plan Designations	Acres	Percent of Watershed
RESIDENTIAL		
City of Redding		
20 to 30 units/acre	33	0.11%
10 to 20 units/acre	169	0.58%
6 to 10 units/acre	339	1.16%
3, 5-6 units/acre	969	3.31%
1 to 5 units/acre	2,055	7.03%
2-3, 5 units/acre	3,338	11.42%
1 to 2 units/acre	304	1.04%
1 unit/5 acres+	3	0.01%
Shasta County		
1 unit/2 acres	8,914	30.49%
1 unit/5 acres	39	0.13%
Residential Subtotal	**16,163**	**55.28%**
COMMERCIAL		
City of Redding		
General Office	241	0.82%
General Commercial	379	1.30%
Limited Office	78	0.27%
Heavy Commercial	312	1.07%
Neighborhood Commercial	23	0.08%
Mixed Use Core	61	0.21%
Shopping Center Commercial	26	0.09%
Airport Service	108	0.37%
Shasta County		
Mixed Use	26	0.09%
Commercial Subtotal	**1,254**	**4.29%**
INDUSTRIAL		
City of Redding		
General Industrial	228	0.78%
Shasta County		
Industrial	36	0.12%
Industrial Subtotal	**264**	**0.90%**
RESOURCE		
Shasta County		
Mineral Resource	48	0.16%
Resource Subtotal	**48**	**0.16%**
PUBLIC FACILITY		
City of Redding		
Public Facility – Institutional	1,063	3.64%
Public Facility – School	183	0.63%
Public Facility Subtotal	**1,246**	**4.26%**
PUBLIC LAND AND OPEN SPACE		
City of Redding		
Greenway	4,059	13.88%
Park	151	0.52%
Park Golf	6	0.02%
Recreation	29	0.10%
Shasta County		
Open Space	331	1.13%
Public Land	5,688	19.45%
Public Land and Open Space Subtotal	**10,264**	**35.10%**
WATERSHED TOTAL	**29,239**	**100.00%**

CEQA/NEPA

All local and state agency approvals of land use actions that can result in physical changes to the environment are subject to review under the California Environmental Quality Act (CEQA). Some local and state actions (i.e., those with federal funding or permits), and all federal approval actions, require review under the National Environmental Policy Act (NEPA). Both laws are similar, requiring public disclosure of environmental impacts and providing mitigation measures and alternatives to avoid or reduce environmental impacts to less than significant levels. CEQA and NEPA reviews cover a broad range of issues extending beyond the natural environmental realm of flora, fauna, water, soil, and air. Human impacts are given equal consideration including conflicting land uses, noise, safety, public services, transportation, and consistency with land use plans.

Both laws are similar, requiring public disclosure of environmental impacts and providing mitigation measures and alternatives to avoid or reduce environmental impacts to less than significant levels. CEQA and NEPA reviews cover a broad range of issues extending beyond the natural environmental realm of flora, fauna, water, soil, and air. Human impacts are given equal consideration including conflicting land uses, noise, safety, public services, transportation, and consistency with land use plans.

Federal Clean Water Act

The primary purpose of the 1972 Clean Water Act was to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." To achieve that goal, the law prohibits the discharge of pollutants into "navigable waters," defined in the act as "waters of the United States," without a permit. The law has historically been understood to protect traditionally navigable waters; tributaries of navigable waters; wetlands adjacent to these waters; and other wetlands, streams and ponds that, if destroyed or degraded, could affect interstate commerce.

Federal and State Endangered Species Acts

The Federal Endangered Species Act (FESA) requires all federal agencies, in consultation with the US Fish and Wildlife Service or NOAA Fisheries, to ensure that their approval actions, whether on public or private lands, will not jeopardize the continued existence of endangered or threatened species, or result in the destruction or modification of critical habitat. Section 2050 et al. of the California Fish and Game Code requires similar protections to ensure that actions are not likely to jeopardize the continued existence of any species listed under the California Endangered Species Act (CESA).

These laws provides set asides of critical habitat for endangered species resulting in changed land use patterns and open space policies.

Historic Preservation Act

Section 106 of the National Historic Preservation Act requires reviews for cultural resources prior to most land use development. Where cultural resources are found, coordination with the State Historic Preservation Officer (SHPO) is required to determine the effects a project may have on properties listed, or eligible for listing, on the National Register of Historic Places (NRHP). Typically, if cultural resource sites are discovered, documentation and avoidance of impacts to the site is the most feasible option.

Table 7-2
PERMIT-ISSUING AGENCIES

Agency	Function	Area
Local:		
City/County Planning Department	Many city or county planning departments have local ordinances pertaining to grading creeks and wetlands, and depending on the nature of the project, several other permits/exceptions/approvals may be required as well. Planning departments are commonly the lead agency for CEQA documentation. County planning department are commonly the lead agency for mine applications	Modoc, Lassen, Shasta Counties
City/County Environmental Health Department	Local Environmental Health Departments provide monitoring and enforcement relating to food and hazardous materials handling. This agency may be involved if work on the stream, or discharge into the stream pose a pubic health hazard, such as with water re-use. Health departments commonly are lead agency for well permits, water re-use and reclamation, and underground storage tank contamination limited to soil.	Modoc, Lassen, Shasta Counties
Local Irrigation, Water, or Flood Control District	Irrigation, Water, or Flood Control Districts are empowered to protect water resources within their jurisdiction which may require a permit for certain projects	Modoc, Lassen, Shasta Counties
State:		
California Department of Fish and Game	The California Department of Fish and Game requires a Stream Alteration Agreement (1600 permit) for projects that will divert or obstruct the natural flow of water, change the bed, channel or bank of any stream, or use any material from a streambed. The 1600 permit is a contract between the applicant and the CDFG stating what can be done in the riparian zone and stream course. The permit is required for removal of vegetation and such activities as placement of culverts requires independent CEQA review for all 1600 permits and will serve as lead agency if the review is not considered previously. CDFG can also be expected to provide input to projects through the CEQA and NEPA review process.	Region 1 (Northern California & North Coast Region) 601 Locust Street Redding, CA 96001 (530) 225-2300
California Regional Water Quality Control Boards	There are nine Regional Water Quality Control Boards. Regional Boards engage in a number of water quality functions. One of the most important is preparing and periodically updating Basin Plans, which set water quality standards. Regional Boards regulate all pollutant discharges that may affect either surface water or groundwater. Private, state, and federal projects require RWQCB permits. The permits obtained from the RWQCB would include: Waste Discharge Requirements The discharge of waste or waste water to land that may impact water quality. The RWQCB is allowed through regulation to issue waivers for certain discharges if a set of specific conditions applies. The RWQCB recently adopted waivers for discharge from 1) irrigated lands and 2) timber harvest. National Pollution Discharge Elimination System (NPDES) Permit – This permit is required when proposing to, or discharging of waste into any surface water. For discharges to surface waters, these requirements become a federal National Pollution Discharge Elimination System (NPDES) issued by the RWQCB. Federal Clean Water Act (CWA) Section 401 Water Quality Certification – This certificate is required for every federal permit or license or for any activity which may result in a discharge into any waters in the United States. Activities include flood control channelization, channel clearing, and placement of fill. Federal CWA Section 401 requires that every applicant for a US Army Corps of Engineers CWA Section 401 permit or Rivers and Harbors Act Section 10 permit must request a state certification from the RWQCB that the proposed activity will not violate state and federal water quality standards. The RWQCB reviews the request for certification and may waive certification, or may recommend either certification or denial of certification to the State Board Executive Director.	Redding Branch Office (5R) Redding, CA (530) 224-4845

Table 7-2 (cont.) **PERMIT ISSUING AGENCIES**		
State (cont.):		
State Water Resources Control Board Division of Water Rights	Anyone wanting to divert water from a stream or river not adjacent to his or her property must first apply for a water rights permit from the State Board. The State Board issues permits for water rights specifying amounts, conditions, and construction timetables for diversion and storage. Any persons or agencies intending to take water from a creek for storage or direct use on non-riparian land must first obtain a Water Rights Permit. The goal of the Board is to assure that California's water resources are put to a maximum beneficial use and that the best interests of the public are served. CDFG also must concur on the permit.	Division of Water Rights 1001 "I" Street, 14th Floor Sacramento, CA 95814 (916) 341-5300
Federal:		
U.S. Army Corps of Engineers	Federal and state projects planning work in a river, stream, or wetland may require a Corps permit. The regulatory authority of the Corps for riparian projects is based on Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. Section 404 of the Clean Water Act requires Corps authorization for work involving intentional or unintentional placement of fill or discharge of dredged materials into any "waters of the United States." This applies even if there is a chance the winter rains may cause erosion leading to sediment discharges into the "waters." Section 10 of the Rivers and Harbors Act requires Corps authorization for work or structures in or affecting "navigable waters." Corps jurisdiction extends up to the ordinary high water line for non-tidal waters. Corps review can be shortened through the use of General Permit categories. These are areas where the AOC has determined with SWRCB concurrence that a special permit is not required and published BMPs or General Permit conditions are acceptable	Sacramento District – (916) 557-5250 New Redding Office
U.S. Fish and Wildlife Service	The US Fish and Wildlife Service (USFWS) is the principal federal agency for conserving, protecting, and enhancing fish, wildlife, plants, and their habitats. USFWS and National Marine Fisheries Service share responsibility for administration of the Endangered Species Act. USFWS enforces the federal Endangered Species Act, ensures compliance with the National Environmental Policy Act, and reviews and comments on all water resource projects. The Fish and Wildlife Coordination act requires that all federal agencies consult with the USFWS, the National Marine Fisheries Service, and state wildlife agencies for activities that affect, control, or modify waters of any stream or bodies of water. Under the Act, the USFWS and NMFS have responsibility for project review. In addition, the USFWS functions in an advisory capacity to the Corps of Engineers under the provisions of the Fish and Wildlife Coordination Act and other legislation. Incidental Take Permits – If a project may result in "incidental take" of a listed species, an incidental take permit is required. An incidental take permit allows a non-federal landowner to proceed with an activity that is legal in all other respects, but that results in "incidental taking" of a listed species. Habitat Conservation Plan – A Habitat Conservation Plan must accompany an application for an incidental take permit. The purpose of an HCP is to ensure that the effects of the permitted action on listed species are adequately minimized and mitigated. The incidental take permit authorizes the take, not the activity that results in the take. The activity itself must comply with other applicable laws and regulations.	2800 Cottage Way, Room W-2606 Sacramento, CA 95825-1846 (916) 414-6464

Table 7-2 (cont.) PERMIT ISSUING AGENCIES		
Federal (cont.):		
National Marine Fisheries Service	The National Marine Fisheries Service (NMFS) is the federal agency responsible for the conservation and management of the nation's living marine resources. Projects or activities that may affect marine fish and related habitat within NMFS jurisdiction are reviewed for any potentially harmful effects. The purpose of reviews conducted by NMFS is to ensure those sensitive populations of marine and anadromous fish (such as salmon and steelhead), as well as the aquatic and riparian habitat that support these fish, can survive, and recover in the presence of human activities. The types of projects and activities of interest to NMFS include streambank stabilization, streambed alteration, habitat restoration, flood control, urban and industrial development, and water resource utilization. When projects or activities require a federal permit, such as a Clean Water Act section 404 permit from the Army Corps of Engineers, then NMFS conducts a consultation with the federal agency under section 7 of the ESA. When there is no federal involvement, then for projects that incidentally "take" a listed species a permit under section 10 of the ESA is required. Because the Upper Pit River Watershed is behind numerous dams, NMFS consultation is not required.	N/a
1 **Tribal Review**		
Tribal Review	For projects on federal and state lands, tribal review is required. For projects on private lands with federal money, review would apply. Private land projects with private money do not require tribal review.	

Table 7-3
PROJECT PERMIT EXAMPLES–COUNTY OR OTHER LEAD AGENCY

Is Your Project:	City/County Planning Dept Grading, Mining, etc	City/County Health Dept	Water/Irrigation Flood Control District	California Dept of Fish & Game		State Water Resources Control Board/Division of Water Rights	Regional Water Quality Control Board			US Army Corps of Engineers	County or Other Agency (CEQA)	National Environmental Policy Act (Federal Lead Agency)	Tribal Review	US Fish and Wildlife Service
				1600	Other		WDR	NPDES	401 Cert					
On federal land with federal funding?												×	×	
On private land with private funding?	×				×						×			
On private land with federal funding?									×	×	×	×	×	×
On private land with state funding?											×			
Result in stormwater discharge into the creek?					×				×					
Divert or obstruct the natural flow; or change the natural bed or bank of the creek?				×		×					×			
Involve repair, rehabilitation, or replacement of any structure or fill adjacent to creek?				×					×	×	×			
Involve fish and wildlife enhancement, attraction, or harvesting devices and activities?				×	×						×			×
Use materials from a streambed (including but not limited to boulders, rocks, gravel, sand, and wood debris?	×		×	×	×		×		×	×	×			
Require the disposal or deposition of debris, waste, or any material containing crumbled, flaked, or ground pavement with a possibility that such material could pass into the stream?				×	×		×		×	×	×			×
Involve grading or fill near the creek?				×				×						
Involve a bridge or culvert?				×				×						
Involve water re-use?		×	×				×							
Involve a septic or leach field?		×					×							
Require water well?		×												
Involve work within historic or archaeological area?											×	×	×	
Remove water from creek for storage or direct use on non-riparian land?						×								
Require that hazardous materials be generated and/or/stored on site?		×					×	×						
Involve a land disturbance of five acres or more?	×					×			×	×				
Involve a project with species listed as endangered or threatened?					×									×

Source: Portions for CARCD Guide to Watershed Project Permitting

Subdivision Map Act

The California Subdivision Map Act includes development and surveying requirements with respect to dividing parcels for sale and development. Most notably and with respect to land use, this law places additional requirements and expense on land divisions creating five or more parcels. To avoid these requirements, smaller and more fragmented residential developments fewer than five parcels are occurring, particularly in rural areas. Small, incremental land divisions (often referred to as "four-by-fouring") make it more difficult to implement comprehensive watershed conservation measures.

Other Factors Affecting Land Use

Aside from regulatory influences on land use, there are many practical limitations.

Availability of Services

Residential and commercial land uses require the availability of services to develop up to the maximum permitted densities in the General Plan. The services in the watershed with the greatest influence on land use are community water service (for drinking water and fire protection), community sewer service, and roads (including emergency access roads). Areas with both sewer and water service could allow urban densities, such as those found in the Redding core. Rural areas in Shasta County have water service but lack sanitary sewer service. This requires septic tanks and septic leach fields and larger parcels of two or more acres. Figure 7-3 shows the jurisdictions and services found in the watershed.

Natural Hazards

Development of structures, such as homes on steep slopes (in excess of 20 percent to 30 percent) or in flood prone areas, can expose people to safety hazards. Development in these areas is discouraged or, in some cases, prohibited (Shasta General Plan, 5.2). Development on steep slopes is also discouraged due to erosion and sedimentation concerns.

Demographics

Demographics refer to the distribution of people and population characteristics by area. The U.S. Census Bureau conducts a census every ten years to provide data, allocate funds, and set election areas. Detailed information is available for distinct geographical areas broken into census tracts, block groups, and blocks. Types of data include population density, race, gender, income, home ownership, education, and transportation. There are portions of 12 census tracts and 29 census block groups within the Shasta West Watershed. Figure 7-4 shows the 2000 Census block and tract boundaries for the Shasta West Watershed. By comparing census population distribution to allowable growth areas under the general plan, areas that may face greater development pressure can be identified.

Historic watershed demographics were discussed in Section 1, "General Watershed History." The highest populations densities are found in the eastern half of the watershed and are concentrated in the City of Redding.

Population trends in the watershed have been on a steady rise in the last 150 years. The first census was taken in 1850. The area has experienced a steady overall climb in population over the years.

From 1960 to 2000, Shasta County's population has almost tripled, with the greatest growth being in the City of Redding. Table 7-4 shows the decennial census population data for 1850 to 2000.

Table 7-4
SHASTA COUNTY DECENNIAL CENSUS DATA

Decade	Population
1850	378
1860	4,351
1870	4,173
1880	9,492
1890	12,133
1900	17,318
1910	18,920
1920	13,361
1930	13,927
1940	28,800
1950	36,413
1960	59,468
1970	92,100
1980	115,715
1990	147,036
2000	163,256

Source: University of Virginia Geospatial and Statistical Data Center.

While generalizations regarding demographics in the Shasta West Watershed can be made, specific comparisons or trends in census data over time cannot be made for the following reasons:

- Census boundaries do not correspond with the watershed boundaries
- Tract and block boundaries are changed with each decennial census
- Tracts and blocks vary in land area, generally increasing in size as population density decreases

Census data is evaluated in additional detail in Section 9.

LAND USE DATA SUMMARY

The Shasta West Watershed totals over 29,000 acres (approximately 46 square miles). Just under half of this area is within the City of Redding. The City of Redding provides urban services, allowing higher development densities.

The watershed includes diverse landscapes, land use, and demographics ranging from the Redding urban core to rural residential uses in the western unincorporated foothills. Public lands and aggressive policies for open space have been a key to maintaining the biological function of many streams in the watershed. Greenways in urban areas are also valuable for aesthetics and recreation, giving urbanized areas a rural feel.

The watershed includes several land use features that help define the area as a cultural center to the region. Key elements include parks (such as Turtle Bay), the Sacramento River Trail, and downtown Redding. The watershed also contains regional services used by residents throughout Shasta County and in neighboring counties. These include hospitals and medical support offices, federal and state government regional field offices, the Shasta County Courthouse, City Hall, and the Redding Convention Center. Taken together, these uses form a hub for regional services in the watershed.

A review of infrastructure needs, general plan designations, and demographic data reveals that areas with the highest potential for growth are within the City of Redding.

City of Redding and Shasta County General Plans

The City of Redding and Shasta County General Plan designations are provided in Figure 7-2. Table 7-5 shows acreage totals by land use type and jurisdiction. The primary land use activities in the watershed are discussed below.

Residential
Residential land use designations comprise 55 percent (16,163 acres) of the watershed area. More than half of this residentially designated land (8,953 acres) is within Shasta County. Nearly all Shasta County designations allow up to one residence per two acres. City of Redding designations permit up to 30 units per acre for multi-family housing. Single-family housing densities in the City of Redding are predominantly 2 to 3.5 units per acre. Although 55 percent of residentially designated property in the watershed is within Shasta County, allowable densities in Shasta County would permit one-tenth of the residential units allowed in the City of Redding.

Commercial and Office
Commercial and Office land use designations comprise 4.3 percent (1,254 acres) of the watershed area. All but 26 acres are within the Redding city limits. Commercial designations range from light commercial, such as small retail sales, to Heavy Commercial, such as automobile repair. General Commercial areas, such as those around downtown, are the most predominant designation. Office uses include limited office space blended into residential areas, such as those near the County Courthouse, to large-scale office complexes.

Industrial
Industrial land use designations comprise 0.9 percent (264 acres) of the watershed. Thirty-six acres are in Shasta County, a lumber mill on Keswick Dam Boulevard. The remaining 228 acres are in the City of Redding, primarily along the State Route 273 corridor south of downtown.

Resource Use
Resource uses include special designations for agricultural use, timber production, or mineral extraction. Perhaps the most striking characteristic of the watershed is the lack of any of these designations. The only exception is a 48-acre Interim Mineral Resource Designation on Keswick Dam Boulevard adjacent to a lumber mill. This is used for aggregate mining (the Crystal Creek

Aggregate facility). Interim Mineral Resource Designations are intended for areas where mining is likely to discontinue within the next 30 years (Shasta General Plan, 6.3).

There is only one commercial gold mining operation in Shasta County near French Gulch. It is estimated that 10 to 15 active small lode mines, claims, and dredging operations are active on an intermittent basis. Other minerals that occur in the watershed include copper, iron, zinc, talc, and aggregate. None of these resources are currently mined within the watershed (Shasta General Plan, 6.3).

Public Facility - Government and Institutional
Public Facility and Institutional Use comprises 4.26 percent (1,246 acres) of the watershed. All these lands are within the Redding city limits. Other public facilities, such as schools, are located in Shasta County but not designated as such in the General Plan. This classification includes schools, government buildings (including the County Courthouse Complex, City Hall, the Convention Center and Turtle Bay Park and Museum) fire stations, water and wastewater facilities, electrical substations, Benton Airpark, and Redding's two hospitals. The total acreage of Public Facility and Institutional designations are nearly identical to Commercial and Office designations within the watershed. Again, this is indicative of the area's role as an institutional hub to the Northstate.

Public Land, Open Space, and Parks
Considering that much of the watershed is urbanized, it is remarkable that Public Lands, Open Space, and Parks comprise 35.1 percent (10,264 acres) of the watershed. This is the result of strong open space policies on steep slopes and along streams in Redding (4,059 acres of designated greenway) and 5,688 acres of federal lands within Shasta County. Most of these lands are either BLM or NPS. Figure 7-1 shows BLM and NPS boundaries within the watershed. Public lands serve both as Open Space and recreational for public use. The NPS manages land use through the Whiskeytown Management Plan. The NPS area within the watershed primarily serves as a park and fire protection buffer to adjoining private property. The BLM manages lands within the watershed pursuant to the Redding Resource Management Plan. The Shasta State Historic Park on State Route 299 in Old Shasta receives a substantial number of visitors. The park is not specifically designated in the General Plan.

Services

Nearly all areas within the City of Redding have full city services including sewer, water, electric power, solid waste handling, police, and fire protection. Shasta County provides police, fire protection (under contract with CDF), solid waste handling, and limited water services (Keswick Community Service Area). Independent Community Service Districts (Shasta and Centerville C.S.D.s) provide water to most remaining unincorporated areas. The water districts in the unincorporated area rely exclusively on Central Valley Project water allocations (Shasta County Water Resources Plan). No wastewater treatment services are provided in the unincorporated areas. Therefore, densities higher than one unit per two acres will continue to be restricted. Figure 7-3 shows the jurisdictions and services within the watershed.

Solid waste generated in the watershed is sent to the West Central Landfill located south of the study area in the Clear Creek Watershed (Shasta General Plan, 7.5).

Circulation

Circulation in the downtown Redding area consists of a conventional grid road pattern over undulating terrain. The downtown area is also where State Routes 44, 299, and 273 converge. State Route 299 is the Trinity Scenic Highway starting just west of Redding City limits. Circulation in the watershed is constrained by the Sacramento River and the Union Pacific Railroad. Figure 7-5 shows the circulation map of the watershed area. Major improvements planned within the next 10 years include the following:

- Widen Highway 299 (Now Highway 44) from four to six lanes over the Sacramento River to Downtown Redding
- Widen Cypress Avenue Bridge from four to eight lanes over the Sacramento River
- Widen Bonnyview Drive from two to four lanes from the Sacramento River to Highway 273
- Widen Placer Road from two to four lanes from Benton Airpark to the Redding City limits (Shasta County Regional Transportation Plan)

The City of Redding and BLM continue to develop an extensive trail system centering along the Sacramento River with feeder trails extending into park and greenbelt areas (Redding General Plan, Transportation Element).

Circulation in the western portion of the watershed has become a development issue because of the requirements for secondary emergency access routes. Secondary access routes for large subdivisions must be full-sized, dedicated, and paved roads.

Sacramento River Trail

The Sacramento River Trail is over 10 miles long and runs through the center of Redding. The river corridor has provided a unique opportunity to develop an urban trail system within several miles of lush riparian habitat. Construction began in 1986 with funding from the McConnell Foundation, City of Redding, California State Department of Parks and Recreation, the National Park Service, and the Federal Highway Administration. Figure 7-6 shows the location of the Sacramento River Trail.

Central to the trial is the Turtle Bay Exploration Park and Museum that includes a visitor's center, a 34,000 square foot museum, Paul Bunyan's Forest Camp, a 220-acre arboretum, and the new Sundial Bridge. The bridge is uniquely designed to clear span the Sacramento River. A 218 foot white steel spar anchors cables slanting diagonally to support the bridge deck. The bridge was completed in the summer of 2004.

Several other trails are nearby including the 1.5-mile Blue Gravel Mine and 1-mile Canyon Creek Trail near Buenaventura Boulevard, the Westside Trail and Mary Lake Trail west of the Mary Lake Subdivision, and the 7.1-mile trail along the old railroad grade adjacent to Keswick Reservoir.

Long-range plans, including the Redding General Plan and the Parks, Trails and Open Space Master Plan call for linking all these trails into one contiguous network connecting parks, open spaces schools, residential neighborhoods, museums, the downtown, and other major public attractions.

Shasta-Trinity Trail

The Shasta-Trinity Trail is a proposed trail project that will connect the Sacramento River, Clear Creek, and Shasta, Trinity, and Whiskeytown Lakes with approximately 100 miles of trail. It will connect existing trails including the Sacramento River Trail, the Westside Trail, the Horsetown Clear Creek Preserve, and those of the Whiskeytown National Recreation Area. The trail will be open to hikers, equestrians, and mountain bikers, as well as allowing partial access to motorized trail users where it crosses official off-road vehicle recreation areas (National Park Service, 2004).

The project is assisted by the Rivers and Trails Program and a coalition of agencies and organizations including the BLM, City of Redding, McConnell Foundation, the National Park Service, Shasta County, U.S. Forest Service, and the Western Shasta Resource Conservation District.

LAND USE DATA ANALYSIS

Both the Shasta County and City of Redding General Plans were recently updated. The plans recognize the importance of the Shasta West Watershed both in terms of land use and natural resources. The plans include policies with protective measures for the watershed.

Redding and Shasta County General Plans

Residential

Development to the maximum allowable densities of the General Plans throughout the watershed is not practical due to previously mentioned development constraints such as services, roads, natural hazards, and wildlife habitat. Areas used for roads, drainage, or other infrastructure also limits land that could otherwise be used for allowed housing.

Residential densities are limited by steep terrain. In Redding, development is discouraged on slopes in excess of 20 percent. In Shasta County, development is discouraged on slopes over 30 percent. Section A, Figure A-5 shows slopes within the watershed area. Table 7-5 shows acreage of slope classifications within the watershed. Several goals are in place to limit grading and development on hillsides by limiting roads and housing construction. (Redding General Plan, Goal CDD7). Table 7-6 shows the potential residential growth for the watershed.

The residential areas of South Redding, such as the Country Heights Subdivision, and Central and West Redding are all identified as neighborhoods with distinctive character and histories that should be preserved. Some of the City of Redding's most unique and historic homes are located in Central Redding. Several focus areas are identified in the Redding general plan due to special characteristics and the need for tailored development guidelines (Redding General Plan, Community Development and Design Element, Page 35). Focus areas in the watershed include the following neighborhoods:

- Downtown
- Magnolia Neighborhood
- Park Marina
- Parkview Neighborhood

Commercial and Office
Downtown Redding is the location of the City of Redding's original commercial and office core. Commercial and Office uses in the watershed are still generally confined to the downtown area and along Highway 273 to the south. Nearly all of these areas are currently developed. New Commercial and Office uses will likely focus on redevelopment of blighted or underdeveloped areas. Redding is pursuing downtown redevelopment on several fronts to enhance downtown's role as a community center (Redding General Plan, Community Development and Design Element).

Industrial
Industrial uses in the watershed are limited and unlikely to expand to new areas. This is due to General Plan restrictions and a predominance of residential, institutional, and open space uses that would be incompatible with a new industrial activity. Redding has made deliberate efforts to shift new industrial activities to the east near the Redding Municipal Airport (Redding General Plan).

Resource Use
Despite a history of intensive mining in the vicinity near the Shasta West Watershed as described in Section 1, "General Watershed History," there are no plans for further large-scale mining in the watershed area. Similar to industrial uses, it would be difficult to reestablish large mining operations, even if the market were favorable, given surrounding residential land use sensitivities (Shasta General Plan, 6.3). Agricultural and timber production are not designated in these areas because growing conditions for merchantable products are not present on a large enough scale (Shasta General Plan, 6.1 & 6.2).

Public Facility – Government and Institutional
The watershed remains well suited for regional government and institutional services. Institutional land use activities should continue to grow, particularly in the area of medical services, as the population ages. Local, state, and federal government land uses tend to remain stable despite economic or demographic changes.

Public Land, Open Space, and Parks
The City of Redding's open space policies have been well received by the public. Strong general plan policies and public acceptance should leave these areas intact, or increasing in size, despite urban encroachment (Redding General Plan, Community Development Element). Open space easements are often required as a condition of development along streams or slopes in excess of 20 percent (Redding General Plan, Natural Resources Element). Further work is needed to increase awareness and understanding of habitat and water quality protection within the Shasta West Watershed. This information could be used to strategically designate new open space and obtain optimal natural resource and public benefits.

Land designated as open space is less predominant in the unincorporated area of the watershed because recreational opportunities and natural areas are relatively numerous. Open Space designations are generally reserved for areas needed for habitat protection, floodplain management, or community amenities (Shasta General Plan. 6.9).

BLM has actively sold BLM-owned property to private individuals in the watershed. Typically, these lands are converted to residential uses at densities of two units per acre. BLM's Redding Management Plan encourages these sales so they can purchase areas of higher habitat values and public benefit. A policy of the Plan states: "Enhance the ability to acquire high value resource lands within the Redding Resource Area by disposal of public land interests within the Shasta Management Area" (BLM, Redding Resource Management Plan, Page 44). This practice will continue to be controversial, particularly to residents living near these converted areas. Most high value lands acquired by BLM in place of these disposed lands have been outside the watershed area. This will continue to result in decreased open space in the study area as lands are sold and developed.

Services

Urban and rural levels of service are high in the watershed compared to surrounding areas. Between various districts and the City of Redding, water service districts cover a majority of the Shasta West Watershed. The Centerville CSD, Anderson Cottonwood Irrigation District, and the Shasta Co. SA #25 – Keswick overlap with City of Redding services. Sewer services are provided by the City of Redding, and extension of these services could only occur with annexation of new areas to the City of Redding. Redding General Plan Policy CDD1B states that annexations of unincorporated areas would only be considered if it would result in either:

- A more logical service area boundary
- The elimination of an existing Shasta County island
- More efficient provision of urban services
- Resolution of an existing safety concern
- A neutral or positive fiscal impact to the City of Redding

Circulation

Road circulation is generally adequate within the Shasta West Watershed as measured by statewide standards. With the aforementioned improvements planned for the area, major urban congestion should remain at bay over the next ten years. Beyond this time frame, major improvements will be needed and new funding sources identified (Shasta County Regional Transportation Plan). Environmental stewardship in road design and construction, such as storm water runoff from roads, by Shasta County, City of Redding, and Caltrans has markedly improved. This trend should continue as new transportation projects are developed in the watershed.

Table 7-5 CONSTRAINED RESIDENTIAL BUILDOUT BY GENERAL PLAN DESIGNATION								
General Plan Designation	**Acres**	**Percent of Watershed**	**Maximum Permitted Units**	**Percent Over 30% Slope**	**Slope Constrained Maximum Units**	**Constrained Units Assuming 75% Buildout**	**Estimated Full Residential Buildout by General Plan Designation**	
							Units	**Persons**
Residential								
City of Redding								
20 to 30 units/acre	33	0.11%	990	3.03%	960	720	720	1,764
10 to 20 units/acre	169	0.58%	3,380	0.59%	3,360	2,520	2,520	6,174
6 to 10 units/acre	339	1.16%	3,390	0.88%	3,360	2,250	2,250	6,174
3, 5-6 units/acre	969	3.31%	5,814	0.52%	5,784	4,338	4,338	10,628
1 to 5 units/acre	2,055	7.03%	10,275	0.73%	10,200	7,650	7,650	18,743
2-3, 5 units/acre	3,338	11.42%	11,683	2.10%	11,438	8,579	8,579	21,017
1 to 2 units/acre	304	1.04%	608	5.26%	576	432	432	1,058
1 unit/5 acres+	3	0.01%	1	0.00%	1	1	1	2
Shasta County								
1 unit/2 acres	8,914	30.49%	4,457	24.73%	3,355	2,516	2,516	6,165
1 unit/5 acres	39	0.13%	8	2.56%	8	6	6	14
Residential Use	**16,163**	**55.28%**	**40,606**	**4.04%**	**39,042**	**29,281**	**29,281**	**71,739**

Table 7-6 POTENTIAL RESIDENTIAL GROWTH OF THE WATERSHED		
	Units	**Population**
Residential Buildout Under General Plans	29,281	71,739
2000 Census Residential Units/Population	19,218	47,163
Future Growth Potential Under General Plans	10,063	24,576
Total Growth	52.36%	
Annual Growth Rate Through 2030	1.57%	

Trail systems, within the watershed, are one of the regions signature amenities. Efforts to construct new trails and trail extensions or connections appear to be generating public enthusiasm. New trail construction is likely to continue within the Shasta West Watershed and beyond at an accelerated rate.

Efforts to provide secondary emergency access in the western foothill portion of the watershed will continue to be a challenge for both the City of Redding and Shasta County. Further policy work is needed to ensure that roads can be provided, built, and maintained in ways that are sensitive to the watershed (Shasta General Plan, 5.4).

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SECTION 7: LAND USE AND DEMOGRAPHICS

Issues Identified

Residential development on steep slopes and the use of open space easements as mitigation for developments on steep slopes in excess of 20%.

Residence of the watershed need to be informed on the effects of illegal refuse disposal in the watershed.

There is a lack of a consolidated recreation development plan for the watershed.

Federal Management Plans are not subject to local general plans or zoning ordinances. The practice of selling off BLM owned property for residential development in order to purchase areas of higher habitat value.

Unknown effects of power transmission lines and the associated footprint and maintenance accesses upon soils, wildlife, fisheries, and urban development.

Data Gaps

There is a lack of data on the effects of illegal refuse disposal in the watershed.

There is little data on the 'footprint' impacts of power transmission lines such as amount of cleared land, and access road miles.

There is a need to perform an economic survey of the value of wildland habitat in the watershed. Such surveys could use know economic valuation methods such as the "Contingent Valuation Method", "Travel Cost Method" and "Hedonic Regression Method" and others to estimate the economic value of wildland habitats in the watershed.

Action Items

Work with the City and County to assess the effects of illegal refuse disposal and develop and provide education on the effects of illegal trash dumping.

Encourage adherence to zoning and land use management plans and collaborate with appropriate agencies to review and update BMP's to protect ecological resources in the watershed.

Work with power line operators and agencies to assess power transmission line effects upon the watershed.

Work with agencies, landowners and users of the watershed to develop a comprehensive recreation use and development plan that incorporates the need for different types of recreation while minimizing negative effects upon the natural resources in the watershed.

Collaborate with local universities and agencies to perform an economic survey of the value of wildland habitat in the watershed in order to determine the habitat value.

FIRE & FUELS
SECTION 8

Section 8
FIRE AND FUELS MANAGEMENT

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Section 8
FIRE AND FUELS MANAGEMENT

INTRODUCTION

This section presents an overview of fire and fuel issues in the watershed.

SOURCES OF DATA

California Department of Forestry (CDF) and Fire Protection and City of Redding Fire Department data were the primary sources for watershed specific information on fire history and fuel loading within the Shasta West Watershed. The California Department of Forestry and Fire Protection, Fire and Resource Assessment Program (FRAP) data for fuel ranks, and fire hazard severity zones were the sources used to categorize fuel distribution and potential fire severity areas. The City of Redding GIS database also provided fire severity and vegetation hazard and density rankings for the area within the Redding City limits. A variety of literature provided general information on fire and fuels management in areas with similar characteristics to the Shasta West Watershed. The general information included published results of regional, statewide, or national research on issues such as fuel, fire severity, policy, and protection. A complete bibliography of references is included at the end of this section. Several sources of remote-sensed imagery were also analyzed to help describe the current distribution of fuels in the watershed.

FIRE HISTORY

Fire frequency, and its subsequent management, has had a significant effect on the landscape of ecosystems in the Shasta West Watershed. Throughout California, as well as the Shasta West Watershed, early Native Americans, sheepherders, and cattlemen used fire as a tool to manage natural landscapes. Ecologists disagree as to whether fires were beneficial or damaging. What is a fact is that fire did open large areas of mountain and foothill communities for additional or transitional grazing (Menke et al. 1996). Since fire suppression in the 1920s, most, if not all, of this original transitional range has been lost to over-dense brush or timber (Menke et al. 1996).

Pre-European Fire

The 300 or more years of dry, cool weather preceding the arrival of European man, coupled with Native American fire use, resulted in many frequent, low-intensity fires. The hot, dry summer climate provided suitable weather conditions and dry fuels for burning. Lightning provided a ready ignition source, supplemented by Native Americans, who used fire for a variety of purposes. Fires could spread until weather conditions or fuels were no longer suitable.

Fire-scar records in tree rings have shown variable fire-return intervals in pre-settlement times. Median values are consistently less than 20 (and as low as 4) years for the ponderosa pine and mixed conifer zones of the Sierra Nevada (McKelvey et al. 1996). Only one study in high-elevation red fir found a median fire-return interval greater than 30 years (see Table 8-1).

The variable nature of pre-settlement fire helped create diverse landscapes and unstable forest conditions. In many areas, frequent surface fires minimized fuel accumulation, keeping understories relatively free of trees and other vegetation that could form fuel ladders to carry fire into the main canopy. The effects of frequent surface fires would largely explain the reports and photographs of those early observers who described Northern California forests as typically "open and park-like." However, such descriptions must be tempered by other early observations emphasizing dense, impenetrable stands of brush and young trees.

Table 8-1
HISTORIC FIRE-RETURN INTERVALS
COMPARED WITH 20th CENTURY PATTERNS

Forest Type	Fire-Return Period (Years)	
	20th Century	Pre-1900
Red fir	1,644	26
Mixed conifer-fir	644	12
Mixed conifer-pine	185	15
Ponderosa pine	192	11
Blue oak	78	8

Note: McKelvey et al. 1996

Almost all scientists agree that fire played a significant role in shaping the vegetative patterns and systems of California vegetation. There is a significant divergence of views as to fire frequency and vegetative composition of pre-settlement fire. The differences in point of views centers on the belief that there were probably many variations in the return frequencies and fire intensity patterns that contributed to the mosaic of vegetation patterns on the landscape today.

A second major point of difference relates to the relative "openness" of forests before the disturbances caused by settlers. Alternative views conclude that forest conditions were not largely "open or park-like" in the words of John Muir; rather they were a mix of dark, dense, or thick forests in unknown comparative quantities. Select early accounts support an open, park-like forest, but there were many similar accounts that describe forest conditions as dark or dense or thick. J. Goldsborough Bruff, a forty-niner who traveled the western slopes of the Feather River drainage between 1849 and 1851, kept a detailed diary. He clearly distinguished between open and dense forest conditions and recorded the dense condition six times more often than the open. Many other accounts of early explorers (e.g. John C. Fremont, Peter Decker, and William Brewer) identify dark or impenetrable forest; the pre-settlement forest was far from a continuum of open, park-like stands. From these records, it seems clear that Northern California forests were a mix of different degrees of openness and an unknown proportion of dark, dense, nearly impenetrable vegetative cover with variations from north to south and foothill to crest.

A third point of departure has to do with the frequency of stand-terminating fires in pre-settlement times. One group concludes that such events were rare or uncommon. The alternative view is that stand-threatening fires were probably more frequent. They were heavily dependent upon combinations of prolonged drought; an accumulation of dead material resulting from natural causes (e.g., insect mortality, windthrow, snow breakage); and severe fire weather conditions of low humidity and dry east winds coupled with multiple ignitions, possibly from lightning associated with rainless thunderstorms. Such fires were noted during, the last half of the nineteenth century by newspaper accounts, official reports (John Leibergv U.S. Geological Survey 1902), and diaries. Settlers, stockmen, or miners caused most fires. Fuel loads were sufficient at that time, thus strongly suggesting that similar conditions existed in earlier times with unknown frequencies.

It is now widely accepted that early Native Americans used fire as a tool, both for hunting and to manage the resources needed for survival (Blackburn and Anderson 1993). There is evidence for almost every tribe in the western Unites States having used fire to modify their respective environments. This included the burning grasslands to improve basket materials; foothills to assist in hunting small game and to encourage new edible shoots, and 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 (Blackburn and Anderson 1993). Within California, 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.

The Wintu, Karuk, and Shasta are reported to have burned grass, brush, and riparian areas of valley and hill slopes to improve basket-making raw materials. Hazel sticks, required for ribs of baskets had prime shoots available one to two years after fire (Blackburn and Anderson 1993). Especially common in the fall, fire was also used as a tool to improve habitat for deer and other animals, and to move mammalian game and insects to be collected for food. Deer were driven into snares or circled by fire and killed. The Wintu are reported to have collected grasshoppers "by burning off large grass patches" in chaparral, woodland grass, and coniferous forest areas (DuBois 1935). Unfortunately, neither the specific vegetational cover nor the time of year in which the burning took place is mentioned. Holt 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 (Blackburn and Anderson 1993).

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. Whether fall or spring burning, 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 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 were readily exploited.

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 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.

The purpose of fire to the Native American Indians was to shape the ecosystem to benefit the tribal survival and sustain thriving, growing societies (Williams 1999). Great variations for the intentional burning of the forest and wildlands by Native Americans have been recorded. Native peoples had a least 70 different reasons for burning vegetation (Kay C.E. 1994). In doing so, burning their ecosystem was dependent upon what resources were being managed, setting fires that, for the most part, were not destructive of entire forests or ecosystems, relatively easy to control, and designed to encourage new growth of plant species (Williams 1999). Lightning and Native Americans ignited forests. Early Spanish explorers and missionaries documented the use of fire by the Native Americans to increase the amount of oaks to increase acorn harvesting (Ainsworth 1995). Fire was also used in ancient European times to control various agricultural insect pests in crops, field borders, range, and pasture lands (Kozlowski 1974).

Historic pre-European forests in the vicinity of the Shasta West Watershed are not documented. Most scientists agree that the vast ponderosa pine forests of the West evolved with frequent low-intensity ground fires. In some places, land that had as many as 30 or 40 large ponderosa pines scattered across an acre in the early 1900s, in grassy park-like stands, now have 1,000 to 2,000 smaller-diameter trees per acre (Trachtman 2003). These fuel-dense forests are susceptible to destructive crown fires, which burn in the canopy and destroy most trees and seeds.

Post-European Fire

Conservation, since it's beginning with Gifford Pinchot in the late 1890s, has led many to believe that fire is the bane of the forest (Williams 1999). The national firestorms of 1910 cemented the exclusion of fire from national forests. It was believed that fire should be suppressed and eliminated to allow young forests to grow. The understanding that humans influenced ecosystems through the use of fire shifted after European settlement in North America, when it was believed that fire should and could be controlled to protect both public and private land (Williams 1999).

At the turn of the century, some settlers used "light-burn" as a farm management tool. The Forest Service experimented with the same theory in the 1910s, but determined that it was too damaging to young seedlings needed for regeneration (Williams 1999). By 1933, with the advent of the Civilian Conservation Corps (CCC), fire fighting and the suppression of wildfires became a fulltime occupation. Thousands of men were trained to fight fire on public and private lands.

The primary fire-related mission of land management agencies was to stop fires whenever possible, and to prevent large fires from developing (Moore 1974). Indiscriminate use of fire by sheep men and miners from approximately 1870 to 1900 resulted in significant environmental damage and furthered the developing cause for fire suppression.

The decision to exclude fire from public lands came about as a result of a debate over whether to permit light fire, such as Indian burnings, or use complete suppression. Logging and grazing interests held that light fires were beneficial because they reduce fuel loading and create more open forests (Ayers 1958; Cermak 1988). The U.S. Forest Service excluded fire on national forests after the "Big Blow Up" in 1910, a firestorm that "incinerated 3 million acres in Idaho and Montana" (Trachtman 2003). The California Forestry Commission was created to hear disagreement on both sides of the argument. Finally, a study completed by Show and Kotok in 1923 showed that although repeat burning maintained an open and park like condition, it killed young trees and discouraged regeneration of forests. The argument continued that if forests were to provide a sustainable timber supply, regeneration was required. In 1924 the Clarke-McNary Act was passed by Congress and clearly established fire exclusion as national policy. Decades ago, Aldo Leopold warned that working to keep fire out of the forest would throw nature out of balance and have untoward consequences. "A measure of success in this is all well enough," he wrote in the late 1940s, "but too much safety seems to yield only danger in the long run."

Forests today have undergone significant changes in species composition and structure. They now contain multi-level stands with a ladder fuel structure. Fires that occur are carried into the tree crowns by the ladder fuels. Once in the tree crowns, the fires move quickly with greater intensity. Fires that do occur have become larger and more devastating.

By the 1950s controlled burns to reduce fuels and improve habitat for wildlife had become commonplace in much of California's rangelands, but all other fires were vigorously controlled. In 1963, Leopold and others (Leopold 1963) published a report on the ecological conditions of the National Parks in the United States, and, as a result, managers and the public began to see the benefit of fires in the wildlands (Lyon et al. 2000). The Leopold Report stated that wildlife habitat is not a stable entity that persists unchanged, but rather a dynamic entity. Suitable habitat for many wildlife species and communities must be renewed by fire. As a result to the Leopold Report, by 1968, the fire policy of the National Park Service changed as managers began to adopt the recommendations of the report (Lyon et al. 2000).

Today wildfire suppression is a full time occupation. Many agencies are involved coordinating, controlling, and fighting fire including Forest Service; Bureau of Land Management; National Park Service; Fish and Wildlife Service; Native American tribes; state forestry departments; and many local fire-fighting agencies. As agencies and the general public sought to "protect" the forest from fire, a consequence was the increased levels of fuel loads, setting the stage for larger and more devastating wildfires.

Wildfire History

There is considerable variability in the seasonality of fires in the Shasta West Watershed. Fuels are driest and ignition sources are most frequent in the summer. Thus, the vast majority of fires occur in summer, while winter and early spring fires are relatively uncommon. Historical fires (CDF data) and causes in the Shasta West Watershed from 1940 to 2001 and a summary of acreage burned are included on Tables 8-2 and 8-3, and on Figure 8-1.

Table 8-2
CDF HISTORICAL FIRE IGNITION SOURCES: 1910 - 2001

Cause	Number of Fires	Number of Acres	Percent of Total Fires	Percent Acres
Lightning	8	10,057	89%	99.42%
Unknown /Unidentified	1	59	11%	0.58%
TOTALS	**9**	**10,116**	—	—

Source: California Department of Forestry and Fire Protection. Includes timber fires ≥ 10 acres, brush fires ≥ 50 acres, grass fires ≥ 300 acres, wildland fires destroying ≥ 3 structures, and wildland fires causing ≥ $300,000 in damage.

Table 8-3
ACREAGE BURNED SUMMARY

Date	Total Acres Burned	% Watershed Burned
1940-1950	3,237	11%
1951-1960	1,817	6%
1961-1970		0%
1971-1980	5,003	17%
1981-1990	59	0%
1991-2001*		0%
Total	**10,116**	—

Source: California Department of Forestry and Fire Protection

Lightning related fires make up almost 90 percent of all fires in the Shasta West Watershed. The largest documented lightning fire was the Swasey Drive #3 Fire in 1972 that burned 3,172 acres. Through 2001, the CDF reports nine total fires in the watershed boundary: eight of which were caused by lightning and one of which the cause is not known.

FIRE BEHAVIOR

Understanding basic fire behavior is helpful in better comprehending the current and historical role of fire in the watershed. Fire behavior is a complex science, but can be generally described as the speed a fire travels or rate of spread, and the intensity with which it burns. There are three key factors that influence fire behavior:

- Fuel
- Weather
- Topography

All three factors can influence fire behavior independently, but they are all interconnected and accounted for in assessing fire behavior (NWCB S-290 1994).

Fuels

Fuel loading, fuel arrangement, and fuel moisture are key characteristics of fuels that can influence fire behavior. The intensity with which a fire burns is often dictated by the type and amount of fuel available to burn (NWCG 2001). Fuel loading pertains to the amount of fuel over a given area and is a significant factor in determining the fire behavior. Grass vegetation types, which have a fuel loading significantly lower than heavy timber types, ignite more readily and support fires of more rapid spread; but generally burn with a lower intensity than fuels with a higher load (Anderson 1982). Fuel arrangement pertains to the compactness and continuity of fuels. Less compact fuels tend to ignite easier than those that are more compact (NWCG S-290 1994). Fuel continuity describes the distribution of fuels. It is further described by both horizontal and vertical continuity. Horizontal continuity pertains to the amount of ground covered by fuel and the distance between surface fuels. Vertical continuity relates to the spatial relationship between surface fuels and aerial fuels such as brush and tree canopy (NWCG 2001).

Another factor in defining fire behavior is fuel moisture as based on fuels in a given vegetation community. Fuel moisture pertains to both live and dead fuels and how it fluctuates slowly over a season for heavier fuels or drastically over just a few hours for fine fuels. Current weather conditions can greatly affect fuel moisture of fine dead fuels such as small twigs and leaf litter; this concept will be described in more detail below. Vegetation type also can dictate the fluctuation of live fuel moisture based on a plant's physiology. Drier fuels burn more readily and with greater intensity than do fuels with higher moistures (Anderson 1982).

Recognizing fire's natural role in and effects to different vegetation types is imperative to understanding not only the different fire management practices and policies that are implemented within the watershed, but also the potential effects to the ecosystem of total fire exclusion. See Section 5, "Botanical Resources," for a more detailed description of the various vegetation types within the watershed; information on their distribution; and other factors that influence them. Limited information on pre-European civilization fire history is available for the Shasta West Watershed. A fire history study, specific to the watershed, would provide additional insight to the natural fire return interval of the different vegetation types. Such information would offer a better understanding of the fuel conditions that would exist in a natural fire ecosystem, which could support fire managers in their planning activities.

Blue Oak Foothill Pine Community

Fire is historically a natural part of the Blue Oak-Foothill Pine vegetation community, which burns every 15 to 30 years. While Blue Oak seedlings and saplings can be top-killed by fires, they often re-sprout within the first year following a fire. Mature trees are more fire resistant, but a higher intensity fire can kill them, which can occur where there is thick brush. Mature Foothill Pines (*Pinus sabiniana*) are a more fire-resistant species, with a thick bark and the adaptation to shed lower lying limbs. One report states that, due to fire suppression, the number of Foothill Pine are increasing in this community but prescribed burning could return this community to a more natural species balance.

Mixed Chaparral Community

The several species that make up the chaparral community have physiological adaptations, including chemical composition and physical plant structure that encourage more severe fires.

As mentioned in Section 5, "Botanical Resources," chaparral species often reestablish quickly after intense fires. Fire suppression in this community results in unnaturally dense fuel loads, which can result in extremely severe fire behavior when a fire does occur.

Knobcone Pine Community

The variable nature of pre-settlement fire helped create diverse landscapes and unstable forest conditions. In many areas, frequent surface fires are thought to have minimized fuel accumulation, keeping understories relatively free of trees and other vegetation that could form fuel ladders to carry fire into the main canopy. The effects of frequent surface fires would largely explain the reports and photographs of those early observers who described Northern California forests as typically "open and park-like." However, such descriptions must be tempered by other early observations emphasizing dense, impenetrable stands of brush and young trees.

Weather

Weather can be the most erratic of the three key factors in influencing fire behavior. During the fire season, fire managers continuously monitor weather patterns to assess burning conditions of on-going fires or in the event of a new start. However, it is important to keep in mind that local weather patterns often differ greatly from the regional pattern. Furthermore, a large fire can also influence the local weather. Wind speed and direction can dictate not only the rate of spread but also the direction of a fire. Higher winds bring not only additional oxygen to a fire, increasing its intensity, but also assist in pre-heating fuels ahead of the fire. Relative humidity also influences fire behavior primarily by affecting fuel moisture of fine dead fuels, as mentioned above. These fuels are often the primary earner of surface fires and are receptive fuel beds for spot fires. Wind and lower relative humidity can independently or jointly dry fine dead fuels, increasing the fire behavior in these fuels. Ambient temperature is a major factor in controlling relative humidity, particularly the changes in humidity that occur throughout a 24-hour period. Within the Shasta West Watershed, summers are typically hot and dry, and the dominant wind direction typically blows from the southwest to the northwest.

Topography

Topography describes the lay of the land, and the three components of topography that are of particular interest to fire managers are slope, aspect, and elevation. With all other factors held constant, the steeper the slope, the faster fire travels up it. Aspect of a slope describes the direction that slope is facing. In the United States, south and west facing slopes receive greater portions of the hotter afternoon sun. This heats up the fuels and lowers the fuel moisture on these slopes, allowing for an increased rate of fire spread and fire intensity. Shifts in elevation affect ambient air temperature and relative humidity, which, as mentioned above, affect fuel moisture. Topography can often influence local weather conditions, particularly wind. Thus, as mentioned above, local wind direction and speed may be quite different from the regional conditions. All of these topographical influences can alter fire behavior as fire moves across the landscape. The topography of the watershed is summarized on Figure 8-2.

POTENTIAL FIRE SEVERITY

In an effort to measure potential fire behavior and identify areas of concern, fire managers have developed numerous techniques to assess an area's potential for severe fire. Often these techniques combine fuel and topography factors to develop a ranking schematic that can be applied across the landscape. With this single measurement, the fire potential of different areas can be readily compared.

CDF has developed two such ranking systems to assist with their fire planning in the state. In 1985 CDF created a spatial dataset of Fire Hazard Severity Zones for State Responsibility Area (SRA) lands. These datasets were created in response to the Oakland Hills fire and the subsequent "Bates Bill," which mandated that CDF identify high severity fire areas throughout California. The Redding City Council has also adapted the statewide dataset and created a Very High Fire Severity boundary for land within the Redding city limits. The Very High Fire Severity boundary for land within the Redding City limits contains approximately 6,200 acres. Although these datasets are the most current available, the information supplied with the data indicate that there are inconsistencies in the data and extreme caution should be used in its interpretation. It is important to consider that the dataset was developed on a state-wide level with input from numerous land managers, and, in cases such as the City of Redding, it was further adapted for local use. Because of these factors, "it should not be used as a measure of the risk faced by individual structures" (CDF-FRAP 2001). A map of the areas designated as Very High Fire Severity within the Shasta West Watershed combining City of Redding and CDF data is included as Figure 8-3. Table 8-4 contains the acreage statistics of the fire hazard severity zones within the watershed. Note that, according to these datasets, 59 percent of the SRA and City of Redding lands within the watershed are considered to be very high fire severity (CDF-FRAP 2003).

Table 8-4
FIRE HAZARD SEVERITY ZONES ACREAGE STATISTICS

Area of Severity	Acreage	Percent of Watershed
City of Redding:		
Very High Fire Boundary	6,191	21%
State Responsibility Areas:		
Very High	7,931	27%
High	4,109	14%
Not State Responsibility Area (Severity Not Assigned)	17,891	59%

The validity of these results is further questioned when compared to a second ranking system that was also developed by CDF and published more recently in 2003. Developed for a different purpose and using different techniques, the second dataset describes the expected fire behavior based on fuel and topography modeling under extreme weather conditions. A rank of 1 through 3, with 1 being moderate and 3 being very high, was assigned to each 30-meter by 30-meter spatial unit across the state. A fuel rank map for the Shasta West Watershed is included in Figure 8-4. Table 8-5 contains the acreage statistics of the fuel ranks within the watershed.

Table 8-5 FUEL RANKS		
Fuel Rank	**Acreage**	**Percent of Watershed**
Non-Fuel	2,053	7%
Moderate	15,336	51%
High	9,440	32%
Very High	3,102	10%
Source: California Department of Forestry and Fire Protection		

Note that based on these datasets, just over one-half of the watershed is designated as the lowest fuel rank, "moderate," and only 10 percent of the entire watershed is designated as a very high fuel rank. Synchronizing the conflicting results from these similar, but not identical, data is beyond the scope of this report, but it is a clear indicator of the ambiguity of such data. Thus, information of this type should be used carefully when assessing the potential for severe fire behavior in a specific area within the Shasta West Watershed.

The City of Redding also has vegetation density and vegetation hazard ranking map layers. The vegetation density is based on a ranking of low, medium, and high. A vegetation density map of the City of Redding vegetation ranking is included on Figure 8-5. Table 8-6 contains the acreage statistics of the vegetation densities in the City of Redding. The vegetation hazard rankings were developed by multiplying the vegetation densities (low = 1, medium = 2, and high = 3) and the slope classifications. The slope classifications are from the US Geological Survey 10-meter digital elevation model and are classed as: 0-10 percent slope = 1; 10-20 percent = 2; and 20 percent slope and above = 3. The result is the vegetation hazard rating. Figure 8-6 is a vegetation hazard-rating map of the City of Redding based on this technique. Table 8-7 contains the acreage statistics of the vegetation hazard rating.

Table 8-6 CITY OF REDDING VEGETATION DENSITY		
Vegetation Class	**Acres**	**Percent of Watershed**
Low	1,639	5%
Medium	2,298	8%
High	2,382	8%
Total	6,318	21%
Notes: Simple vegetation density polygons, hand-digitized and operator classified from USGS 1-meter (1993) photography. Source: City of Redding		

Table 8-7 CITY OF REDDING VEGETATION HAZARD RANKINGS		
Hazard Rating	**Acres**	**Percent of Watershed**
1	1,219	4%
2	1,664	6%
3	1,072	4%
4	707	2%
6	1,180	4%
9	483	2%
Source: City of Redding		

The strategies to manage fire and fuels within the watershed can vary based on landowner and the current conditions not only within the watershed but also on a regional, and sometimes even national, level. Following is a brief discussion of the most common fire management tactics used either independently or in combination with one another to achieve various management goals.

Suppression

This is the tactic that most of the general public associates with wildland fire. It is the action taken to stop the spread of and put out an active fire. However, the actual techniques to achieve this goal can vary based on weather and fuel conditions; fire behavior; the location of the fire; and even the availability of fire personnel. If possible, fire crews may directly attack the fire, keeping it as small as possible. However, if fire behavior is too severe to safely or effectively put personnel on it directly, management may opt to indirectly attack the fire. This entails moving away from the fire's edge and establishing a control line, whether it is a natural barrier, such as a river, or a line built by fire crews in an area where they expect diminished fire behavior, such as in an area with sparser fuels and/or on a shallower slope. Once a line is established, fire crews may perform a burnout, under cooler temperatures and favorable wind conditions, in which fuels between the control line and the uncontrolled fire's edge are ignited.

The City of Redding has developed a map showing the two-minute response times for emergencies, including fires, within the city boundary. However, these response times do not include the two minutes of "call-to-station-exit" times. Figure 8-7 shows the map of the response times as provided by the City of Redding GIS department. Table 8-8 shows the acreage statistics for the City of Redding emergency response times.

Table 8-8
CITY OF REDDING EMERGENCY RESPONSE TIMES

From (minutes)	To (minutes)	Acres	Percent of Watershed
0	2	5,482	18%
2	4	6,672	22%
4	6	2,055	7%
6	8	740	2%
8	10	0.006	0%
Total		**14,950**	**49%**

Notes: These are two-minute response bands. It does not include the two minutes of "call-to-station-exit" time.

Pre-Suppression or Pre-Fire

Pre-suppression entails actions taken before an actual fire occurs. It includes treating fuels in an area by installing fuel breaks or clearing around structures (a requirement of law). It also pertains to organizing the necessary equipment to ensure its availability in the event of a fire. Finally, it involves training fire personnel so that individuals are prepared to safely assess and attack if a fire falls under this category.

Prevention

Preventing unintentional human-caused fires involves public education and awareness as well as development and enforcement of fire codes within a community. California law requires a 30-foot clearance (defensible space) around all structures. Wildfire researchers have proven, however, that a clearance of 100 feet is your best defense against threat of wildfire. The larger the area of defensible space is, the more protection against wildfire. Fire-resistant roofing also helps decrease damage if fire does reach a home (Shasta Fire Safe Council 2003). The Shasta Fire Safe Council recommends:

- Don't leave the ground bare – bare ground can be an erosion hazard
- Reduce ground cover (shrub) height to less than 12 inches in the 30 foot zone, less than 18 inches in the 100 foot zone
- Thin yard trees so canopies do not touch
- Prune lower branches of yard trees to eliminate ladder fuels
- Favor slow burning plants
- Move combustible material away from buildings (such as firewood and lumber)
- Enclose deck foundations
- Keep rain gutters clear of leaves, needles, etc.
- Clear at least 10 feet around propane tanks
- Remove all tree branches within 20 feet of a chimney and 10 feet of the roof

The Shasta Fire Safe Council (see page 8-27) recognizes three defense zones for residential fire prevention. They are "Home & Yard Zone" (the 30-feet immediately around the home); the "Transition Zone" (the next 30 to 70 feet); and the "Forest Zone" (the edges of property extending into the wildlands).

In addition to development of regional fuel management plans, the council recommends the following activities for each identified zone relating to residential structure protection:

- The Home Yard Zone:
    - Use Concrete, bare soil, and ponds
    - Consider green lawns and fire resistant plants
    - Mow grasses and weeds to two inches high

- Clear leaves, pine needles, and other debris from roof and rain gutters
- Use fire-resistant roofing
- Create space between bushes and trees
- Propane tanks should be at least 30 feet from the house; clear vegetation from around them
- Firewood and scrap wood piles should be at least 30 feet from structures
- Mowing with a tractor should be done early in the morning when grass is moist to avoid setting a fire

- The Transition Zone
  - If area is heavily wooded, remove some of the trees; keep trees 10 to 15 feet apart; make it parklike
  - Remove all ladder fuels
  - Prune limbs and branches on tall trees to 6 to 10 feet from the ground

- The Forest Zone
  - The fringes of this area should be trimmed and thinned. How much work needs to be done depends on steepness and the amount of dead plant material.

Fuels Management

Fuels management is currently the most common method of fire management. Fuels management includes many types of vegetation and debris management activities including thinning, biomass sales, and clearing dead and down material. Creation of a fuel treatment area for firebreaks is a primary goal of most fuel management programs. The overarching goal of most removal projects is either harvesting timber or thinning fuel to limit a fire's severity. Regardless of the aim of a particular project, studies have shown that both methods can reduce fire hazard (SAF 1997). Mechanically thinning fuels is often used in preference to prescribed burning in areas with excessive fuel accumulation or where burning is not deemed a safe or cost effective alternative. The process of thinning fuels can include the construction of fuel breaks or shaded fuel breaks. Once constructed, such large breaks in an otherwise continuous line of fuels can be used in fire control operations in a large wildland fire (Whiskeytown National Recreation Area 2003).

Numerous fuel management projects have been undertaken in the Shasta West Watershed. Most of these entail creation of shaded fuel breaks to assist fire suppression activities in the event of a major fire. Shasta Fire Safe Council has received a grant to publish a map of fuel breaks within Shasta County. The project is still in the draft phases. Draft maps of the fuel break areas in the vicinity of the Shasta West Watershed are included as Figures 8-8 A, B, C, and D.

Fuel Management Plan

One of the first steps in fuel management strategy is the development of a fuels management plan. The Western Shasta Resource Conservation District has completed a Fuel Management Plan for the Shasta Fire Safe Council and for the Shasta West Watershed. The purpose of the plan is to identify and layout a network for the construction of shaded fuel breaks and ridge-top fuel breaks and to recognize other community activities that can increase protection for those living in the watershed area. Other plan objectives include protecting values at risk; providing better fire fighter safety; identifying safe transportation routes in event of wildfire; develop a plan and funding sources to maintain fuel break effectiveness; and continuing to improve the fuel break planning. The plan focuses on the rural urban interface areas within the watershed and does not attempt to address fuel management activities within the urban areas managed by the City of Redding. The City of Redding has developed its own wildfire defense strategy.

The Shasta West Watershed is classified by CDF as a wildland urban interface zone (I-zone) where homes are located within areas of rough topography and heavy fuel loads. Fires in these areas are often hot fast-moving fires that result in significant damage to structures and wildland resources.

Up through 2000 developments in Redding were required to leave certain areas as green belts. In most instances these "green belts" were deeded back to the City of Redding for fire access and beautification. This subdivision requirement resulted in numerous "un-maintained" fuel areas within City of Redding subdivisions. Recent revision to the subdivision laws have resulted in the development of maintenance contracts for the control of vegetation and maintenance of fuels within these greenbelt areas.

Shaded Fuel Breaks

This section was adapted from the Draft Fuel Management Plan for the Shasta West Watershed. Shaded fuel breaks are constructed as a means to create a defensible space in which firefighters can conduct relatively safe fire suppression activities. Fuel breaks may also slow a wildfire's progress enough to allow supplemental attack by firefighters. The main idea behind fuel break construction is to break up fuel continuity and prevent a fire from reaching the treetops, thus forcing the fire to stay on the ground where it can be more easily and safely extinguished. Fuel breaks may also be utilized to replace flammable vegetation with less combustible vegetation that burns less intensely. In addition to fuels reduction, a well-designed shaded fuel break also provides an aesthetic setting for people and a desirable habitat for wildlife. The California Board of Forestry has addressed the requirement to strengthen community fire defense systems, improve forest health, and provide environmental protection. The Board rules allow a Registered Professional Forester to use a special silvicultural prescription when constructing or maintaining a community fuel break; exempts community fuel breaks from an assessment of maximum sustained production requirements; and allows defensible space prescriptions to be used around structures.

The WSRCD has developed the following Fuel Break Standards:

- The typical minimum width of a shaded fuel break is 100 feet, but can be up to 300 feet wide. The appropriate width is highly dependent on the slope, fuel density, fuel type, fuel arrangement, and landowner cooperation.

- Fuel breaks should be easily accessible by fire crews and equipment at several points. Rapid response and the ability to staff a fire line are very important for quick containment of a wildfire.

- The edges of a fuel break are varied to create a mosaic or natural look. Where possible, fuel breaks should compliment natural or man-made barriers such as meadows, rock outcroppings, and roadways.

- A maintenance plan should be developed before construction of a fuel break. Although a fuel break can be constructed in a few weeks, maintenance must be conducted periodically to keep the fuel break functioning properly.

- The establishment of a shaded fuel break can lead to erosion if not properly constructed. Short ground cover, such as grass, should be maintained throughout the fuel break to protect the soil from erosion.

A properly treated area should consist of well-spaced vegetation with little or no ground fuels or understory brush. Tree crowns should be approximately 10-15 feet apart. The area should be characterized by an abundance of open space and have a "park like look" after treatment.

The Pile and Burn method is commonly utilized when constructing fuel breaks. Material is cut and piled in open areas to be burned. Burning takes place under permit on appropriate burn days. Burn rungs can be raked out after cooling as a means to decrease their visual effect.

In dealing with chaparral, a relatively new technique called "crush and burn" combines mechanical fuels treatment with burning. It is more effective in eliminating chaparral than a low-intensity prescribed burn, which has difficulty competing with the high moisture content of live chaparral. In this method, the chaparral is mechanically crushed, then piled and burned. It is a good technique for areas adjacent to communities and to encourage chaparral regeneration in riparian zones.

Mechanical Treatments

This section was adapted from the Draft Fuels Management Plan for the Shasta West Watershed. Using mechanized equipment for reducing fuels loads on suitable topography and with certain fuel types can be very effective. Depending on the use of the equipment, it may require environmental review and documentation. Using equipment to remove excess vegetation may enable the landowner to process the debris to a level where it can be marketed as a product for use in power generation. The debris then becomes labeled as "biomass" or "biofuels."

Mechanical methods to remove fuels include, but are not limited to, the utilization of bulldozers with or without brush rakes; excavators; chainsaws; mechanized falling machines; masticators; chippers; and grinders. Mechanical treatments are typically conducted on chaparral landscapes with some type of masticator, which grinds standing brush and reduces it to chips, which are typically left on the ground. Brush may also be mechanically removed and fed into a grinder for biomass production. Mechanical treatments are also utilized on industrial and non-industrial timberlands where trees are thinned by mechanized tree cutting or falling machines. In most cases, stands of trees are thinned from below as a means to eliminate the fuels that allows a fire to shoot higher into the tree canopy (ladder fuels). However, stands of trees may also be thinned from above to eliminate crown continuity.

Mechanical treatments can be used successfully on stable ground up to 50 percent slope, but should only be conducted during dry periods when soils are not saturated to minimize erosion and compaction. The drastic visual impacts should be considered when planning projects so that all parties are aware of how the area will look when the project is completed. Initial planning should address mitigation for erosion potential, using measures such as waterbars, ditching, and mulching in critical areas. Furthermore, the impacts on wildlife and archaeological resources must be addressed.

Due to air quality concerns, the mechanical treatment method is fast becoming the acceptable method of fuel reduction in Urban Interface areas. Compared to prescribed fire, mechanical treatment involves less risk; produces less air pollutants; is more aesthetically pleasing; and allows landowners to leave desirable vegetation.

Defensible Fuel Profile Zones (DFPZs)

DFPZs are strategically located lineal fuel reduction and fire protection areas that are generally constructed a quarter mile wide along public and private roads that traverse communities, watersheds, and areas of special concern. These are similar to shaded fuel breaks. The shaded fuel break objective is to reduce fire intensity while DFPZ fuel management is designed to allow fire fighters quicker and safer access for attacking and suppressing oncoming forest fires. The DFPZ is more of a defensive line fighting area that manages fire behavior through fuels management. The lineal connectivity of the DFPZ network allows various property owners within a watershed the opportunity to connect fuel reduction projects to adjoining properties through local County Fire Safe Councils. The DFPZ network is the starting point for addressing the scale of the existing hazardous fuel problems at the appropriate pace of annual acres treated. At this time no DFPZs, using the quarter mile wide definition, are located in the Shasta West Watershed.

DFPZs are best initially placed primarily on ridges and upper south and west slopes and, where possible, along existing roads. They also should be located with respect to urban-wildland intermix and other high-value areas (such as old-growth or wildlife habitat areas), areas of high historical fire occurrence, and/or areas of heavy fuel concentration. Thinning from below and treatment of surface fuels can result in fairly open stands, dominated mostly by larger trees of fire-tolerant species. DFPZs need not be uniform, monotonous areas, however, but may encompass considerable diversity in age, size, and distribution of trees. The key feature should be the general openness and discontinuity of crown fuels, both horizontally and vertically, producing a very low probability of sustained crown fire. DFPZs should offer multiple benefits by providing not only local protection to treated areas (as with any fuel-management treatment) but also safe zones within which firefighters have improved odds of stopping a fire; interruption of the continuity of hazardous fuels across a landscape; and various benefits not related to fire, including improved forest health, greater landscape diversity, and increased availability of relatively open forest habitats dominated by large trees. Typical DFPZ density is included on Figure 8-9.

Prescribed Fire

Prescribed fire is the controlled application of fire to the land used to accomplish specific land management goals. These goals can vary from annual burning around residences to clear grass and weeds; agricultural field burning for preparation of crop planting; burning of brush piles; and landscape burning of forest to remove brush and accumulation of forest fuel. Forestlands can benefit from prescribed fire by attempting to regulate or moderate the frequency and intensity of wildfires. The advantages of using fire and improvement cuttings to restore and maintain seral, fire-resistant species include:

1. Resistance to insect and disease epidemics and severe wildfire
2. Providing continual forest cover for esthetics and wildlife habitat
3. Frequent harvests for timber products
4. Stimulation of forage species
5. Moderate site disturbance that allow for tree regeneration (Amo 2000)

By returning to regular burning, forests can achieve a measure of protection from catastrophic loss by reducing the amounts and concentration of brush and other forest fuels.

Historical land-use changes in the upper watershed make a return to the pre-historical fire regime impractical. Not only are structures, infrastructures, and managed forests at risk of fire damage too expensive to permit burning at the pre-settlement rate, but regulatory constraints and social costs of fire and its effects (e.g., low air quality) also prohibit burning at pre-European scales (SAP 1997). Although fire remains 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).

Mechanical fuel management can reduce fire hazard. Recent studies of the behavior of fires immediately following harvesting found that harvesting, or biomass fuel reduction with slash and landscape treatments followed by prescribed burning, produced fuel structures that minimize average fire intensities; heat per unit area; rate of spread; area burned; and scorched heights. In contrast, sanitation-salvage harvest without biomass reduction and just lopping and scattering of slash resulted in higher fire intensities. The latter treatments probably result in less severe fires relative to untreated stands, especially after sufficient time has passed to allow the slash to decompose (SAP 1997). In addition, wildfires that burn into areas where fuels have been reduced by prescribed burning cause less damage and are much easier to control.

Prescribed fire can also be an effective tool for managing fuels. 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 of humans). In areas, which prescribed natural fire, plans have been adopted that specify conditions under which planned non-suppression fires are allowed to burn. Following specific fire management activities, prescribed natural fire planning 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. 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 larger in size, intensity, and more uncontrollable fires.

- ***Thinning of overcrowded forests*** that have been thinned by fire. These forests are generally healthier and more vigorous, recover quicker, and 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 wildfire*** by having varying ages and type 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 percent (R. Bursy undated).

- ***Increase in nutrients*** such as phosphorus, potassium, calcium, and magnesium in the ash deposits (Ahlegren, Kozlowski 1974).

The California Vegetation Management Plan (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 historical 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
- Thin young trees
- Prepare seedbeds
- Control pests and disease
- Control competition vegetation
- Increase water yield
- Improve production of grazing
- Improve fish habitat and forest lands
- Improve air quality

- Manage wildlife habitat
- 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 31,000 acres per year) have been treated with prescribed fire under CVMP in California. Cost of the prescribed burning averages $25 to $30 per acre but can vary based on the number of acres and resources necessary for the prescribed fire project. This cost sharing program includes the landowner paying approximately 25 to 30 percent of the total project costs (CDF-CVMP 2003).

Because of the difficulty in using prescribed fire in the Shasta West Watershed neither the CVMP program nor other prescribed burning programs have been widely applied to the watershed. This is due not only to the difficult topography and ownership pattern, but the great risk due to proximity of residence in the west side area. The CVMP program has been used to fund certain vegetation management projects that have created strategically necessary fuel breaks in the watershed. One such project funded by the CVMP was located on a ridge between Middle and Rock Creeks (K. Schori pers. comm.).

Wildland Fire Use

Wildland Fire Use is the management of lightning and other natural caused fires to accomplish resource management objectives. The current and forecasted weather conditions, fuel conditions, availability of fire resources, and resource goals for the specific site are all taken into account before designating a particular fire as fire use. These factors are then continuously monitored as the fire progresses. Furthermore, extremely detailed plans are drafted that outline the conditions required for the fire to continue burning under this designation. The presence of structures in the vicinity of a fire often excludes that area as a fire use zone.

ENVIRONMENTAL CONSEQUENCES

Uncontrolled stand replacing wildfire 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, soil microorganisms, minerals, and nutrients.

Soil

The frequency and severity of wildfire affects the magnitude of accelerated erosion. The potential for accelerated erosion is primarily through its effects and removal of vegetation. During an intense surface wildfire, all vegetation may be destroyed and organic material in the soil may be burned away or decomposed into a water-repellent substance that prevents water from percolating into the soil (hydrophobic soils). The potential for fire to increase erosion increases with fire severity, soil credibility, steepness of slope, and intensity or amount of precipitation. The amount and duration of changes in erosion rate vary widely among sites as a consequence of fire intensity soil infiltration capacity, topography, climate, and patterns of vegetation recovery (Christensen 1994). Post fire erosions rates may be more then 50 to 100 times greater than on a well-vegetated watershed (Sanberg et al 2002). In experiments using the clearing actions of wildfires, changes were found in both overland flow and infiltration after wildfires in a Mediterranean scrubland. Simulated rainfall was used, and overland flow decreased from 45 percent immediately after the fire to 6 percent after 5 years, due to the recovery of vegetation (Sanberg et al 2002). With increased overland flow the loss of root systems may result in the increased rill and sheet erosion plus the facilitation of debris flows in rivers and streams, decreasing water quality (Christensen 1994).

Temperatures at ground level during a wildfire, may reach from 600 to 700°C. Oil resins and waxes that are stored in plants are vaporized due to the intense heat. Despite high surface temperatures, the centimeters just below the surface remain cooler, allowing the oil resins and waxes to condense and form the hydrophobic layer (Ainsworth 1995). The hydrophobic layer slows water infiltration, increasing erosional rates and minimizing evaporation into the root zone (Ainsworth 1995).

As temperatures of the wildfire increases, quality of soil decreases. Minerals and nutrients at temperatures 220 to 460°C begin to mineralize, nitrogen vaporizes, organic materials oxidize, and more sand size particles are formed. At temperatures greater than 460°C, permanent changes in structure, texture, porosity, plasticity, and elasticity occur.

Soil pH may increase after a wildfire. This is a result of the addition of ash minerals leaching out after precipitation events. Many fungi and bacteria thrive in basic conditions and with the increased pH levels and the scarring effect of fire may incease the likelihood of disease to the forest (Ahlegren and Kozlowski 1974).

Wildfires result in the net loss of nutrients from the ecosystem. Although there are few estimates of such loss Christensen (1994) proposed five mechanisms to account for these losses:

1. Oxidation of compounds to a gaseous form (gasification), nitrogen and sulfur, easily oxidized, are directly proportional to the loss of organic matter

2. Vaporization of compounds that were solid at normal temperatures, nitrate

3. Convection of ash particles in fire generated winds, loss of important plant development nutrients
4. Leaching of ions in solution out of soils

5. Erosion following the fire

The relative importance of these mechanisms varies for each nutrient and is a consequence of variations in fire intensity, site soil and topography, and climatic pattern.

During prescribed burning, physical changes in soil features such as texture or mineralogy are negligible. Where parent rock is exposed, weathering may be accelerated as a consequence of spalling (Christensen 1994). Impacts of any particular fire regime on soils and biogeochemical process depend on basic site characteristics such as slope, parent rock material, and soil properties (Christensen 1994).

Water

The increase of river sediment in rivers is one of the most dramatic responses associated with fire. Loss of ground cover such as needles and small branches and the chemical transformation of burned soils make watersheds more susceptible to erosion from precipitation events. Runoff, where at least 75 percent of the vegetation has been removed, can increase discharge. Depending upon the amount of precipitation, the discharge to the basin can range from 0.1 to 0.8 acre-foot per acre of burned forest. Additional sediment storage can alter a stream's form and function in a deleterious manner. Studies in the Stanislaus National Forest indicate large, intense fires produce an average of 20 to 50 tons per acre per year of erosion for the first two years (CDF 1995).

After a precipitation event, sediment transported from a recent wildfire into local waterways can be detrimental to aquatic organisms and many fish species. After the rivers and streams settle, sediment fills voids in the streambeds eliminating essential habitat, covering food sources, spawning sites and smothering bottom-dwelling organisms. Sediment deposition also reduces the capacity of stream channels to carry water and of reservoirs to hold water. This decreased flow and storage capacity can increase flooding and diminish water supplies (Golden et al. 1984). Sediment entering the stream channels from increased runoff can be deposited on spawning gravel preventing the emergence of fry and the deposition of eggs. Sediment can also fill pools, widening and flattening the stream channel removing summer and winter rearing habitat for small fish.

A rise in suspended sediment results in an increase of turbidity, limiting the depth to which light can penetrate and adversely affecting aquatic vegetation photosynthesis. Suspended sediments can also damage the gills of some fish species, causing them to suffocate. These sediments can limit the ability of sight-feeding fish to find and obtain food. Immediate effects are arise directly from the fire, such as changes in water chemistry due to ash deposition and abrupt changes in food quality. 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. Changes in water quality due to wildfire are thought to be minimal and short-lived. However, in some cases increases in ions or pH following fire can cause fish mortality. Large woody debris jams will likely increase post-fire because of fire-killed snags, but new recruitment of debris will be reduced in subsequent years. In addition, retention of woody debris (which creates pools and habitat for fish) may be decreased post-fire because of increased flow.

Turbid waters tend to have higher temperatures and lower dissolved oxygen concentrations. A decrease in dissolved oxygen levels can kill aquatic vegetation, fish, and other aquatic organisms. Increases (or decreases) in water temperature outside the tolerance limits can be detrimental, or even lethal, to aquatic organisms, especially cold-water fish such as trout and salmon (Brown 2000).

Large, intense fires have a much greater effect on stream ecology than smaller, less-intense fires. In addition, the size of the watershed burned and the proportion of the burned area within the watershed also influences the effects of the fire on stream ecology. Tree removal reduces evapotranspiration, which increases water availability to stream systems. Increased stream flows can scour channels, erode stream banks, increase sedimentation, and augment peak flows. Hoyt and Troxell first documented the effects of wildfire on stream flow in 1932. They found that burning chaparral caused the average annual stream flow of Fish Creek in California, to increase 29 percent. In addition they found that peak discharges and sediment loads carried by the streams also increased (Rambel 1994).

Air

Air quality is a particular concern in California and within the Shasta West Watershed. Residents generally seek out rural lifestyles because of 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, which reduces smoke emissions. However, delaying a natural event to a later date, poor air quality is simply pushed to a future time. Estimating the impacts from air pollutants is difficult in general, and is more complex in a wildland setting. Wildfire smoke, and in some cases prescribed burning, can affect visibility, human health, vegetation, and pollution rights. Overall air quality impacts of smoke are important, especially given the fact that the Sacramento Valley Air Basin has 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). A single wildfire that consumes 100 acres of heavy forest fuels can emit as much as 90 tons of particulate matter into the atmosphere. Wildfires generally occur during the time of year, summer and fall, when smoke and particulate matter is trapped in lower lying areas, increasing exposure to the effects of smoke and reducing visibility. A reduction of visibility may result in a reduction of recreational activities and tourism. Visibility can also be utilized to estimate human health as seen in Table 8-9.

Health issues contributed to prescribed burns and wildfires affect the younger and older generations, as shown in the Table 8-9. Reactions to smoke exposure range from itchy and scratchy throat to more serious reactions such as asthma, emphysema, and congestive heart failure (DEQ 2003).

National ambient air quality standards (NAAQS) are defined in the Clean Air Act as the amount of pollutants above which detrimental effects to public health or welfare may result. NAAQS has established criteria for particulate matter (PM) also called total suspended solids (TSP), based upon size. PM10 is particulate matter less than 10 microns in diameter and PM2.5 is less then 2.5 microns in diameter. The major pollutant for wildfire in smoke is fine particulate matter, PM10 and PM2.5. Studies show that 90 percent of all smoke particles emitted during wildland burning is PM10, and 90 percent of PM10 is PM2.5 (Sandbe et al. 2002).

Further studies have shown that PM2.5 are largely responsible for the health effects including mortality, exacerbation of chronic disease, and increased hospital admissions (Sandbe et al. 2002). The 1988 Yellowstone National Park wildfire impacted communities in three states due to the exceeded the NAAQS of PM10 triggering public health alerts and advisories.

Ozone, a product of biomass combustion, is a precursor to greenhouse gases. Although ozone produced by prescribed fire usually is quickly diluted and dispersed into the air, it may bring wildland fire under scrutiny as a contributor to the greenhouse effect. Additionally wildland fires contribute approximately one fifth of the total global emissions of carbon dioxide (Sandbe et al.

2002).

Wildlife

Assessing the economic implication of fire on wildlife without a recognized valuation technique makes quantifying problematic. However wildlife can be generally expressed in terms of the value of a consumptive use (i.e. hunting) or non-consumptive use (viewing, bird watching). Due to wildland fires, loss of revenue may be seen in hotels, restaurants, gasoline stations, and grocery stores because patrons are not visiting the area.

The major impact of wildfire on wildlife centers is 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. Vegetation also decreases the rate of erosion along stream banks.

Change 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. However, in chaparral, mountain lions are attracted to the edges of the burned area where deer tend to congregate (Lyon et al. 2000). Low intensity fires do not generally result in significant changes to vegetation composition and resulting wildlife species, but may have similar benefits by increasing the diversity of vegetation mosaics providing better food and cover border areas.

Table 8-9
HEALTH EFFECTS BASED ON VISIBILITY

Visibility Range	Health Category	Health Effects	Cautionary Statements
10 miles and up	Good	None	None
6-9 miles	Moderate	Possibility of aggravation of heart or lung disease among persons with cardiopulmonary disease and the elderly	None
3 to 5 miles	Unhealthy for sensitive groups	Increasing likelihood of respiratory symptoms in sensitive individuals, aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly.	People with respiratory or heart disease, the elderly and children should limit prolonged exertion.
1 V_2 to 2 Va miles	Unhealthy	Increase aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; increased respiratory effects in general population.	People with respiratory or heart disease, the elderly and children should avoid prolonged exertion; everyone else should limit prolonged exertion.
1 mile	Very unhealthy	Significant aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; significant increase in respiratory effects in general population.	People with respiratory or heart disease, the elderly and children should avoid any outdoor activity; everyone else should avoid prolonged exertion.
Under 1 mile	Hazardous	Serious aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; serious risk of respiratory effects in general population.	Everyone should avoid any outdoor exertion; people with respiratory or heart disease, the elderly and children should remain indoors.

Source: Air Quality: Department of Environmental Quality, Oregon

Bird populations generally respond to changes in food, cover, and nesting caused by fire. Fire effects on insect and plant eating bird population depend on alterations in food and cover. Some species of birds may increase in numbers after a fire, such as the swallow, swifts, and flycatchers, allowing greater access to forage. Several species such as the California gnatcatcher require structure and cover provided by mature scrub (Lyon et al. 2000). Bird nest site selection, territory establishment, and nesting success can be affected by season of fire. Spring burns may destroy active nest (Lyon et al. 2000).

Direct effects on wildlife population due to wildfires vary depending on body size, mobility of the species, and intensity of the fire. Majority of animals move away from wildfires, but some (insectivorous birds, raptors) may be attracted, to take advantage of available prey (Lyon et al. 2000). Large mammal mortality most likely occurs when fire fronts are wide and fast moving, fires are actively crowning, and thick ground smoke occurs (USGS 2000). Although few studies have been conducted, it is believed that losses to wildlife caused by fire are negligible. The large fires of 1988 in the Greater Yellowstone Area killed about one percent of the elk population. Most of the larger animals died of smoke inhalation (Lyon et al. 2000). However, like birds, spring fires may impact mammal population due to limited ability of offspring, cover, and the availability of food. Carnivores and omnivores are opportunistic species and although little increase in species occurs, they tend to thrive in areas where their preferred prey or forage is most plentiful, often in recent burn areas (Lyon et al. 2000).

Indirect effects on the wildlife population come in the form of preference to certain forest structural attributes characteristic of plant communities indirectly lost through habitat modification. For example, a major concern is fire risk to the preferred habitat of the California spotted owl (CDF 1995).

Recreation

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 loses habitat and forage will disperse to other locations, resulting in lower hunting numbers for several years. Additionally, wildfires that significantly change the vegetation composition (forest to brush) result in more visitors passing through these areas.

While direct economic loss from land use can be measured, it is more difficult to estimate losses to recreational activities. Recreation use numbers tend to display visitors in terms of users per day and are detailed towards specific attractions (campgrounds, park, forests). Three National Park Service (NPS) studies determined that air quality conditions affected the amount of time and money visitors are willing to spend at NPS units (USDA 2000). In the Shasta West Watershed, the loss in recreational 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. These are masked by other overriding economic factors, such as the increase in gasoline costs.

Human Resources

Wildfire poses a significant risk to human health and property and fire fighter safety. Population growth has climbed steadily in the areas outlining population centers. Human-caused ignitions generally tend to increase with population. Losses are both economic and social, as there are many non-renewable cultural resources in the form of historical buildings and sites, as well as memories of family.

FIRE POLICY

Federal

Prior to 1996, the Forest Land and Resource Management Plan governed fire and fuel management activities. Changes in the Federal Wildland Fire Management Policy established the National Fire Plan. After the record-breaking wildfire season of 2000, the President requested a national strategy for preventing the loss of life, natural resources, private property, and livelihoods in the wildland/urban interface. Working with Congress, the Secretaries of Agriculture and

Interior jointly developed the National Fire Plan (NFP) to respond to severe wildland fires, and reduce their impacts on communities, and assure sufficient fire fighting capabilities for the future. The NFP includes five key points:

- Firefighting preparedness
- Rehabilitation and restoration of burned areas
- Reduction of hazardous fuels
- Community assistance
- Accountability

As part of the community assistance, the USFS, BLM, and tribes identified "at risk" communities. Each National Forest or BLM area has a Forest Land Management Plan (LMP), which guides their actions. These are still in effect even though there have been separate policies and programs that provide direction specifically on fire management.

Significant headway was made in 2001 to meet both the intent and specific direction from Congress in the 2001 Interior and Related Agencies Appropriations Act. There are also tracking and reporting mechanisms in place to provide accountability as accomplishments are made in firefighting, rehabilitation, and restoration; hazardous fuels reduction; community assistance; and research.

The National Fire Plan is a long-term investment that will help protect communities and natural resources, and most importantly, the lives of firefighters and the public. It is a long-term commitment based on cooperation and communication among federal agencies, states, local governments, tribes, and interested publics.

An Urban Wildlife Intermix Zone (UWIZ) is an area where human habitation is mixed with areas of flammable wildland vegetation. In order to protect human communities from wildland fires and minimize the spread of fires that might originate in the UWIZ, the highest priority has been given to fuel reduction treatment activities within the UWIZ. A UWIZ contains an "inner defense zone" that is located within one-quarter mile from the inner defense zone outward for 1.25 miles. Fuels are treated less intensively within the threat zone than in the inner defense zone.

The desired condition for UWIZ is that fuel conditions allow for efficient and safe suppression of all wildland fires. Fires are controlled through initial attack under all but the most severe weather conditions. Under high weather conditions, wildland fire behavior in treated areas is characterized as follows:

- Flame lengths at the head of the fire are less than four feet

- The rate of spread at the head of the fire is reduced to at least 50 percent of pre-treatment level for a minimum of five years

- Hazards to firefighters are reduced by keeping snag levels to two per area and production rates for fire line construction are doubled from pre-treatment levels

In general, landscape-level fuels treatment strategies are designed to limit wildland fire extent, modify fire behavior, and improve ecosystems. These strategies allow fire managers to control fires and set priorities that protect fire fighters, the public, property, and natural resources. Strategically Placed Area Treatments (SPLATs) are one of those strategies. SPLATs are blocks of land ranging from 50 to 1,000 acres where the vegetation has been modified to reduce fuel loading. The spatial pattern of the treated areas reduces the rates in which fires spread and intensify at the head of the fire. The SPLAT strategy treats a relatively large portion of the landscape that facilitates fire reintroduction. SPLATs are designed to burn at lower intensities and slower rates of spread during wildfires than comparable untreated areas. Hence, wildfires are expected to have lighter impacts and be less damaging in treated areas. The desired condition will result in integrating fuels objectives with other natural resource objectives that address the role of fire as well as maintaining a level of resource protection commensurate with values.

UWIZs are designed to protect human communities from wildland fires as well as minimize the spread of fires that might originate in urban areas. The management objective in the urban intermix is to enhance fire suppression capabilities by modifying fire behavior inside the zone and provide a safe and effective area for possible future suppression activity. The intent here is to provide a buffer between developed areas and wildlands. The intermix zones are broken into two categories with differing treatment standards:

- **Defense Zone —** This is a .25 mile buffer zone around the urban development itself. In this zone where canopy cover is less than 40 percent, desired flame lengths are under 4 feet, crown bulk densities are at .05 kg/m^2, and live crown base are at an average of 15 feet high. Snag levels are kept under two snags per acre for firefighter safety. The predicted rate of spread of the fire is 50 percent of pre-treatment levels and line construction accomplishment rates are doubled.

- **Threat Zone —** This is a 1.25-mile buffer zone beyond the defense zone. In this one where canopy cover is less than 40 percent, desired flame lengths are less than six feet with crown bulk densities and live crown base levels the same as the defense zone.

The desired condition is to provide for efficient and safe suppression of all wildland fire starts in the hopes of controlling them under even the most severe weather conditions. These zones include not only the sites themselves but also the continuous slopes and fuels that lead directly to the urban sites in need of protection, thus the modification of the fuel profile around them.

State of California

The State Board of Forestry and the CDF drafted a comprehensive update of the fire plan for wildland fire protection in California. The planning process defines a level of service measurement, considers assets at risk, incorporates the cooperative interdependent relationships of wildland fire protection providers, provides for public stakeholder involvement, and creates a fiscal framework for policy analysis.

The overall goal is to reduce total costs and losses from wildland fire in California by protecting assets at risk through focused pre-fire management prescriptions and increasing initial attack success.

The California Fire Plan has five strategic objectives:

- To create wildfire protection zones that reduces the risks to citizens and firefighters.
- To assess all wildlands, not just the state responsibility areas. Analyses will include all wildland fire service providers — federal, state, local government, and private. The analysis will identify high risk, high value areas, and develop information on and determine who is responsible, who is responding, and who is paying for wildland fire emergencies.
- To identify and analyze key policy issues and develop recommendations for changes in public policy. Analysis will include alternatives to reduce total costs and losses by increasing fire protection system effectiveness.
- To have a strong fiscal policy focus and monitor the wildland fire protection system in fiscal terms. This will include all public and private expenditures and economic losses.
- To translate the analyses into public policies.

Five major components form the basis of an ongoing fire planning process to monitor and assess California's wildland fire environment.

- **Wildfire protection zones —** A key product of this Fire Plan is the development of wildfire safety zones to reduce citizen and firefighter risks from future large wildfires.
- **Initial attack success —** The fire plan defines an assessment process for measuring the level of service provided by the fire protection system for wildland fire. This measure can be used to assess the department[3]s ability to provide an equal level of protection to lands of similar type, as required by Public Resources Code 4130. This measurement is the percentage of fires that are successfully controlled before unacceptable costs are incurred. Knowledge of the level of service will help define the risk to wildfire damage faced by public and private assets in the wildlands.
- **Assets protected —** The plan will establish a methodology for defining assets protected and their degree of risk from wildfire. The assets addressed in the plan are citizen and firefighter safety, watersheds and water, timber, wildlife and habitat (including rare and endangered species), unique areas (scenic, cultural, and historic), recreation, structures, and air quality. Stakeholders — national, state, local, private agencies, interest groups, etc. — will be identified for each asset at risk. The assessment will define the areas where assets are at risk from wildfire, enabling fire service managers and stakeholders to set priorities for prefire management project work.
- **Fiscal framework —** The Board of Forestry and CDF are developing a fiscal framework for assessing and monitoring annual and long-term changes in

California's wildland fire protection systems. State, local, and federal wildland fire protection agencies, along with the private sector, have evolved into an interdependent system of prefire management and suppression forces. As a result, changes to budgeted levels of service of any of the entities directly affect the others and the services delivered to the public. Monitoring system changes through this fiscal framework will allow the Board of Forestry and CDF to address public policy issues that maximize the efficiency of local, state, and federal firefighting resources.

National Park Service

National Park Service policy requires that each park with vegetation capable of burning prepare a plan to guide a fire management program responsive to natural and cultural resource objectives, protection of developed facilities, and safety considerations for park visitors and staff. Whiskeytown National Recreation Area is currently operating under a Fire Management Plan that was written in 1985 and revised in 1993. The existing plan addresses various fire management techniques, including fire suppression, prescribed fire, and the limited use of mechanical treatment to reduce forest fuels. The National Park Service currently is revising Whiskeytown's Fire Management Plan in order to provide the best protection to the public and the park in the event of a wildfire. Many different land management techniques are proposed to reduce or alter fuel loading and arrangements in strategic areas of the park. These fire and fuel management techniques can have a dramatic effect on fuels; however the resulting impacts to the park's resources are uncertain. Of particular concern is the combined impact of fire and mechanized equipment on soil physical and biological properties and the potential increase in non-native plant species. In light of these concerns, the park, with the support of the Joint Fire Science Program, has begun a three-year study to address these management questions. The study evaluated seven differing treatments. In addition, the Whiskeytown National Recreation Area has expanded its prescribed fire program and has developed a detailed network of fuel breaks. Although most of the work on the Whiskeytown National Recreation Area is outside of the Shasta West Watershed area, many of the Whiskeytown National Recreation Area fuel breaks are part of the growing network of interconnected fuel breaks. The California Department of Forestry and Fire Protection, the Bureau of Land Management, the Resource Conservation District, the California Department of Corrections, the National Park Service, and local residents are all working together to design and implement a system based on interagency partnership and cooperation.

In November 2001, Whiskeytown National Recreation Area completed the 720-acre Sunshine prescribed burn. This prescribed burn was the first significant burn Whiskeytown National Recreation Area had completed in three years. The Sunshine burn was an interagency project to help reduce the threat of wildfire to Old Shasta and west Redding, and enhance the effectiveness of fuel breaks already in place.

The Fire and Resource Management Divisions are busy updating the park's fire management plan. This plan outlines Whiskeytown National Recreation Area's fire goals for the next 10 years. Because of Whiskeytown National Recreation Area's complex fuels, sensitive resource issues, and adjacent communities, the park developed an Environmental Impact Statement. This was an intense project that involved staff from many different fields of expertise. The staff was involved with public scoping sessions and researched how fire and fuel reduction projects would affect park resources. This Environmental Impact Statement was completed in 2002.

Black oak and ponderosa pine forests burned frequently with fires generally of low to moderate severity and historical fire regimes from two to twenty-three years. Mixed in with these communities are the chaparral and knobcone pine plant communities, which usually support severe stand-replacement fires. Higher up in elevation, frequent fires of low to moderate severity characterize where the mixed conifer plan community blends into where ponderosa pine and mixed oak woodlands dominate. Every seven to fifteen years, this fire regime can vary considerably in both frequency and severity, depending on site-specifics. From a landscape perspective, it appears that many of these high-elevation forest areas were generally more open than they are today, due mostly to the frequency of fires. This may have promoted more grasses and herbs than are associated with most forest stands today. Many of the park's ponderosa pine and mixed conifer stands have become denser, mainly in small and medium size classes of shade-tolerant and fire-sensitive species. Stands have also become less complex and more homogeneous in terms of spatial arrangement.

Wildland fire management activities in National Park sites are essential to the protection of human life, personal property, and irreplaceable natural and cultural resources. Because of the proximity to communities like French Gulch, Old Shasta, Centerville, Igo, and Redding, the National Park Service has identified Whiskeytown National Recreation Area as being at high risk for high severity wildland fire. Continued fire suppression will be required. Suppression alone will only exacerbate the growing problems, particularly in areas of overly dense stands and excessive fuels. Given the narrow windows available in which fire management is able to execute prescribed burns, it is inconceivable that fire in its presettlement frequencies and severities could be fully restored. Prescribed fire alone cannot fully mimic the ecosystem functions of presettlement fire because the forests have changed greatly and the effects of reintroduced fire are likely to be quite different than those of presettlement fire.

City of Redding

The City of Redding promotes fire prevention throughout the community by conducting inspections, making presentations, and enforcing homeowner vegetation abatement practices. The City of Redding Fire Department (Department) conducts over 5,000 fire and life safety inspections in commercial buildings every year. In addition, approximately 750 inspections are conducted annually on new businesses and licensed care facilities. Public education of fire prevention practices result in approximately 100 Department presentations throughout the communities annually.

The area to the north and west of the city, encompassing over 5,000 parcels, is designated as a "Very High Fire Hazard Severity Zone" by CDF. The Department manages this area through a homeowner self-inspection program of suggested abatement procedures. A citation is issued to those homeowners unwilling to participate and physical inspections occur randomly to verify self-inspections. Additional vegetation problems, including weed control, are addressed when a complaint is filed with the Department. Upon receipt of a complaint an inspection is conducted to issue proper abatement procedures to the landowner.

Fire Safe Councils

Fire safe councils are an outgrowth of the National Fire Policy Firewise program. Most are funded through the National Fire Plan grant funds to initiate and develop community based outreach and education programs. The Fire Safe Council is a coalition of public and private sector organizations and individuals that share a common vested interest in wildfire prevention and loss mitigation. Fire Safe Councils are dedicated to saving lives and reducing fire losses by making their communities more fire safe. Over 60 councils in California are working to make individual communities safer places to live. This is accomplished through:

- Development of emergency preparedness plans for the community prior to fire occurrence

- Providing an opportunity for community residents and organizations to voice concerns about public safety issues and to protect the social and economic interests in their community

- Increasing chances that homes in certain communities will continue to be insurable

The Shasta County Fire Safe Council can be contacted at:

Shasta County Fire Safe Council
Western Shasta Resource Conservation District
6270 Parallel Road
Anderson, CA 96007
(530) 365-7332

The mission of the Shasta County Fire Safe Council is to "*be a framework for coordination, communication and support to decrease catastrophic wildfire through out Shasta County.*" This is accomplished through development of education programs to address fire preparedness and planning for local residents, coordinated mapping and data collection projects, and development of individual grant funded projects for shaded fuel break and DFPZ construction.

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SECTION 8: FIRE AND FUELS MANAGEMENT

Issues Identified

Dominate fuels in the watershed are at high and severe fire risk, which threatens wildland habitats and urban developments with large wildfires.

The completed Shasta West fuels management plan needs to be implemented.

Communities in the Shasta West watershed need to work together and with resource agencies to reduce the risk of fire.

Fuel mapping needs to be updated in the watershed.

Fuels management needs to continue to coincide with ecological goals of habitat preservation.

Data Gaps

Fuels mapping needs to be updated and corrected for inaccuracies in dominate vegetation types that will carry wildfire.

There is limited information on the fire history of the watershed.

Action Items

Acquire and analyze recent color aerial photographs for the watershed. Followed up by field investigation. Collaborate with agencies involved with fire management to determine what are the dominate vegetation types that will carry wildfire. All updated information should be presented to the FRAP program for review.

Work with agencies and landowners to support, fund and implement the Shasta West Fuels Management Plan. Review and update the fuels management plan as needed to address ecological needs, fuel type changes and continued urban development.

Collaborate with agencies and landowners to perform a thorough fire history study of the watershed. Locating historical fire sites, burn intervals and estimation of fire intensity would give insight into native fuel conditions of the watershed which could assist resource managers in planning fuel treatments that benefit both the urban population and the ecology of the watershed.

Encourage and collaborate with agencies and landowners to promote fuel management activities that promote wildland and urban protection as well as biodiversity and habitat improvement.

Advertise and encourage support for the Shasta West Fire Safe Council and the Shasta County Fire Safe program. Work with agencies to retain a full time watershed coordinator to help coordinate with the Fire safe program and other activities.

Appendix 8-A

2005 Defensible Space Update

CULTURE
SECTION 9

Section 9
CULTURE AND DEMOGRAPHICS

TABLES

FIGURES

APPENDIX

Section 9
CULTURE AND DEMOGRAPHICS

INTRODUCTION

This section examines heritage, cultural and demographic resources within the Shasta West Watershed. Appendix A contains various articles pertaining to cultural and community issues of the Shasta West Watershed.

SOURCES OF DATA

Several agencies in the watershed are responsible for heritage resources. The City of Redding Development Services Department, Planning Division and the Shasta County Department of Resources Management, Planning Division has decision-making authority over most projects in the watershed. Therefore, heritage resource analysis must be conducted as part of a CEQA review. These agencies also have cultural resource policies in their General Plans.

The United States Bureau of Land Management (BLM) owns over 4,000 acres within the watershed. BLM management policies regarding heritage resources apply (BLM, Redding Resource Management Plan). Approximately 700 acres in the northwest portion of the watershed are within the eastern fringe of the Whiskeytown National Recreation Area. The National Park Service has responsibility over heritage resources on these lands (Whiskeytown Unit, General Management Plan).

A list of primary references for heritage resources in the watershed is provided below:

- City of Redding General Plan
- Shasta County General Plan
- BLM, Redding Resource Management Plan
- National Park Service, Whiskeytown National Recreation Area Management Plan
- Shasta Historical Society Photo Archives
- Various heritage resources surveys conducted in the watershed
- California Archaeological Inventory, Northeast Information Center, Chico

Other data is available that was not incorporated into this assessment. Specific information concerning the type and location of recorded heritage resource sites in the watershed are available but not provided in this report. This is due to the sensitive nature of the information and the potential for illegal artifact collection. Site-specific information has been obtained and will be provided to the Western Shasta Resource Conservation District. The archeological information is confidential and cannot be published in this document. This information can be considered during new project undertakings.

Heritage resource sensitivity maps can also be developed and provided by the Northeast Information Center. Use of these maps are not advised because they can lead to unauthorized collection of artifacts or over reliance by a public agency in determining whether cultural resource surveys should be conducted (Hubarland, pers. comm.).

An attempt was also made to obtain Environmental Impact Reports (EIRs) prepared pursuant to CEQA for projects in the watershed. It was determined that no EIRs have been prepared in the watershed in the last ten years (Stokes & Manuel, pers. comm.). Older EIRs contained no detailed information regarding heritage resources.

A formal list of references used for this report is provided at the end of this section.

HERITAGE RESOURCES

The term heritage resources, as used in this assessment, include all forms of archaeological, historical, and other cultural resources. These commonly occur in the form of both prehistoric and historic archaeological sites, usually containing features and/or artifacts. Many of these sites, both on an individual basis and taken as a whole, are significant under the criteria used to evaluate heritage resources. These sites can be associated with events that made a significant contribution to the broad patterns of our history; they can be associated with the lives of important persons in our past; some embody distinctive characteristics of a type, period, or method of construction; and many have the potential to yield information important to the understanding of prehistory or history. The importance of the prehistoric sites to living Native Americans is also an important consideration. Conserving heritage resources within the watershed contributes to recreational, aesthetic, and educational values.

Ironically, many watershed restoration projects performed in the study area today are to remediate the effects of historic mining activities. Nevertheless, watershed restoration activities and all other actions need to be sensitive to heritage resources.

The purpose of this section is to review available heritage resource information and characterize the data in relation to the watershed. More specifically, this section will examine the following:

- Types of heritage resources in the watershed
- Regulations for the protection of heritage resources
- Methods of determining the significance of heritage resources
- On overview of the history and prehistory of the watershed
- A general description of the types of heritage resources found in the watershed
- Issues and challenges for future activities affecting heritage resources

The term Heritage Resources describes several different types of properties that are known or may be expected within the watershed such as:

- Prehistoric Native American archaeological sites predating sustained Euro American settlement in 1850, such as habitation sites marked by house pit depressions and temporary camps containing scatters of flaked and groundstone artifacts

- Historic archaeological sites typically dating from 1850 to 1953 (50 years is the general threshold for recognizing historic period resources) such as mining camps, collapsed structural remains, and refuse dumps

- Historic period architectural features older than 50 years, such as buildings (e.g., schoolhouse) and structures (e.g., bridges)

- Traditional cultural places important to contemporary Native Americans who have heritage ties to the watershed, such as sacred sites, burial grounds, areas where native plants are gathered for use in making baskets or as traditional foods and medicines

The California Public Resources Code (PRC) and Federal law and regulations define criteria for determining the legal significance of heritage resources. The California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA) recognize that only those heritage resources determined to be "significant" qualify for consideration of mitigation.

Agencies with jurisdiction in the watershed (i.e., City of Redding, Shasta County, Bureau of Land Management, and National Park Service) are responsible for managing all heritage resources in consultation with the California State Historic Preservation Officer (SHPO).

CEQA defines a significant heritage resource as "a resource listed or eligible for listing on the California Register of Historical Resources." For a heritage resource to be eligible for listing in the California Register, it must meet one or more of the following four criteria (PRC 5024.1(c)):

- Is associated with events that have made a significant contribution to the broad patterns of California's history or cultural heritage

- Is associated with the lives of persons important in our past

- Embodies the distinctive characteristics of a type, period, region, or method of construction, or represents the work of an important creative individual, or possesses high artistic values

- Has yielded, or has the potential to yield, information important in prehistory or history

In addition to meeting one or more of the above criteria, the resource must be at least 50 years of age. A resource less than 50 years of age may qualify for the National Register if it is exceptionally important to understanding our more recent history.

A significant resource that meets one or more of the above criteria must also retain at least two types of integrity as defined below:

- Location is the place where the historic property was constructed or the place where the historic event occurred

- Design is the combination of elements that create the form, plan, space, structure, and style of a property

- Setting is the physical environment of a historic property

- Materials are the physical elements that were combined or deposited during a particular period of time and in a particular pattern or configuration to form a historic property

- Workmanship is the physical evidence of the crafts of a particular culture or people during any given period in history or prehistory

- Feeling is a property's expression of the aesthetic or historic sense of a particular period of time

- Association is the direct link between an important historic event or person and a historic property

Data Summary

Types of data gathered for the watershed include site records, maps showing general historical activities, historic photos, management plan policies for protection of heritage resources, and general background information regarding human activity in the watershed.

The majority of the recorded sites in the watershed are historic resources associated with mining activities. Most prehistoric areas are midden sites that exhibit dark soils, fire fractured rock, obsidian, and other deposits. Historic sites include mines, foundations, dams, ditches, dumps, and artifact scatters. Many of these sites are eligible, but have not yet been listed in the National Register of Historic Places (BLM, West Redding Foothills Survey Project).

Four of the City's structures in the watershed have been listed on the National Register of Historic Places: Old City Hall, Pine Street School, the Cascade Theater, and the Frisbie House. Redding has numerous historic structures dating from the Victorian period, and good examples of architecture dating from the 1920s to 1940s (Redding General Plan, Natural Resources Element).

Management Plans

All general plans and management plans applicable to the watershed include policies for the protection of heritage resources. Select policies from Shasta County, City of Redding, BLM, and the National Park Service are provided below:

- (Shasta County) "Development projects in areas of known heritage value shall be designed to minimize degradation of (heritage) resources. Where conflicts are unavoidable, mitigation measures to reduce such impacts shall be implemented. Possible mitigation measures may include clustering, buffer or nondisturbance zones, and building siting requirements."

- (City of Redding) "Refer development proposals that may adversely affect archaeological sites to the California Archaeological Inventory. Encourage public and private efforts to identify, preserve, protect and/or restore historic buildings, structures, landmarks, and important cultural resources."

- (BLM) "General management direction applicable to all cultural resources and land use management alternatives include: Administrative and physical measures to protect sites, monitoring of known sites on lands in long-term BLM administration, surveillance by law enforcement personnel in problem areas, and use of qualified organizations or the public in cooperative study of cultural resources."

- (National Park Service) "The park maintains a significant collection of historical, archeological and natural history specimens. Archaeological specimens are important for documenting the history and prehistory of the Northern Sacramento Valley since much of that interpretation remains to be completed."

Shasta State Historic Park

Shasta State Historic Park, located six miles west of Redding, consists of 19 acres of the historic town of Shasta. This area prospered for over 40 years from 1850-1890. The park includes a museum, visitors' center, and a renovated store and bakery. In 1852, fire destroyed much of the town but many of the old foundations are preserved within the park. The brick ruins, readily evident from State Route 299, are the decayed remnants of a once thriving shopping district. Hotels, barbershops, bookstores, butcher shops, and stables once occupied a mile long stretch of roadway.

Today, visitors can walk historic trails and roads to see cottage ruins, gardens, orchards, and a cemetery where many of Shasta's prominent citizens are buried. The courtroom, jail, and gallows have been restored to its 1860s condition and furnished with many original items from gold rush times. The Pioneer Barn area includes farming and mining implements of the 1800s; and the hay barn houses an original stagecoach.
A Courthouse Museum includes galleries that display 100 years of California Art. The restored building served as the Shasta County Courthouse for three decades in the late 1800s. The building currently houses the visitor center and information desk along with interactive exhibits depicting the history of Shasta.

Shasta State Historic Park plays a key role in the preservation of Shasta County's gold rush era history.

Heritage Census Information

Data analysis of heritage resources is difficult since much of the data, particularly prehistoric data, is incomplete in the watershed. Like putting together a jigsaw puzzle, enough pieces are needed to reveal a picture. To date, most site information has been revealed incrementally and in scattered areas as ground-disturbing activities occur. Little funding exists to prepare comprehensive heritage studies or surveys, or to comprehensively analyze all surveys previously conducted. As new uses are approved in the watershed, and new ground disturbing activities undertaken, we will continue to add to the mosaic of cultural resource information. Coordination, follow-through in site documentation, and support from groups like the Northeast Information Center, Shasta Historical Society, and Wintu Tribe will be essential to recovering the most from both existing sites and undiscovered sites.

CENSUS DATA

Current census data for the watershed is included in this section.

Growth Areas

Growth during each of the ten-year census surveys could not be tracked because of the census tract boundary changes for each survey. Residential growth permitted under the City of Redding and Shasta County general plans, however, can be determined and generally compared to the number of existing units in the watershed. Population growth can also be determined based on average residents per household.

At full development under the City of Redding and Shasta County General Plans, up to 29,281 units could be developed in the watershed, including existing units. 2,522 of these (less than 10 percent) would be in the unincorporated area. 3,240 of these would be at multiple-family (apartment) densities of 11-plus units per acre.

Population

Figure 9-1 shows population densities (persons per square mile) based on 2000 U.S. Census Bureau data. The most populated areas are in and around downtown Redding. Densities drop off sharply beyond the Redding city limits.

Income

Figure 9-2 shows average annual household income by Census Block Group based on 2000 US Census Bureau data. Generally, as development densities increase, average household income declines due to smaller, more inexpensive land and housing. Two notable exceptions are: the Rock Creek area near Old Shasta and Keswick which has lower income levels in a low density area; and land between SR 273 and the Sacramento River from the Parkview Drive area to Girvan Road which have higher income levels in an area with high development densities.

Race

Table 9-1 shows ethnic race by Census Block Group based on 2000 US Census Bureau data. The Census Bureau defines how ethnic races are classified. There are several notable concentrations of different ethnic populations in various tracts and block groups. Areas where the population of an ethnic race is more than double the watershed average are highlighted in gray.

Table 9-1 SHASTA WEST RACE BY TRACT AND BLOCK GROUP							
Block Group	Total	White	Black	American Indian	Asian	Pacific Islander	Other
Block Group 1, Tract 115	916	869		29		7	11
Block Group 2, Tract 123.0	1,058	912		60		36	50
Block Group 5, Tract 110	917	861		49			7
Block Group 6, Tract 110	787	710	13	38			26
Block Group 1, Tract 111	2,742	2,553	15	15	61	6	92
Block Group 2, Tract 109	1,674	1,608		8	18		40
Block Group 3, Tract 110	1,163	1,017	5	71	19	21	30
Block Group 4, Tract 104	1,122	1,031	34				57
Block Group 3, Tract 104	687	609		27		4	47
Block Group 1, Tract 110	1,171	1,143					28
Block Group 2, Tract 110	2,813	2,361		97	135	144	76
Block Group 1, Tract 109	2,180	1,829	29	147	102	17	56
Block Group 2, Tract 124	764	719		19		6	20
Block Group 1, Tract 103	1,519	1,242		62	119	20	76
Block Group 2, Tract 104	1,143	1,062		28	4		49
Block Group 1, Tract 104	1,182	938		58	64	60	62
Block Group 3, Tract 105	1,317	1,110	40	42	65	27	33
Block Group 2, Tract 101	755	638	3	3	3	85	23
Block Group 2, Tract 105	1,505	1,266	11	36	7	123	62
Block Group 3, Tract 106	4,631	4,353	5	47	88	59	79
Block Group 1, Tract 105	1,866	1,598	35	21	33		171
Block Group 3, Tract 107.0	2,940	2,667	29	22	90	24	108
Block Group 1, Tract 102	2,099	1,864		14	138	14	69
Block Group 1, Tract 101	851	680	4	27	93		5
Block Group 1, Tract 107.0	3,789	3,300	32	26	206	96	129
Block Group 1, Tract 106	2,180	1,857	8	21	101	78	115
Block Group 3, Tract 124	1,711	1,606		30		10	53
Block Group 2, Tract 106	1,320	1,260		20		3	37
Block Group 1, Tract 124	361	337		10	2		7
TOTALS	47,163	42,000	263	1,027	1,348	840	1,618
[shaded] = Race Proportion is more than double the watershed average.							

COMMUNITY YOUTH INVOLVEMENT

There is a large amount of past, ongoing, and proposed future involvement of local community youth in the Shasta West Watershed. Students of the Sequoia Middle School, Mistletoe Elementary School, Chrysalis Charter School, Turtle Bay Elementary School, and Shasta College, as well as youth from the Boy Scouts, Shasta High, and Shasta Flyfishers have all participated in various ventures independently and in cooperation with efforts from various community groups and organizations including Redding Rotary. Because each of the named watercourses in the Shasta West Watershed passes within walking distance of area schools, their student bodies serve as the "eyes and ears" for what is happening. They know these streams better than anyone and participate in such activities as releasing juvenile salmon (Mistletoe) to labeling storm drains, operating heavy equipment as class work, and helping to pick up stream litter.

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SECTION 9: CULTURE AND DEMOGRAPHICS

Issues Identified

There is a need for active watershed stewardship in the Shasta West watershed that involves community's agencies, resource users and organizations.

With urban development, cultural resources such as Native American heritage sites are at risk of being lost or damaged.

Historical natural resource data from agencies needs to be preserved in order to compare current management practices to historical conditions.

Resource managers need to identify environmental justice issues in the watershed in regard to environmental laws, regulations and policies.

Data Gaps

The quantity of historical cultural and natural resource data that may have been collected by agencies and organizations is unknown, leaving gaps in data for cultural risk and natural resource assessments.

There is a lack of complete cultural heritage assessments and prehistoric resource data for the watershed.

Action Items

Work with agencies and landowners to promote and support educational and volunteer initiatives that enhance public awareness and increase direct participation in watershed stewardship. Encourage residents and resource users to become active stewards in their everyday activities and through volunteer involvement. To help coordinate these activities, work to fund a full time watershed coordinator.

Collaborate with agencies and organizations such as the Northeast Information Center, Shasta Historical Society and the Wintu Tribe to perform comprehensive cultural resource surveys and document newly discovered resources. Work to bring the documentation into a centralized and consolidated database of cultural resources that would aid future urban development in locating and protecting cultural heritage.

Collaborate with agencies and organizations to locate and preserve historical natural resource data.

Appendix 9-A

Articles Pertaining to Cultural and Community Issues