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Clear Lake Integrated Watershed Management Plan

Chapter 1

INTRODUCTION

1.1 BACKGROUND

Clear Lake has been described by many superlatives; it is the largest natural freshwater lake entirely within the boundaries of California, it is an ancient lake at least 450,000 years old and up to 2.5 million years old, it is an important resource for birds in northwestern California, it is the “Bass fishing capitol of the West.” Clear Lake has also been described in negative terms; it is subject to nuisance algal blooms, it is contaminated with mercury from past mining activities, it has areas of dense aquatic plant growth that interfere with boating. All of these descriptions are true and support the need for an integrated, multidisciplinary, watershed approach to the management of Clear Lake.

The effort to develop the Clear Lake Integrated Watershed Management Plan (CLIWMP) was first conceived by the County’s Algae Abatement Committee formed in 1980 to evaluate water quality and supply issues. The Algae Committee acknowledged a need to develop a long-term management plan to address a number of resource and institutional issues using a watershed approach. In 1990, the Lake County Board of Supervisors established a multi-disciplinary advisory body called the “Clear Lake Basin Coordinated Resource Management Committee” (RMC). The RMC restructured the Algae Abatement Committee into the Clear Lake Advisory Subcommittee (CLAS). The purpose of CLAS is to provide guidance on Clear Lake related matters to the RMC. Development of the Clear Lake Management Plan has been a collaborative effort involving local and regional agencies, interest groups, and members of the public through numerous public workshops. CLAS, which represents 18 different organizations, has played a major role in incorporating the many findings and conclusions of numerous studies conducted in the watershed into the current understanding of lake stewardship needs.

The original plan was titled the Clear Lake Basin Plan (CLBP), and in early 2000, numerous drafts of portions of the plan were widely distributed for public comment. Comments were received and incorporated; however, because of a shortage of county resources, the plan was not completed. The consulting firm Jones and Stokes was retained in December 2000 to continue work on the CLBP with on-going input by county staff and through CLAS review. In 2003, the Lake County Special Districts Department (LCSDD) assisted in completing a draft form of the CLBP known as the September 2003 Draft Clear Lake Basin Management Plan. Although the 2003 plan was not completed, many of the specific actions identified in the earlier CLBP and September 2003 Draft have

been implemented by the Lake County Public Works Department, LCSDD, and other agencies.

A CALFED Watershed Program grant was awarded in February 2007 to the West Lake Resource Conservation District (WLRCD) to produce three sub-watershed assessments for the largest tributaries to Clear Lake, and to complete the Clear Lake Basin Management Plan, renamed the “Clear Lake Integrated Watershed Management Plan.” The watershed assessments for the Kelsey Creek, Scotts Creek, and Middle Creek Watersheds provide supporting watershed information for an area comprising approximately 49% of the land surface of the Clear Lake Watershed.

1.2 PURPOSE

The purpose of the CLIWMP is to describe the existing conditions of the watershed based on findings and conclusions of previous studies, to describe past and current watershed management, and to use this information to identify opportunities to improve and/or protect the health and quality of conditions in the watershed and provide a guidance document useful in future watershed planning efforts. The Management Plan is both programmatic and project-based in nature and sets the stage for future implementation actions. The intent of this strategy is to develop an overall framework for management of the watershed, while simultaneously moving toward implementation of projects that can garner stakeholder involvement and support through an iterative and adaptive management process.

1.2.1 Goal

The goal of this watershed management is to plan and work toward an environmentally and economically healthy watershed that is sustainable for future generations.

This shall be done by using a watershed approach, a systemic approach that addresses multiple issues, such as water quality and the land use practices that affect it, natural habitats and ecosystem restoration, and economic uses such as tourism, recreation, and water supply.

Implementing this plan requires collaboration among the numerous agencies, organizations, and Tribes who participate in management of the Clear Lake watershed. A vital component of plan implementation is public outreach and education. During the decision-making process, it is necessary to ensure that all communities have the opportunity to participate. The decision-making process shall be non-discriminatory and take into the account the concerns of all communities.

1.2.2 Objectives

A set of objectives of the Management Plan has also been identified. Achieving the following objectives will help the county reach its goal of achieving a healthy watershed:

- Improve surface and ground water quality.
- Improve water supply management.
- Improve land management practices.
- Improve fish and wildlife habitats.
- Improve tourism and recreation opportunities.
- Prevent the introduction or spread of invasive species.
- Improve lake floodplain management.
- Improve lake and lakeshore management practices.
- Improve education and outreach.
- Improve coordination among agencies, organizations, and Tribes.
- Ensure participation of all communities when developing and implementing programs and projects.

1.2.3 Adaptive Management Process

Adaptive watershed management is used to ensure that watershed management is effective and to adapt to changing conditions and priorities. The United States Environmental Protection Agency (USEPA) defines adaptive management as “the process by which new information about the health of the watershed is incorporated into the watershed management plan” (USEPA 2000). Adaptive management involves developing the adaptive management plan, monitoring the results of management actions, evaluating the results from monitoring, and adjusting the plan according to the results. An example of the process in this plan would be to implement one or several site remediation projects at the Sulphur Bank Mercury Mine, monitor and evaluate changes in mercury loads to Clear Lake, and decide on further steps. As individual projects and programs recommended in this plan are implemented, this adaptive management approach will ensure their effectiveness.

The adaptive management process also needs to be applied to the entire watershed management plan through periodic review. Actions recommended in this plan are based on current lake and watershed conditions, and as conditions change, the priority for implementing actions will change and new actions will be required. For this reason, progress on implementing the plan will be reviewed on an annual basis, and the plan will be updated once every five years. To ensure the participation of all communities in the planning process, public comment and review will be sought during the update process. The updates will include a review of projects and programs that have been implemented under the plan during the past five years, new information on watershed and lake conditions, a reassessment of plan priorities, and changes or additions to recommended actions.

1.3 WATERSHED OVERVIEW

1.3.1 What is Watershed?



Figure 1- 1 Clear Lake viewed from the south shore of the lower arm. Much of the watershed is comprised of steep and rugged terrain. *Photo courtesy of Lake County.*

A watershed is an area of land that drains down slope to the lowest point. Water moves through the watershed in a network of drainage pathways, both above and below ground. For a creek, the lowest point of the watershed would be the mouth of the creek. For a lake, it would be the outlet of the lake. For the purposes of this document, the lowest point of the Clear Lake Watershed is the Cache Creek Dam. Watersheds of tributaries to Clear Lake are referred to as sub-watersheds.

A watershed not only represents an assemblage of natural resources, it also defines a community of people who live there and ideally share an interest in the health and abundance of its natural resources. The people who live within the boundaries of the watershed have a direct impact on the health and condition of their watershed. Residents, landowners, government agencies and officials, and businesses influence the condition of the watershed through their daily actions and decisions. Stewardship of a watershed implies a shared responsibility for the condition and improvement of the land and water resources within its boundaries.

1.3.2 Description of the Watershed

Located in the central Coastal Ranges of Northern California approximately 80 miles north of San Francisco, Clear Lake is the largest natural freshwater lake located entirely in California (Plate 1). It drains to the east via Cache Creek to the Sacramento River. The 43,790 acre (68 square miles when full) lake has 100 miles of shoreline and is generally divided into 3 main areas known as the Upper Arm (28,000 acres), Lower Arm (8,200 acres), and Oaks Arm (2,800 acres). The mean depth of each arm is 23, 34, and 36 feet, respectively. The lake is 18 miles long (maximum length), 7.5 miles wide (maximum width), and drains approximately 465 square miles. The Cache Creek Dam regulates water storage in the lake. It is operated by Yolo County Flood Control and Water Conservation District, which has water rights to use up to 150,000 acre feet of water in the lake.

Approximately 57% of the lake inflow is from the Scotts Creek and Middle Creek Watersheds (Richerson *et al.* 1994), which enter the lake to the northwest through Rodman Slough. Clear Lake discharges into Cache Creek through the Cache Creek Dam, which is approximately five miles downstream of the lake. The five mile portion of Cache Creek between Clear Lake and the Cache Creek Dam is often referred to as the Clear Lake Outlet Channel. Other major tributaries to Clear Lake include Adobe Creek, Kelsey Creek, Clover Creek, and Schindler Creek.

The Clear Lake Watershed, an area of approximately 528 square miles, is in the northern Coast Ranges geomorphic province of California. The topography in the Clear Lake Watershed is generally steep and rugged, although there are some gently sloping alluvial terraces and valleys. Elevations range from 4,840 feet at the top of High Glade in the Middle Creek Watershed to 1,318 feet at the level of Clear Lake.

1.3.3 Geology

Mesozoic marine sedimentary rocks of the Franciscan Complex and Great Valley Sequence underlie much of the Clear Lake Watershed (Plate 2, 65-205 Ma). Around the center of Clear Lake are the Clear Lake Volcanics, dominated by Mt. Konocti (Plate 2, Andesite). Eruption of this volcanic field began about 2 million years ago. The most recent volcanic activity dates to about 10,000 years ago, and the Clear Lake volcanic field is considered to be potentially active (USGS 2004). Unconsolidated Quaternary alluvium fills the low-lying basins of the watershed.

Clear Lake is located in a structural depression created by the San Andreas Fault system. The geologic structure of the region is dominated by north/northwest-south/southeast valleys and ranges created by the action of the San Andreas Fault system along the Pacific-North American plate boundary (Christensen Associates 2003).

The Clear Lake Basin has evolved as a result of three processes: (1) the San Andreas fault system has been the dominant control, by initiating the broad subsidence and controlling the margins, probably by the mechanisms outlined by Crowell (1974); (2) eruption of the Clear Lake Volcanics has caused local subsidence and has filled part of the basin; (3) erosional and depositional processes have influenced the distribution, character, and amount of basin fill (Hearn *et al.* 1986).

Clear Lake is an ancient lake that has existed for 450,000 years, and possibly longer. Over much of its history the lake has apparently existed as a shallow, eutrophic lake because downward movement of the basin has been approximately equal to the rate of sedimentation (Sims *et al.* 1988).

The Clear Lake Watershed lies in a topographic divide between the Russian River system to the west and the Sacramento River system to the east, and its drainage has alternated between the two systems in the past. Prior to a landslide, which occurred to the east of Blue Lakes around 10,000 years ago, the lake drained west to the Russian River. It now drains to the east via Cache Creek, and its minimum level is maintained by the Grigsby Riffle, a rock sill located at the confluence of Cache Creek and Seigler Canyon Creek.

The Geysers geothermal field is located south of Clear Lake in the area of the Clear Lake volcanics. A large silicic magma chamber (approximately 8.7 miles in diameter) lies about 4.3 miles below the surface, providing the heat for the geothermal field. The magma chamber is the source of heat for numerous thermal springs in the area and for hydrothermal ore deposits, such as the Sulphur Bank Mercury Mine, which is still the site of active mercury deposition (USGS 2004). Areas of mercury enrichment occur throughout the California Coast Range, which

was one of the leading areas worldwide for mercury mining (Wiener and Suchanek 2009).

Over 70% of the soils of the watershed are shallow (less than 20 inches deep to bedrock), and the shallowest soils are found on steep slopes in the upper watershed. Due to their limited depth, it takes relatively little precipitation for these soils to become saturated and produce runoff (USACE 1997).

1.3.4 Climate

The county has a modified Mediterranean climate, which is typified by warm, dry summers and moist, cool winters. In winter, high temperatures are in the 50s (Fahrenheit) and lows are in the 30s (Figure 1-2). Temperatures below freezing can occur throughout the watershed, although they are less common adjacent to Clear Lake. In the summer average high temperatures at lake level are in the low 90s, but they can go over 100°F. On most nights during the summer, there is significant cooling (30-40°F). Most precipitation in the Clear Lake area occurs as rainfall with minor amounts of snow at the highest elevations. At lake level, the average annual rainfall is approximately 30 inches per year, and the amount increases considerably at higher elevations (Plate 3). Prevailing winds are from the west and have greater velocities during the winter months. In general, mornings on the lake are calm and afternoons are breezy.

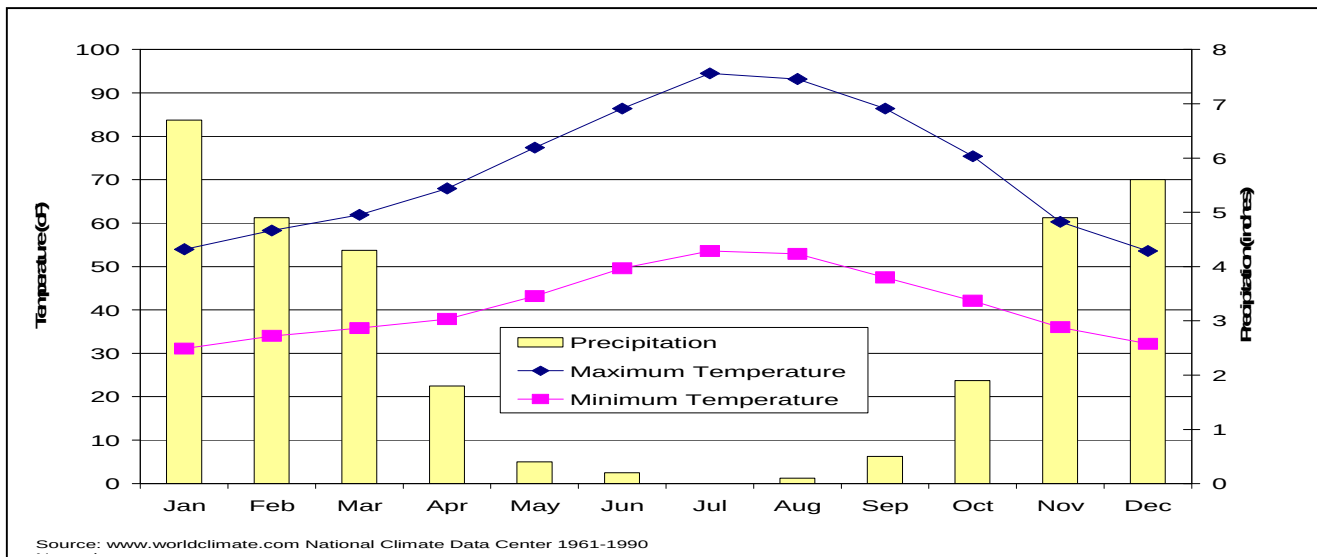


Figure 1- 2 Temperature and precipitation at Lakeport California. Monthly averages based on the years 1961-1990.

1.4 RELATED PLANS, REGULATIONS, AND DOCUMENTS

In addition to this Management Plan, the Clear Lake Watershed is addressed by a variety of other plans and regulations that affect resource management. There is an extensive framework of federal and state regulations that provide a level of

protection to local creeks. Some of the more important regulations include the Federal Clean Water Act including the USEPA stormwater and pesticide discharge regulations through the National Pollutant Discharge Elimination System (NPDES), Federal Endangered Species Act, California Porter-Cologne Water Act, California Fish and Game Code, and California Environmental Quality Act (CEQA). At the local level, Lake County has numerous policies and regulations in the county's General Plan and County Code that facilitate the protection and restoration of local creeks. Several documents provide extensive background on Clear Lake and its watershed.

County Plans

- General Plan
- Area Plans
- Lake County Clean Water Program
- Floodplain Management Plan*
- Lake County Aggregate Resource Management Plan
- Integrated Regional Water Management Plan**
- Mount Konocti Master Management Plan**
- Community Wildfire Protection Plan
- Integrated Aquatic Plant Management Plan
- Lake County Invasive Species Plan**
- Lake County Multi-Use Trails Plan**
- 2006 Lake County Regional Bikeway Plan

County Regulations

- Chapter 9 – Health and Sanitation
- Chapter 23 – Clear Lake Shoreline
- Chapter 25 – Floodplain Management
- Chapter 26 – Clear Lake Aquatic Plant Management
- Chapter 28 - Groundwater
- Chapter 29 - Stormwater Management
- Chapter 30 – Grading Ordinance
- Illegal Dumping Ordinance
- Off-Highway Vehicle (OHV) Ordinance
- Quagga Mussel Ordinance

State Plans

- Central Valley Regional Water Quality Control Board Basin Plan
- California Water Plan
- California Aquatic Invasive Species Management Plan
- California Floodplain Management Plan
- California Fisheries Management Plan
- California Outdoor Recreation Plan

State Regulations

- California Water Code
- California Environmental Quality Act
- California Fish and Game Code
- California Endangered Species Act
- California Harbors and Navigation Code
- California Streets and Highways Code
- California Health and Safety Code
- California AIR QUALITY Act

Federal Plans and Regulations

- Clean Water Act
- Clean Air Act
- Endangered Species Act
- Homeland Security Act
- Bureau of Land Management Ukiah Field Office Resource Management Plan
- Mendocino National Forest Land and Resource Management Plan
- National Environmental Policy Act

Tribal Plans and Regulations

- Water Pollution Prevention Ordinances
- Non-Point Source Management Plans

*Plan is being updated.

**Plan is under development

Important Documents

- The Causes and Control of Algal Blooms in Clear Lake, “Clean Lakes Report” (Richerson *et al.* 1994)
- An Economic Analysis of Potential Water Quality Improvement in Clear Lake: Benefits and Costs of Sediment Control (USDA SCS 1994)
- Monitoring and Implementation Plan Clear Lake Mercury and Nutrient Total Maximum Daily Loads (TMDLs) (CLTSC 2008)
- Final Report Clear lake Watershed TMDL Monitoring Program (LCWPD 2009)
- Kelsey Creek Watershed Assessment (ELRCD and WLRCD 2009)
- Middle Creek Watershed Assessment (WLRCD 2009)
- Scotts Creek Watershed Assessment (WLRCD 2009)

1.5 IDENTIFICATION OF ISSUES

Conducting an inventory of resource conditions and related information is an important first step toward creating a watershed management plan. This inventory can serve as the basis for developing implementation measures that will improve resource conditions and identify locations in the watershed where specific measures would be especially appropriate or effective. An equally valuable purpose of an inventory is to document current watershed conditions so that changes can be accurately detected in the future.

Early in the planning stage of this document, an initial list of issues of concern was developed by the RMC and its subcommittees, including CLAS. Additional issues were identified during public forums and through review of written public comments. A total of 47 issues covering a broad spectrum were identified. In order to present a more manageable and refined discussion, these 47 issues were categorized into eight subject areas:

- Land uses and management practices.
- Surface and ground water quality and quantity.
- Lake, lakeshore, and lakebed management practices.
- Flood control and public safety.
- Fire control and public safety.
- Fish and wildlife habitat.
- Prevention and management of invasive species.
- Tourism, recreation and public access.
- Education and outreach.

- Agency, organization and tribal coordination.

Because of the inherent overlap that occurs in resource management conditions, many of the 47 issues are listed in more than one category. Successful resolution of these issues will depend upon understanding their origins and interrelationships with one another.

1.6 PAST AND ON-GOING ACHIEVEMENTS

Many programs and projects in recent decades have contributed to improvements in Clear Lake water quality, water supply management, flood control, and/or watershed health. Substantial progress has been made on other programs that will lead to further improvements. These programs and projects are listed in Table 1-1.

Table 1- 1 Clear Lake watershed past and on-going achievements.

Program or Project	Time of Program, Project Completion, or Adoption of Regulations
Adobe Creek Flood Control Project	1964
Middle Creek Flood Control Project	1965
Construction of Wastewater Collection Systems in Major Communities around Clear Lake	1960s-1980s
Department of Water Resources Clear Lake Monitoring Program	1969-Present
Clear Lake Algal Research Unit	1969-1975
Construction of Kelsey Creek Detention Structure	1987
Lake County Grading Ordinance	1981, Updated 2007
Lake County Creek Management Plan	1981
Lake County Aggregate Resource Management Plan	1992
UC Davis Study on the Causes and Control of Algal Blooms in Clear Lake, the “Clean Lakes Report”	1991-1994
UC Davis Clear Lake Environmental Research Center	1994-2001
Clear Lake Mercury TMDL	2002
Clear Lake Nutrient TMDL	2006
Lake County Clean Water Program	2003
Integrated Aquatic Plant Management Plan	2005
Completion of First Two Phases of “Full Circle” Wastewater Collection System around Clear Lake	Phase I- 1997 Phase II- 2002
Lake County Groundwater Management Plan	2006
Third Phase of “Full Circle” Project	On-going
Middle Creek Flood Damage Reduction and Ecosystem Restoration Project	On-going
USEPA Clean-up of Sulphur Bank Mercury Mine on Clear Lake	On-going
Clear Lake Watershed TMDL Monitoring Program	2007-2009

Lake County Weed Management Plan	On-going
Lake County Mussel Prevention Plan	On-going
Lake County Aquatic Invasive Species Plan	On-going
Konocti Regional Trails Plan	On-going
Lake County General Plan, Water Resources Element	2008
Lake County Community Wildfire Protection Plan	2009
Integrated Regional Water Management Plan	On-going

1.7 ORGANIZATION OF THE MANAGEMENT PLAN

The body of this plan is divided into the following major topics:

- Water Resources.
- Land Use Impacts.
- Wildlife and Wildlife Habitat Resources.
- Recreation and Aesthetics.
- Invasive Species.
- Lake Floodplain Management.
- Lake Management.
- Climate Change.

Each of these topics includes a description and evaluation of past and/or existing conditions and management. Issues of concern are identified, and their environmental/ecological impacts to the Clear Lake Watershed are assessed.

Based on identified issues and impacts, a set of actions is proposed for each resource topic. These are described according to an overall implementation strategy and specific action measures. The action measures take the form of either recommended policies for adoption by the county and/or specific projects or programs that should be undertaken by watershed stakeholders. The implementation actions are intended to equip watershed managers with information to do one or more of the following:

- Initiate policy/program/project development.
- Create partnerships for implementation.
- Pursue funding.



Clear Lake Integrated Watershed Management Plan

Chapter 2

WATER RESOURCES

2.1 INTRODUCTION

Clear Lake is the centerpiece of Lake County's water resources due to its large size, central location, and importance as a resource for recreation and tourism, fish and wildlife habitat, and municipal, domestic and agricultural water supply (Plate 4). Clear Lake's tributaries are important because of their influence on the lake's water quality, as local water supplies, and as essential fish and wildlife habitat. The Clear Lake Watershed is also home to the largest groundwater supplies in Lake County, which supply agricultural, domestic, and urban water uses.

This chapter begins with an overview of these water resources. It then follows with sections on surface water quality, surface water supply, groundwater quality and groundwater supply. Each section includes background on the topic and a description of management of the resource. The chapter ends with proposed actions to improve resource management.

2.1.1 Clear Lake

As the largest, natural, freshwater lake located entirely in California, Clear Lake is a valuable natural, recreational, and economic resource for county residents. The lake is an important source of domestic and agricultural water supplies, supports extensive recreational fishing and boating activities, and is home to a diverse population of fish and wildlife.

During much of the 20th century, the lake sustained visible deterioration of water quality from frequent blooms of nuisance blue-green algae, and this issue was investigated and documented in several important scientific studies (Richerson *et al.* 1994, Horne 1975). Beginning in 1992 lake water clarity has improved significantly, and this resulted in an increase in rooted aquatic plant growth.

Mining operations at the Sulfur Bank Mine located along the shore of the Oaks Arm area continued until 1957 and resulted in large quantities of mercury deposition in the lake that contaminated aquatic sediments and has resulted in a fish consumption advisory for some species of fish, such as bass. The nuisance algal blooms and mercury contamination have led to Clear Lake being listed as an "impaired water body" under Section 303d of the Federal Clean Water Act, and to the adoption of mercury and nutrient reduction targets called Total Maximum Daily Loads (TMDLs) in 2002 and 2006, respectively.

The Central Valley Regional Water Quality Control Board (CVRWQCB) identified 8 beneficial uses of Clear Lake. Table 2-1 shows these uses and those that are impaired by mercury or nutrients.

Table 2- 1 Beneficial uses of Clear Lake and whether they are impaired by nutrients and/or mercury.

Beneficial Use	Status	Impaired by nutrients	Impaired by mercury
Municipal and Domestic Supply	Existing	√	
Agriculture (Irrigation and Stock Watering)	Existing		
Recreation (Contact and Non-contact)	Existing	√	√
Freshwater Habitat (Warm)	Existing	√	
Spawning (Warm)	Existing		
Freshwater Habitat (Cold)	Potential	√	
Wildlife Habitat	Existing	√	√
Commercial and/or Sport Fishing	Existing	√	√

Clear Lake is naturally eutrophic (high in nutrients), and studies indicate that it has been shallow and eutrophic for approximately 500,000 years (Sims *et al.* 1988). Clear Lake's abundant algae and plant life support substantial invertebrate and fish populations in the lake, which in turn feed water fowl and other animals that live around the lake. Clear Lake fish populations include both native and introduced warm water species, including a wide range of minnow species. The lake is a world renowned bass fishery, and a large recreational economy in the county has developed to take advantage of this resource. Clear Lake was known historically for its large nuisance populations of the Clear Lake gnat, an aquatic insect that inhabits the lake as larvae and then emerges for a short mating period. The gnat is now managed primarily by biological rather than chemical methods.

The Richerson *et al.* (1994) and Horne (1971-1975) reports contain more recent details on the physical and chemical characteristics of Clear Lake. The lake is relatively shallow with an average depth of 23.3 feet in the Upper Arm, 33.8 feet in the Lower Arm, and 36.4 feet in the Oaks Arm (Plate 5). The average residence time of water in the lake is relatively short at 4.5 years. Residence time is the average time that it would take to completely replace the water in the lake with the current rates of water inflow and outflow. The lake water is characterized as having moderate hardness and electrical conductivity because of the inflow of salts and effects of evaporative concentration in the lake. The lake is generally well mixed with stable temperature stratification between surface and deeper waters only occurring for short periods during the hot summer periods when wind patterns are calm; maximum surface water temperatures in July and August are typically near 24°C (75°F). Numerous gas vents and subsurface springs help induce mixing in the lake as well. Dissolved oxygen is typically depleted to some degree toward the end of the summer and in the deeper waters of the lake as a result of suspended organic matter decay that exceeds the aeration rate from water mixing.

Although Clear Lake is a large water supply with the potential to provide more than Lake County's total water use in most years, its stored water is managed by the Yolo County Flood Control and Water Conservation District (YCFCWCD).

Clear Lake water levels are described with respect to the Rumsey Gage. The zero foot elevation was determined by the State Lands Commission survey in the late 1960s to be 1318.26 feet (1929 NGVD¹). From 1914 until the present, Clear Lake's water level has been manipulated by operation of the Cache Creek Dam in accordance with the Gopcevic, Bemmerly, and Solano Decrees. The Cache Creek Dam, located approximately three miles downstream of the Riffle, was built by the Yolo Water and Power Company. This reinforced concrete gravity dam is now owned and operated by YCFCWCD. The dam is operated to generate hydroelectric power and to regulate YCFCWCD's appropriative water right between zero and 7.56 feet Rumsey. The case of Gopcevic vs. Yolo Water and Power Company, 1920 (The Gopcevic Degree) defines the Rumsey gage, stipulates minimum (0 feet Rumsey) and maximum (7.56 feet Rumsey) lake levels under non-flood conditions, permits lake levels between 7.56 and 9.0 feet Rumsey for up to 10 consecutive days for the temporary storage of floodwaters, and prohibits a lake level above 9.0 feet Rumsey at any time. Because of the physical constraints of the outlet channel, it is impossible to comply with these provisions during major flood events. The Solano Decree (approved in 1978, revised in 1995) specifies how much water is available for use by YCFCWCD and their customers and how much water is available in each month of the summer. If Clear Lake is full (7.56 feet Rumsey) on May 1, 150,000 acre-feet of water is available to Yolo. On Clear Lake, 150,000 acre-feet amounts to approximately 3.5 feet depth. No water is available to YCFCWCD for release if the level is below 3.22 feet Rumsey by this date. An additional 3.1 feet of water evaporates from the surface during the summer months. This means that when the lake starts full on May 1, the level will be approximately 1.25 feet on October 31. Clear Lake can drop from 3 - 6.5 feet in any given summer and fluctuates 5.5 feet each year on average.

2.1.2 Tributaries

Most flow of the tributaries to Clear Lake occurs during winter months, and by mid-summer flow into Clear Lake ceases. The major tributaries to Clear Lake are Scotts and Middle Creeks entering the lake at Rodman Slough to the northwest and Kelsey Creek in Big Valley to the south in the Clear Lake Watershed. The combined area of these three sub-watersheds constitutes 50% of the Clear Lake Watershed. Combined stream flow from these tributaries is estimated to be 73% of the total stream flow of 287,850 acre-feet into Clear Lake² (Richerson *et al.* 1994). Other significant streams flowing into Clear Lake include Manning, Adobe, and Cole Creeks in Big Valley, Seigler Canyon, Copsey, and Herndon Creeks entering the lake to the southeast just above the Cache Creek Dam, Burns

¹NGVD is the abbreviation for National Vertical Geodetic Datum, or sea level in common language.

² Percentage of flows were calculated from the 1993 water year. The flows on these three creeks are gaged, however Middle Creek is gaged above the point where Clover Creek enters it, and the Scotts Creek gage covers only approximately 54% of the watershed. Therefore, Richerson *et al.* increased total Scotts Creek flows in proportion to the total watershed area, and for the % flow and area cited here, the Middle Creek flow reported by Richerson was adjusted up in proportion to the additional land area of the Clover Creek watershed.

Valley Creek in the City of Clearlake, and Schindler Creek draining High Valley through Clearlake Oaks.

2.1.3 Groundwater

Groundwater provides most of the water for agriculture and for communities that do not directly border the lake. A current study of water supplies in Lake County estimates that 72%, 31,000 acre-feet, of water used in the Clear Lake Watershed comes from groundwater and 28%, 12,000 acre-feet, from surface water (CDM 2006c). The largest known groundwater resources are in the Big Valley, Scotts Valley, and Upper Lake Valley Basins (Plate 6). Big Valley contains approximately 85%, 60,000 acre-feet, of the combined usable groundwater resources of these three valleys.

In the Clear Lake Watershed, groundwater quality has only been studied in Big Valley, and the data available for these studies are limited. Big Valley studies have found localized areas of hydrothermal influence where water quality is inferior due to higher levels of boron, iron and magnesium (Christensen Associates Inc. 2003, Lake County Flood Control and Water Conservation District 1998). Nitrate, a contaminant can come from fertilizers and/or animal/human waste, has been increasing in some areas.

The groundwater flow into Clear Lake is estimated to be about 1,100 acre-feet, a very small fraction (<0.3%) of total inflow compared to the contributions from rainfall and stream flow (Richerson *et al.* 1994). The Big Valley and Upper Lake groundwater basins contribute about 85% of the total groundwater inflow to the lake. Much of the lake is bordered by fractured Franciscan and volcanic formations that contain groundwater, but information on their flow contribution to the lake is unknown. There are many groundwater springs in the lake which are mainly associated with major geologic faults in the region and are known to contribute some flow to the lake (Richerson *et al.* 1994).

2.2 SURFACE WATER QUALITY

2.2.1 Algae, Sediment and Nutrients

Background

Clear Lake is a productive lake where the presence of suspended algae (phytoplankton) and aquatic vegetation occurs naturally. Phytoplankton are photosynthetic drifting organisms that inhabit the water column. In Clear Lake they include numerous species of green algae, diatoms, flagellates, and blue-green algae. Blue-green algae, or cyanobacteria, are bacteria with the capacity for photosynthesis. Some species of blue-green algae are capable of fixing atmospheric nitrogen into plant available forms. Nuisance algal blooms in Clear Lake are created by blue-green algal species that form colonies and mats. In contrast to phytoplankton, aquatic plants are complex, multicellular organisms that are adapted to live on or be completely submerged in water. Frequently, these plants are rooted in lake bottom sediments. Many spread by, or live as, floating

fragments. Aquatic vegetation is distinct from riparian and wetland vegetation, such as willows and tules, that occurs on the margins of water bodies and cannot survive complete submersion for extended periods of time.

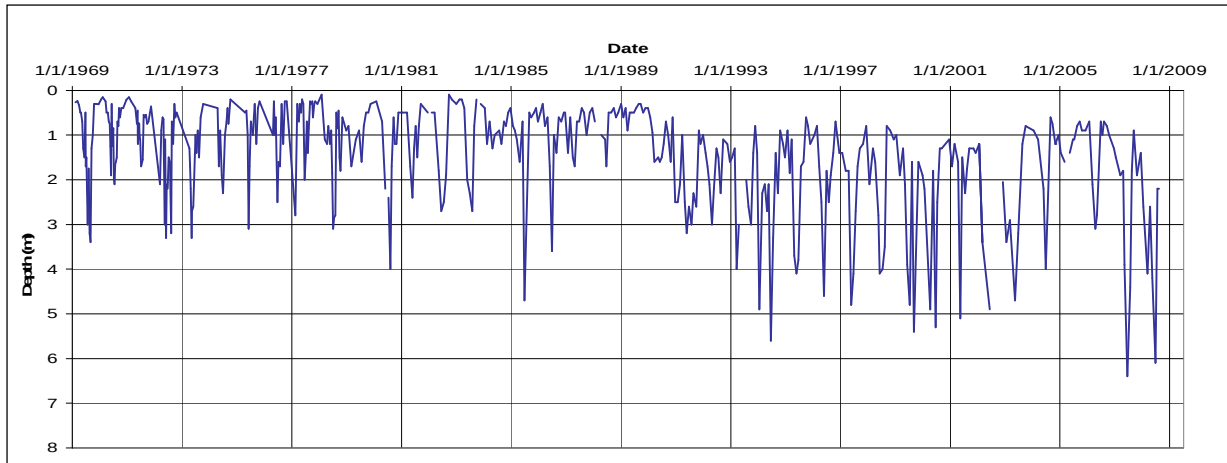


Figure 2- 1 Water transparency depth measured with a secchi disk by DWR in the upper arm of Clear Lake, 1969-2008.

Clear Lake appears to have alternated between an aquatic plant dominated and algae dominated system during the past century. The Clean Lakes Report, a study by University of California (UC) Davis researchers on “the Causes and Control of Algal Blooms in Clear Lake,” cited historical observations indicating that prior to about 1930; Clear Lake water was relatively transparent, with significant aquatic plant growth (Richerson *et al.* 1994). It was also apparently subject to algal

blooms during the fall (Stone 1873). By 1938, water transparency measured by secchi disk was insufficient for aquatic plant growth, and blue-green algal blooms were described (Richerson *et al.* 2000). Beginning in 1992, lake transparency improved and aquatic plant growth increased (Figure 2-1).

Nuisance algal blooms still occur as in 2009 when a bloom of the blue-green algae *Lyngbya* created floating algal mats that covered coves and harbors in the eastern end of the lake for much of the summer. *Lyngbya* has apparently not been a serious problem until 2009. California



Figure 2- 2 Algal blooms visible in Clear Lake near Clear Lake State Park, August 2, 2009. Photo by Richard Coel.

Department of Water Resources (DWR) records from 1969 to 1991 found *Lyngbya* to be present only during the period from 1984-1987 (Richerson *et al.* 1994). The Lake County Vector Control District (LCVCD) began sampling for algae in 1988. They detected *Lyngbya* from 1997-2003, with no detections from 2004-2006. LCVCD *Lyngbya* data for 2007, 2008 were not available at the time this document was published.

The 2009 *Lyngbya* bloom may have been connected to increased water clarity. The greatest water clarity in the Upper Arm of Clear Lake that has been measured since the beginning of DWR sampling in 1969 was measured on May 28, 2009. Some *Lyngbya* species grow on lake bottom sediments, later floating to form surface mats (Speziale and Dyck 1992). Therefore, greater light reaching the bottom of the lake may have contributed to the *Lyngbya* bloom. The *Lyngbya* bloom and mats were most severe in the eastern end of Clear Lake, because prevailing winds carry them in that direction.

It is difficult to judge how current conditions, characterized by increased water clarity and aquatic plant growth, and a reduced frequency of nuisance algal blooms, compare to pre-European conditions. An early observer of Clear Lake, Livingston Stone, visited Clear Lake in 1873 as a field worker for the United States Commission on Fish and Fisheries. Land use activities, particularly those leading to increased erosion and sedimentation, were not thought to have had a significant impact on Clear Lake by that time (Richerson *et al.* 2008). Stone described cloudy water, ‘moss’ that could be interpreted as aquatic plants or floating algal mats, and deteriorating fall water conditions, perhaps due to algal blooms, all conditions that are currently found in Clear Lake. He wrote:

“that the water of Clear Lake is never clear. It is so cloudy, to use a mild word, that you cannot see three feet below the surface. The color of the water is a yellowish brown, varying indefinitely with the varying light. The water has an earthy taste, like swamp-water, and is suggestive of moss and water-plants. In fact, the bottom of the lake, except in deep places, is covered with a deep, dense moss, which sometimes rises to the surface, and often to such an extent in summer as to seriously obstruct the passage of boats through the water” (Stone 1875).

Measurement of the transparency of water had not been standardized by the time that Stone wrote, so it is difficult to compare his observation of three feet of clarity with current measurements. Stone also described what appear to be algal blooms in September. “A green scum covers a large part of the surface, and it is not only uncleanly to look at, but unfit to drink” (Stone 1875).

From approximately 1930-1990, blue-green algal blooms in the summer and fall were a severe nuisance in Clear Lake. The Clean Lakes Report (Richerson *et al.* 1994) describes how “The water becomes completely opaque, and the scums resemble thick olive drab paint covering entire beaches and sometimes creating patches thousands of square meters in size in open water.” Prevailing winds in Clear Lake are from west to east, and therefore the greatest algal accumulations often occur at the east end of the lake in the Oaks and Lower Arms.

Two major research efforts investigated the causes and potential controls of nuisance algal blooms, the Clear Lake Algal Research Unit, directed by Alexander J. Horne from 1969 to 1976, and the Clean Lakes Report and Clear Lake Environmental Research Center headed by Peter. J. Richerson and Thomas H. Suchanek from 1991 to 2001.

Researchers found that several genera of blue-green algae, or cyanobacteria, dominate the scum forming algae. *Microcystis* and *Anabaena* are found from late summer to early fall, and *Aphanizomenon* reaches a peak in late spring and early summer, and late fall. All three genera named above form large colonies with gas vesicles that allow them to float. This enables them to shade out more desirable algae species that remain suspended in the water columns. Because *Aphanizomenon* can tolerate cool water and low light levels, it sometimes reaches high levels even in winter. Following heavy rainfall years that cause substantial turbidity due to erosion, *Aphanizomenon* is more likely to dominate.

Lyngbya, the source of the nuisance algal blooms in 2009, was not considered to be a source of nuisance algal blooms by the authors of the Clean Lakes Report. However, it has been widespread, noxious, and persistent during the summer of 2009.

Some blue-green algae produce toxins that can cause skin irritation and may be harmful or deadly to animals that drink the water. *Lyngbya* is known to cause skin irritation. The California Department of Health Services, now the California Department of Public Health (CDPH) has identified mild toxicity in Clear Lake algal blooms, but concluded that human health affects from short term exposure due to swimming in Clear Lake or drinking water from purveyors drawing from Clear Lake are very unlikely. They were also unable to confirm animal health affects (CDHS 1991). Blue-green algal blooms increase water treatment requirements for utilities using Clear Lake water.

A great deal of work has focused on understanding controls on blue-green algal growth. Algal growth continues until an essential growth factor becomes limiting. These growth factors include light, temperature, and essential elements such as nitrogen or phosphorus. In the phosphorus rich waters of Clear Lake, algal growth is nutrient-limited by nitrogen and iron. The blue-green algae *Aphanizomenon* and *Anabaena* are capable of using atmospheric nitrogen (nitrogen fixation), enabling them to overcome the nitrogen limitation and giving them a competitive advantage over more desirable algae that do not fix nitrogen.

Iron limitation of algal growth in Clear Lake has been demonstrated in several studies (Horne, 1975; Li, 1998). Blue-green algae have a higher iron requirement than many other algal species, and nitrogen-fixing blue-greens require even more iron than non-fixers (Richerson *et al.*, 1994). Understanding how iron availability is controlled has been difficult because it is difficult to measure the forms available for uptake by algae. Frequently, total iron is measured, and this may not be a good indication of the forms available to algae. Based on recent water quality monitoring, the current average annual watershed load is estimated at 4,130 to 5,730 metric tons of total iron per year to Clear Lake (LCWPD, 2009).

Sulfate levels may influence iron availability in Clear Lake waters. Sulfate containing acid mine drainage from the Sulfur Bank Mercury Mines appears to increase iron cycling and stimulate blue-green algal blooms (Richerson *et al.* 2008). Recent DWR water quality data show reduced dissolved sulfate in Clear Lake waters starting in 1991, coinciding with the period of greater water clarity (Figure 2.3). It is not clear why sulfate levels decreased in 1991 and have remained at a reduced concentration. Based on recent water quality monitoring, the current average annual watershed load is estimated at 1,940 to 2,700 metric tons of sulfate per year to Clear Lake (LCWPD, 2009).

Because blue-green algae are capable of nitrogen fixation, and because iron is present in large quantities in sediments, controlling phosphorus inputs to Clear Lake was considered the most practical method of reducing algal growth by Richerson *et al.* in the Clean Lakes Report (1994). The majority of phosphorus entering Clear Lake is bound to sediments. They found evidence that phosphorus had been near limiting levels in recent decades, and recommended erosion control in the Clear Lake Watershed and restoration of wetlands for sediment retention to reduce phosphorus inputs to the lake. Estimates of nutrient inputs due to overflows from wastewater treatment plants and septic leach fields were estimated to be small (4%) relative to sediment nutrient loads (96%) in the Clean Lakes Report (Richerson *et al.* 1994). Based on recent water quality monitoring, the current average annual watershed load is estimated at 90-125 metric tons of total phosphorus and 37-51 metric tons of orthophosphate per year to Clear Lake (LCWPD, 2009).

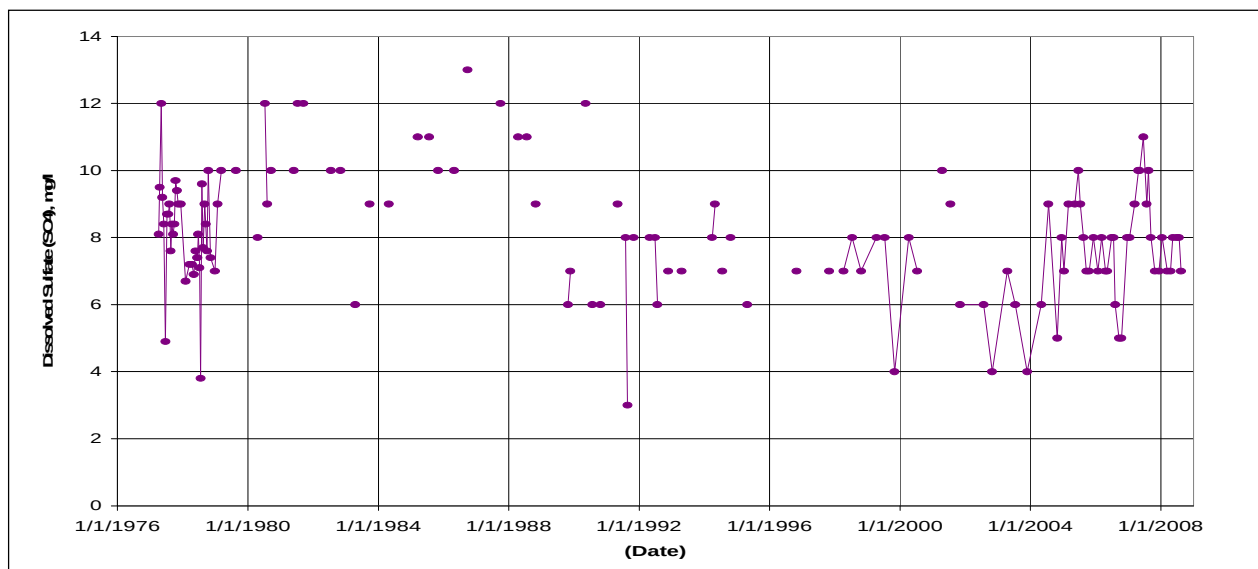


Figure 2- 3 Dissolved sulfate measured by DWR at the surface of the upper arm of Clear Lake, 1977-2008.

Lake sediment cores also helped to explain the changes in Clear Lake water quality (Richerson *et al.* 1994, 2000, 2008). Starting in about 1927, sedimentation rates to the lake increased approximately ten-fold over pre-1927 levels. Researchers attributed the increase in sedimentation to several factors.

The advent of heavy earth-moving equipment enabled increased road building and in-stream gravel mining. At the Sulfur Bank Mercury Mine open-pit mining began in 1927, and tailings were bulldozed into Clear Lake. Starting at the turn of the century, wetlands were reclaimed for agricultural purposes, thus eliminating their function of trapping sediments. Reclamation of Tule and Robinson Lakes, with a combined area of 3,600 acres at the north end of Clear Lake, was completed by 1928 (Richerson 1994, Week 1982). By 1982, an estimated 7,120 acres or 79% of the original wetland area surrounding Clear Lake was drained or filled for agricultural and urban purposes³ (Week 1982).

High sediment loads during storm events create difficulties for water treatment plants using Clear Lake water. Water clarity is reduced by suspended materials including clays, organic particulates, and microorganisms, and the high levels of particulates can interfere with disinfection of microorganisms. During storm events, treatment plants must increase filter back washing, reduce water flow through the plants, and adjust chemicals to optimize sedimentation of particles (Archibald and Wallberg MWH 2002). The combination of the large-scale Fork Fire in the Middle Creek sub-watershed in 1996, and winter storms in January 1997, created high turbidity that treatment plants in Lakeport, Nice, and Lucerne were unable to adequately treat (USDAFS 1999).

Blue-green algae, or cyanobacteria, cause turbidity, taste and odor, and potential toxicity problems for water treatment facilities. Algal mats can clog filtration processes and are difficult to remove. To deal with algal turbidity increased oxidants, reduced plant flow and more frequent back washing are required. Cyanobacteria produce taste and odor problems even when present at moderate levels. They may also release toxins while they are alive or when their cells rupture. Environmental conditions and processes typically used by water treatment plants can destroy their cells. To remove compounds causing taste and odor defects and toxins, several processes are used. Conventional filtration can remove bacterial cells but not the released compounds. Ozone destroys the toxins and odor producing compounds, and granular activated carbon filtration can trap these compounds. True algae also cause clogging, and taste and odor problems, and concentrations of all algae tend to be highest in the eastern arms of Clear Lake due to prevailing winds from the west (Archibald and Wallberg 2002)

Management

The most practical strategies for reduction of nutrient loading and control of algal blooms, erosion control, and wetland restoration are discussed below. Researchers also discussed alternative methods to reduce nuisance blue-green algal blooms (Richerson *et al.* 1994). One method was algal harvesting by skimming the lake for scum-forming algae. For the entire lake, the authors felt the technology was unproven with potential major environmental impacts. At a local scale, harvesting, spraying, or airboat mixing could be effective for confined

³ Based on Week (1982), many studies cite a loss of 84% of the wetlands around Clear Lake. However, Week included the temporary conversion (1976-1977) of 399 acres in Anderson Marsh to agriculture. After 1977, the land reverted to wetland and along with surrounding property, was purchased for a state park in 1982.

channels or local beaches. Several proposals were submitted for harvesting blue-green algae from Clear Lake during the 1990s. Only one of these proposals was tested. In 1997, commercial harvesting of *Aphanizomenon Flos-Aquae* was conducted on an experimental basis. Insufficient quantities of this species of algae were available for harvest and the experiment was discontinued after one year.

A variety of management actions have been taken to reduce erosion and sedimentation in the Clear Lake Watershed in recent decades. (Section 3.8) Lake County first adopted a grading ordinance in 1982, and updated the ordinance most recently in 2007. In-stream gravel mining, once the main source of gravel in Lake County, has been largely eliminated following adoption of the Lake County Creek Management Plan in 1981, which was updated and renamed the Aggregate Resources Management Plan in 1992. Another decrease in nutrient loads to the lake occurred during the late 1970s and early 1980s when many towns and population centers around Clear Lake converted from septic to sewer systems. Beginning in the 1970s, state regulators no longer permitted discharge of sewage or treated wastewater to Clear Lake. Municipal stormwater drains carry sediment, nutrients, and other pollutants into surface waters. The County of Lake and Cities of Lakeport and Clearlake have developed a Stormwater Management Plan to prevent sediment, nutrients, and other pollutants from entering into surface waters from municipal stormwater drains, as required under the Federal Clean Water Act (Section 3.6.2).

Starting in 1996, public treatment facilities along the northern and eastern shores of Clear Lake were constructed to collect and pump treated wastewater to the Geysers Geothermal Resource Area to sustain the capacity of those steam fields for electricity generation (Dellinger and Allen 2004). The system currently collects approximately 85% of the effluent produced in the county. Plans have been initiated to extend the system to the remaining public wastewater treatment facilities along the lake shore, which are located in the communities of Kelseyville and Lakeport (Section 3.6.4).

Nutrient Total Maximum Daily Load (TMDL) for Clearlake

Because nuisance algal blooms are believed to be caused by excess nutrients, Clear Lake was classified as an impaired water body due to nutrients in 1986 under Section 303(d) of the Federal Clean Water Act. This required the State Water Resources Control Board (SWRCB) to establish a TMDL program to manage the pollutant and ensure the beneficial uses of Clear Lake.

The TMDL process begins with technical studies to analyze sources of the pollutant, develop a numeric target for the pollutant level that will achieve water quality objectives, and estimate the amount by which pollutant sources must be reduced to achieve the target. The TMDL technical report (Tetra Tech, 2004) identified phosphorus as the primary nutrient impairing water quality and leading to nuisance blue-green algal blooms. The numeric target level to indicate achievement of water quality objectives was determined to be 73 µg/L of chlorophyll-a, a green photosynthetic pigment found in algae. This target was determined based on two water quality models. One modeled phosphorus loads

from the watershed to the lake, and the other used these loads to simulate chlorophyll-a concentrations (CVRWQCB, 2006).

The TMDL technical report estimated that average annual phosphorus loading to the lake is about 150,000 kg, and calculated that an approximate 40% reduction to 87,272 kg was needed to achieve the chlorophyll-a target. The allowable annual phosphorus load is partitioned to load allocations of 2,000 kg for the urban areas, based on their area of 2.5% of the Clear Lake Watershed area; 100 kg for California Department of Transportation (Caltrans), based on the area of Caltrans maintained roads; and 85,000 kg for non-point sources to make a total of 87,100 kg.

Lake County Public Works Department (LCPWD) staff submitted comments to the CVRWQCB on weaknesses of the nutrient TMDL approach. These comments stated that there are very little data on chlorophyll-a in Clear Lake, making it difficult to verify the model and numeric target. In addition, the time periods that were designated as compliant and non-compliant in order to choose the water quality target level, did not correspond to time periods of greater and reduced water clarity, respectively. The TMDL technical report was based on the Clean Lakes Report (Richerson *et al.*, 1994), which evaluated lake data through 1992. Water clarity since 1992 has remained high relative to previous years while phosphorus levels in the lake have not changed significantly, casting doubt on the Clean Lakes Report and TMDL conclusion that phosphorus reduction would improve water quality (Figures 2-1 and 2-4). This emphasizes the need for additional studies to determine what factor(s) are limiting algae growth. In response, CVRWQCB staff has recognized the need for further studies on the causes of changes to lake clarity and for re-evaluation of the numeric target and phosphorus load allocations. Results of recent water quality monitoring were also inconsistent with the phosphorus loading estimate in the TMDL technical report. The recent estimate is 90,000-125,000 kg of phosphorus per year to Clear Lake compared to the TMDL estimate of 150,000 kg (LCWPD 2009).

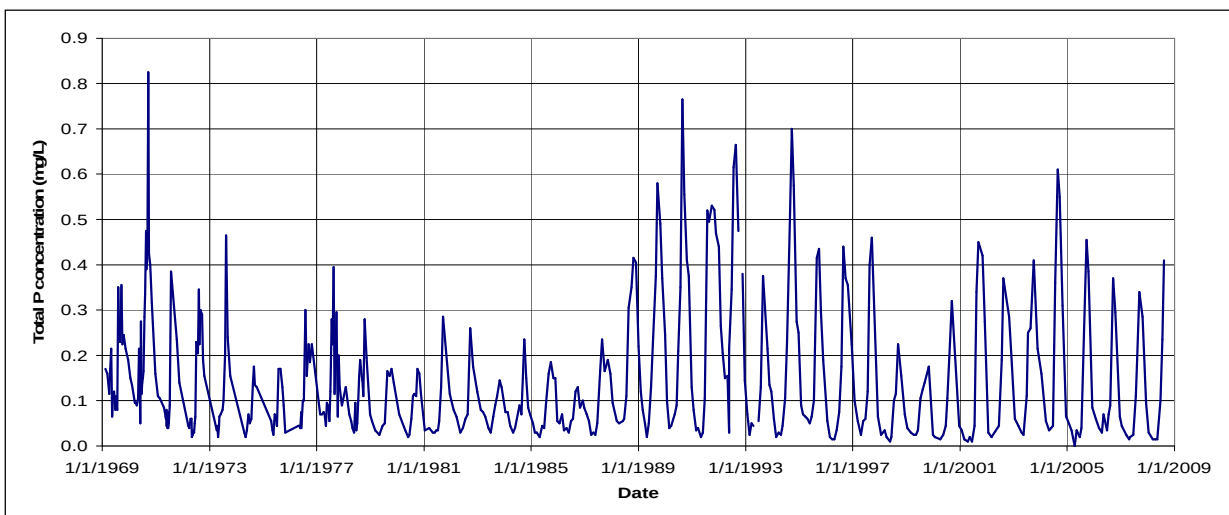


Figure 2- 4 Total phosphorus measured by DWR in the Upper Arm of Clear Lake, 1969-2008.

Development of an implementation plan is the next step in the TMDL process. A monitoring and implementation plan for both the Clear Lake Mercury and Nutrient TMDLs was submitted in October 2008 by the Clear Lake TMDL Stakeholder Committee (CLTSC). The monitoring and implementation plan addresses the following components as required by the Nutrient TMDL:

- Studying which factors affect algal growth.
- Evaluating which parameters (e.g. chlorophyll-a or secchi depth) should be used to monitor for nuisance algae.
- Improving estimates of phosphorus loads to Clear Lake.
- Planning and implementing practices to reduce phosphorus loading to the lake.
- Tracking these practices to determine progress toward achieving load allocations.
- In coordination with the CVRWQCB, developing a definition of conditions that would indicate attainment of beneficial uses.

The amendment to the CVRWQCB Basin Plan for the control of nutrients in Clear Lake was adopted in June 2006 (CVRWQCB 2007).

Lake County initiated a monitoring program in October 2006 funded by a Proposition 13 Water Quality Grant. To estimate annual nutrient loading to Clear Lake, intensive monitoring was conducted during winter storm events at the three stream gaging locations in Middle Creek, Scotts Creek and Kelsey Creek during water years 2007 and 2008 (LCWPD, 2009). Average annual nutrient loads were estimated for the Clear Lake Watershed (Table 2-2). Total phosphorus and suspended solids (sediment) loadings were significantly less than estimated for the Clean Lakes Report (Richerson *et al.*, 1994) or the TMDL (Tetra Tech, 2004). It is not clear why the estimates were so much lower, therefore, additional monitoring is required to verify the estimates. Iron, sulfate, and nitrogen loading estimates were also developed to improve the understanding of Clear Lake's limnology.

Table 2- 2 Clear Lake watershed nutrient loading estimates.

Ortho-P (kg/yr)	Total P (kg/yr)	Suspended Solids (metric tons /yr)	Iron (metric tons/yr)	Sulfate (metric tons/yr)	Total Nitrogen (metric tons/yr)
37,100– 51,400	89,900– 125,000	75,000– 104,000	4,130– 5,730	1,940 - 2,700	273 - 379

This monitoring program was combined with monitoring for the mercury TMDL for Clear Lake ([Section 2.2.3](#)). The final report on this monitoring program was submitted to the CVRWQCB in April 2009.

The CVRWQCB has had chlorophyll-a samples collected concurrent with DWR's water quality sampling in 2005, 2007, and 2008. Exceedances of the 73 µg/l target occurred on five dates in 2005 and 2007. The chlorophyll-a numeric target

will be re-evaluated by the CVRWQCB five years after adoption of the Basin Plan amendment (2006).

The monitoring and implementation plan submitted by the Clear Lake TMDL Stakeholder Committee (CLTSC) in October 2008 recommended the following strategy for determining when Clear Lake is no longer impaired:

- The limnology of Clear Lake must be better understood. The assessment of current limnological conditions and establishment of an obtainable lake condition standard must be completed.
- Determine, as data and information permits, the pre-European condition of Clear Lake to establish a baseline of Clear Lake's water quality (natural conditions).
- When causal relationships are determined, they should be evaluated to determine management and other actions necessary to improve lake water quality to meet the natural conditions determined above.
- When the above tasks have been completed, the stakeholders should conduct a public process to evaluate the findings and establish criteria for determining when Clear Lake is no longer impaired for nutrients. Input from the scientific community and the public will be utilized in the process. The "impairment criteria" developed through this process will be presented to the CVRWQCB for consideration and incorporation into the Basin Plan (CLTSC 2008).

The TMDL emphasizes phosphorus load reductions. The TMDL was based on the Clean Lakes Report, which evaluated data prior to 1992, while lake conditions have improved significantly since 1992. There has been little change in phosphorus concentrations in the lake since 1992, casting doubt on whether phosphorus load reductions will improve water quality. As the prior conclusions to improve lake water quality may not be complete, the monitoring and implementation plan recommends analysis of lake water quality data collected since the Clean Lakes Report to further investigate the causes of high algal productivity and recent improvement in water clarity. To this end, the Lake County Watershed Protection District (LCWPD) has contracted with the UC Davis Tahoe Environmental Research Center to evaluate the more recent data and improve the understanding of Clear Lake's limnology. This evaluation is scheduled for completion in April 2010.

2.2.2 Aquatic Plants

Beginning in 1992, water transparency in Clear Lake increased significantly (Figure 2.1). This time period began with a period of drought from 1986-1992, which reduced sediment input to the lake. The drought was believed to be the cause of the increased clarity. However, multiple subsequent wet years did not result in a loss of clarity. With the increased water clarity, aquatic plant growth has increased, creating congested conditions along the shoreline that restrict swimming, boating, and other recreational activities. As a result, the Clear Lake Integrated Aquatic Plant Management Plan (IAPMP) was approved by the Lake County Board of Supervisors in 2005 (Jones and Stokes 2005). Aquatic plant

management is described in the Lake Management Chapter ([Section 8.10](#)). Problems with invasive non-native aquatic plants are covered in the Invasive Species Chapter ([Section 6.2.1](#)).

The current conditions in Clear Lake may be similar to an early description of the lake, prior to significant impacts from European settlers. Stone (1875) reported on the fishery of Clear Lake in 1872-1873. What he described as ‘moss’ fits well with current conditions of aquatic plant growth. He wrote: “In fact, the bottom of the lake, except in deep places, is covered with a deep, dense moss, which sometimes rises to the surface, and often to such an extent in summer as to seriously obstruct the passage of boats through the water.”

2.2.3 Mercury

Background

Clear Lake is in a region where mercury occurs naturally; however, human activities, especially mercury mining, have greatly increased mercury contamination of Clear Lake. The Sulphur Bank Mercury Mine (SBMM), on the east end of Clear Lake in the Oaks Arm, is a United States Environmental Protection Agency (USEPA) Superfund Site and is estimated to contribute up to 97% of the current annual mercury loads to Clear Lake (CVRWQCB 2002b).

The SBMM opened as a sulfur mine in 1865, but was converted to a mercury mine in 1873 following the discovery of cinnabar (mercury ore) deposits. In 1927, the mine was converted from shaft mining and shallow cuts to large-scale open pit mining with rock and tailings bulldozed into the lake. The advent of open pit mining dramatically increased mercury inputs to Clear Lake as confirmed by sediment cores (Richerson *et al.* 2008). In addition, mercury-containing acid mine drainage from the open mine pit continues to discharge into the lake.

The form of mercury most dangerous to humans and wildlife is methylmercury, an organic form of mercury. It is a serious health concern because it bioaccumulates in aquatic organisms (it is taken up more rapidly than it is eliminated) and it biomagnifies in a food web, (reaches higher concentrations with increasing trophic level or steps in the food chain). Therefore, it is a health concern for top predators and for humans eating fish, especially fish at higher trophic levels. Inorganic mercury, however, does not magnify in food webs, and is not a serious toxicological concern (Wiener and Suchanek, 2008).

In humans methylmercury damages the brain and central nervous system. Consumption of sport fish in California is unlikely to lead to readily observable poisoning. Instead, fish consumption guidelines are designed to protect against potential subtle effects. The guidelines focus on those most vulnerable to this damage; the fetus, children, and women of child-bearing age (OEHHA 2003). For aquatic birds, mammals, and fish, field and laboratory studies have shown a variety of adverse effects including lower reproduction and adult survival (Wiener and Suchanek 2008).

Most methylmercury in Clear Lake is produced by bacteria in lake-bottom sediments. Some of the factors that favor mercury methylation include warm temperatures, low pH, lack of oxygen, organic matter as a food source, high

sulfate concentrations, and low sulfide concentrations (Suchanek *et al.* 2008a). Researchers have found that Clear Lake has lower levels of methylmercury than would be expected based on total mercury loads. They discuss numerous factors contributing to lower-than-expected methylmercury levels. Some of these are: that source minerals from the mine (cinnabar and metacinnabar) are less bioavailable than other forms of inorganic mercury; that the lake has a relatively high pH; and that the lake is well mixed, therefore sustaining more oxic conditions than stratified lakes. Based on analysis of the factors that favor or inhibit mercury methylation, these authors suggest that acid mine drainage from the SBMM is likely to be an especially significant source for methylmercury production

Management

The SBMM Superfund clean-up project on the east end of Clear Lake is on-going under the direction of the USEPA, California Department of Toxic Substances Control, and the CVRWQCB. A remediation project carried out by the USEPA in 1992 controlled sheet erosion and mass wasting from mine tailings along the lake. In 1999-2000, EPA constructed surface water diversions to prevent stormwater from being contaminated by mine wastes or causing an overflow of the Herman Impoundment. In a 2006-2007 project, USEPA removed 28,000 cubic yards of mercury and arsenic contaminated mine waste from residential yards and the roadway system in the Elem Pomo Tribe, which is located beside the SBMM (USEPA 2009).

The USEPA has completed a “Remedial Investigation and Feasibility Study” for the terrestrial portion of the Superfund site, which includes the main mine pit (Herman Impoundment) now filled with water, and surrounding mine waste (Tetra Tech EM Inc. 2004). Remediation will require containment of the solid mine waste and maintaining the water level in the Herman Impoundment low enough to minimize groundwater flow from the impoundment to the lake. The USEPA is currently in discussion with the State of California on treatment requirements and location to discharge the treated water from the impoundment (Richard Sugarek, personal communication). The treated water would be significantly less contaminated than the water that currently reaches Clear Lake after it has passed through the waste rock dam, and therefore discussions of discharge of treated wastewater to Clear Lake are one option being pursued. Investigations are on-going on clean-up of the third and final phase of the Superfund site, which consists of the wetland to the north of the site, and mine waste in the lake.

The Office of Environmental Health Hazard Assessment has an on-going fish advisory for consumption of fish from Clear Lake because of high concentrations of methylmercury in tissue (CalEPA 2005). Clear Lake is also currently designated as an impaired water body because of mercury levels on the federal Clean Water Act Section 303(d) list and has a TMDL for mercury.

Mercury (TMDL) in Clearlake

Clear Lake was placed on the Federal Clean Water Act 303(d) list of impaired water bodies in 1988 based on the 1987 California Department of Health Services

advisory recommending limited consumption of fish from Clear Lake due to elevated mercury levels. As a result of this listing, the TMDL for Control of Mercury in Clear Lake was approved as an amendment to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins in December 2002 (CVRWQCB 2002a).

The CVRWQCB lists wildlife habitat, recreation, and commercial and sport fishing as beneficial uses that are impaired by mercury in Clear Lake. To demonstrate achievement of water quality objectives, the CVRWQCB selected a numeric target level of mercury in fish tissue because it “provides protection to fish consumers and the most direct assessment of fishery conditions and improvement” (CVRWQCB 2002b). The target level is a 60% reduction of current levels to achieve 0.09 and 0.19 mg methylmercury/kg dry weight of tissue in trophic level 3 and 4 fish, respectively. The CVRWQCB estimates that this target can be achieved “by reducing the concentration of total mercury in the surficial layer of lakebed sediment by 70% of existing levels and by further investigation and reduction of other mercury sources believed to have a high potential for mercury methylation.”

The mercury TMDL specifies load allocations for different sources of mercury to Clear Lake in order to achieve fish tissue target levels. The SBMM is estimated to contribute from 1-568 kg of mercury per year to Clear Lake (CVRWQCB 2002a). As the largest source of mercury to the lake, loads from the SBMM are to be reduced by 95%. Groundwater movement of acid mine drainage to the lake is to be reduced to 0.5 kg mercury per year from estimated levels of 1-2.5 kg per year. Mercury inputs from Clear Lake tributaries and land surface run off are estimated to average 18 kg mercury per year and are to be reduced 20% below current levels. Compliance goals for the Oaks Arm will require the USEPA to both reduce loads from the mine site and reduce the mercury that currently exists in the active lakebed sediment layer. Options to achieve the latter reduction include dredging the contaminated sediment, capping it with clean sediments, and reducing transport of the highly contaminated sediment to other areas of the lake (CVRWQCB 2002a).

The Clear Lake mercury TMDL recommends that the USEPA better estimate mercury loads to Clear Lake from the SBMM. Land management agencies such as the United States Forest Service (USFS), United States Bureau of Land Management (BLM), and Lake County are responsible for reducing tributary mercury loads to Clear Lake. These agencies are to carry out monitoring programs to identify potential hot spots of mercury loading and develop implementation plans to reduce loads within five years of the amendment. Load reductions are to be completed within 10 years after approval of the implementation plans.

Lake County initiated a monitoring program in October 2006. To estimate annual mercury loading to Clear Lake, intensive monitoring was conducted during winter storm events at the three stream gaging locations in Middle Creek, Scotts Creek, and Kelsey Creek during water years 2007 and 2008 (LCWPD, 2009). Average annual total mercury, methylmercury, and sulfate loads were estimated for the Clear Lake Watershed (Table 2-3).

Table 2- 3 Watershed mercury loading estimates.

Total Mercury (kg/yr)	Methylmercury (kg/yr)	Sulfate (metric tons/yr)
11.8 – 16.4	0.0565 – 0.0784	1,940 - 2,700

Total mercury loading estimates were 65 to 90 percent of the estimates in the mercury TMDL, and methylmercury estimates are 16 to 22 percent of the estimates in the TMDL. These estimates are a result of improved data and do not appear to represent a reduction in mercury watershed loading. Sulfate loading estimates were also developed to improve the understanding of Clear Lake's limnology and mercury methylation in the lake.

Extensive monitoring of mercury concentrations in sediments within the watershed was conducted to determine if any hot spots existed that could be targeted for remediation to reduce the watershed mercury load. Hot spots were defined as soils having a total mercury concentration greater than 0.4 µg/g. The background mercury concentration for the Clear Lake Watershed appeared to be less than 0.1 µg/g, approximately one half of the background concentration for the Coastal Ranges.

Nine abandoned mercury mines/prospects recorded by the United States Geological Survey (USGS) as being located in the Clear Lake Watershed were investigated. Five could not be accurately located. Stream sediment monitoring downstream of the reported locations did not indicate elevated mercury levels. Two of the sites were possibly located outside of the Clear Lake Watershed. The only new hot spot identified in the watershed (the SBMM is a known hot spot), was the Utopia Mine, located on the northwest side of Lucerne. Extensive hot spot monitoring was conducted near the Utopia Mine, and mercury contamination was discovered in the sediments of Clear Lake adjacent to the mine. With the limited data available, it does not appear that the Utopia Mine is contributing significantly to the elevated mercury levels in Clear Lake, nor does it appear to be a significant on-going source of mercury to Clear Lake. Mercury concentrations in the suspended sediments are at significantly lower concentrations than those in the deep sediments in the Upper Arm, indicating that there do not appear to be significant anthropogenic mercury sources within the Clear Lake Watershed in addition to the SBMM.

This monitoring program was combined with monitoring for the nutrient TMDL for Clear Lake. ([Section 2.2.1](#)) The final report on this monitoring program was submitted to the CVRWQCB in April 2009.

2.2.4 Pesticides

Pesticides that enter aquatic systems have the potential to harm aquatic life and may present a human health hazard. Pesticides are applied directly to water bodies for the control of aquatic plants and disease vectors. Pesticides are applied on land in agriculture, along Caltrans rights-of-way, along county maintained levees and dams, to control disease vectors such as mosquitoes, and in residential

and commercial settings. Land-applied pesticides have the potential to enter water through drift, run off into surface waters, or leaching to groundwater.

The great majority of pesticides currently applied in Lake County are for agriculture. Agricultural pesticide use and regulation is discussed in the Land Use Chapter ([Section 3.4.4](#)). Residential and commercial pesticide use is covered under urban stormwater runoff ([Section 3.6.2](#)).

Aquatic Pesticide Use

A well known and environmentally harmful use of aquatic pesticides occurred in Clear Lake beginning in the late 1940s. The Clear Lake gnat, a non-biting gnat whose larvae live in the lake, once emerged in very large numbers that created a significant nuisance. Following the lakewide application of Dichlorodiphenyldichloroethane (DDD) in 1949, 1954, and 1957, the population of western grebes in Clear Lake nearly collapsed. It was found that DDD is very persistent, and that it biomagnifies (increases in concentration in the tissues of living organisms with each step in the food chain). The use of DDD in Clear Lake became one of the case studies in Rachel Carson's environmental classic, *Silent Spring* (1962). Further treatments using methyl parathion were used to attempt to control the gnat during the 1960s and 1970s. These were discontinued, and it appears that biological control by the Mississippi silversides, a fish introduced in 1967, has permanently reduced gnat populations (Richerson, P.H. and S.O. Richerson 2000).

Currently, pesticides are applied directly to aquatic systems by LCVCD to control mosquitoes and their larvae, and by the California Department of Food and Agriculture (CDFA) and private applicators to control aquatic plants. The IAPMP regulates chemical and non-chemical weed control in the lake. It contains provisions requiring monitoring of the fate of herbicides in the lake, and the plan is described in detail in the Lake Management Chapter ([Section 8.10](#)). CDFA has a program to eradicate the invasive weed hydrilla in Clear Lake. Hydrilla eradication relies on chemical control because mechanical control spreads the weed. CDFA monitors the fate of pesticides used in the Hydrilla Program, and details of the Hydrilla Program are given in the Invasive Species Chapter ([Section 6.4](#)). Vector control pest management is described in the Lake Management Chapter ([Section 8.11](#)).

Local Native American Tribes have expressed concern with the potential for pesticides to accumulate on aquatic and riparian plants used for traditional activities such as basket weaving, and in terrestrial animals which feed along Clear Lake. In addition, they are concerned about potential synergistic effects of multiple chemicals used in Clear Lake (Ryan 2004). The five Native American Tribes in the Clear Lake Watershed are the Big Valley Band of Pomo Indians, the Elem Pomo Tribe, and the Habematolel Pomo of Upper Lake, Robinson Rancheria Band of Pomo Indians, and the Scotts Valley Band of Pomo Indians.

2.2.5 Other Toxins

Arsenic is a naturally occurring mineral that has been linked to cancer and other harmful effects to human health. It is unknown to what extent arsenic levels in Clear Lake are naturally occurring, and to what level they have been affected by human activities. In its website describing the SBMM, the USEPA states that “The soils at the mine property and at the adjacent Elem Tribal Colony are contaminated with high levels of mercury and arsenic. Surface water and groundwater that discharge from the site contain high levels of mercury and arsenic and contaminate the natural wetlands to the north of the mine property and the sediments of Clear Lake” (USEPA 2008). Arsenic has been detected at 12 of 18 water utility intakes around Clear Lake at levels up to 8.8 µg/L (Forsgren Associates Inc. 2007). These levels approach the federal standard for drinking water of 10 µg/L. Arsenic concentrations in lake water fluctuate on an annual basis and are generally highest in the fall (Forsgren Associates Inc. 2007).

A variety of pollutants enter surface waters with stormwater runoff from residential and urban areas. Stormwater pollution is covered in Section 3.6.2.

2.2.6 Water Quality Monitoring

Numerous agencies and organizations monitor a wide range of water quality parameters both in Clear Lake and its tributaries. These agencies are CDFG, DWR, The Lake County Farm Bureau Education Corporation, LCWPD, LCVCD, and Big Valley Rancheria. These water quality monitoring programs were recently described in the “Monitoring and Implementation Plan for the Clear Lake Mercury and Nutrient TMDLs,” and this description of water quality monitoring programs is included in Appendix B.

2.3 SURFACE WATER SUPPLY

Background

Clear Lake’s water supplies are large relative to Lake County’s current water requirements; however, the majority of Clear Lake’s water rights are managed by YCFCWCD (Section 2.1.1). The maximum diversion available to YCFCWCD on years when the lake is full on May 1, is 150,000 acre-feet. This is approximately three times the total water use in Lake County estimated in the 2006 water inventory (CDM 2006c). Two water purveyors, the Highlands Water Company and the City of Lakeport, have limited water rights to Clear Lake. Remaining water purveyors purchase Clear Lake surface water from YCFCWCD. Currently 19 utilities around Clear Lake serve 27,000 Lake County residents with Clear Lake water. Groundwater supplies additional water use in Lake County and supplies appear to be adequate for current water demands (Section 2.6).

A 2006 Lake County water inventory estimated that the amount of surface water used in the Clear Lake Watershed in a year with average rainfall was approximately 14,443 acre-feet (Table 2-4). Most of this surface water use came

from Clear Lake for residential and commercial water use. An approximately 4,200 acre foot of surface water used for agriculture was reported in the Upper Lake area. This is primarily Clear Lake water used in Tule Lake and the Rodman Slough reclamation area. An additional 100 acre-feet of agricultural surface water used in Big Valley could have come from Clear Lake or tributaries such as Kelsey Creek and Adobe Creek. According to the inventory, surface water use increases 6.3% in dry years while groundwater use increases 18.5% (CDM and DWR 2006c).

Table 2- 4 Sources of Clear Lake watershed water supplies for an average year and dry year (acre-feet).

Water Source	Average Year Supply	Dry Year Supply
Surface Water	14,443	15,378
Groundwater	27,915	33,037

Source: CDM and DWR 2006c, Tables 4-4 and 4-7

Surface water bodies that are part of the source waters for Clear Lake include Blue Lakes to the northwest of Clear Lake, and Highland Creek and Adobe Creek Reservoirs to the south of Big Valley. Blue Lakes are two naturally occurring lakes that supply some residential water use and are popular for recreational use. The two reservoirs are managed by the LCWPD for flood control and recreation. Highland Springs Reservoir has the potential to be modified and re-operated to provide spring water flows to enhance groundwater recharge and improve spawning conditions for the Clear Lake hitch. To the south and east of Clear Lake, Thurston Lake, Borax Lake, and Little Borax Lake lie in terminal basins, probably because porous lava rock allows water to drain from the lakes. These lakes have no apparent outlet to Clear Lake, although there may be a minor contribution from groundwater seepage.

Tributaries to Clear Lake dry up in their lower reaches by mid-summer. The major tributaries to Clear Lake are Scotts and Middle Creeks entering the lake at Rodman Slough to the northwest and Kelsey Creek in Big Valley to the south of the Clear Lake Watershed. The combined area of these three sub-watersheds constitutes 50% of the Clear Lake Watershed. Combined stream flow from these tributaries is estimated to be 73% of the total stream flow of 315,000 acre-feet into Clear Lake (Richerson *et al.* 1994). Other significant streams flowing into Clear Lake include Manning, Adobe, and Cole Creeks in Big Valley; Seigler Canyon, Copsey, and Herndon Creeks entering the lake to the southeast just above the Cache Creek Dam; Burns Valley Creek in the City of Clear Lake; and Schindler Creek draining High Valley through Clearlake Oaks.

The USGS maintains a lake level gage in Lakeport. There are four stream gages in the watershed, one USGS gage on Kelsey Creek, and DWR gages on Scotts, Middle, and Kelsey Creeks, the three largest tributaries to Clear Lake. Another critical gage for understanding watershed hydrology is the USGS stream gage on Cache Creek below the Cache Creek Dam, which monitors lake outflow.

Management

The Cache Creek Dam, and therefore Clear Lake's summer water level, is governed by the Solano Decree (1978, modified 1995). The Solano Decree specifies how much water is available for use by YCFCWCD and their customers, and how much water is available in each month of the summer. If Clear Lake is full (7.56 feet Rumsey) on May 1, 150,000 acre-feet of water is available to YCFCWCD. On Clear Lake, 150,000 acre-feet amounts to approximately 3 1/2 feet of lake depth. If Clear Lake is below 3.22 feet Rumsey on May 1, no water is available to Yolo for release. Intermediate amounts are available between these two levels. About 3 feet of water evaporates from Clear Lake during the summer months. Therefore, Clear Lake can drop from 3 to 6 1/2 feet in any given summer. On average, Clear Lake fluctuates 5.6 feet each year.

The 2008 Lake County General Plan includes many policies to manage surface and groundwater resources to ensure adequate supplies (LCCDD 2008). These include collection of information on stream flow in the three major drainages and development of management policies for each drainage. In addition, the county will attempt to develop additional water supplies, for example by water conservation programs and expansion or re-operation of existing water supply facilities. The county will also participate in local, regional, and state water resource management planning such as the Integrated Regional Water Management Plan (IRWMP).

Integrated Regional Water Management Plan (IRWMP)

The IRWMP is an important planning effort related to numerous aspects of watershed management including both surface and groundwater supplies. The proposed planning area for the IRWMP that will encompass the Clear Lake Watershed is comprised of the Cache and Putah Creek Watersheds as well as most of the remaining area of Yolo County (Figure 2-5). The tentative name for the region is the Westside Region. Participating governments/agencies are; Lake, Napa, Yolo, and Colusa Counties and the Solano Water Agency.

The IRWMP will promote a regional and integrated approach to water management and will foster coordination, collaboration, and communication among agencies and organizations responsible for water-related issues. The plan will cover providing water supply reliability, water recycling, water conservation, water quality improvement, stormwater capture and management, flood management, recreation and access, wetlands enhancement and creation, and environmental and habitat protection and improvement. The IRWMP is intended to provide a comprehensive approach to addressing water supplies as a component of the California Water Plan.

Stakeholder meetings for the IRWMP involving Lake County residents, agencies, and organizations began in May 2007. The meetings have gathered input on Lake County priorities, goals, and objectives for the IRWMP. A memorandum of understanding has been signed and meetings are being held among the cooperating agencies. Lake County is in the process of finalizing goals and objectives (by the end of 2009) to be included in the IRWMP. By the first quarter of 2010, the Lake County contribution for a planning grant application will be completed. The goal for completion of the IRWMP is the end of 2012.



Figure 2- 5 Map of proposed Westside Integrated Watershed Management Area.

2.4 GROUNDWATER BASINS

Groundwater aquifers in the county provide the principal source of water supply for agricultural use. Communities isolated from Clear Lake, such as Cobb, Kelseyville, Finley, and Upper Lake utilize groundwater for their water supply, and the City of Lakeport obtains a substantial portion of its water supply from groundwater. Rural housing generally relies on groundwater for the water supply.

The major groundwater basins in the Clear Lake Watershed include Big Valley, Scotts Valley, and Upper Lake Valley. Smaller groundwater basins include High Valley, Burns Valley, and Lower Lake Valley. The combined storage capacity of the major basins is about 122,000 acre-feet and the usable or safe-yield capacity is estimated to be about 70,000 acre-feet (CDM and DWR, 2006c). Safe yield represents the estimated quantity of water that can be withdrawn from the aquifer annually without causing adverse conditions such as long-term overdraft exceeding the rate of recharge, irreversible land subsidence from compression of dewatered aquifer materials, and reduction in water quality. One acre-foot of water is equivalent to about 326,000 gallons, which is approximately the quantity of water used by two, three person households in one year. Significant annual declines in water levels occur in the Big Valley, Scotts Valley, and Upper Lake basins due to extensive withdrawal for irrigation and domestic uses. The groundwater level recovers with winter rains in all but very dry years (CDM and DWR 2006c, Andrews and Humphrey, 1987,). Permanent loss of groundwater storage capacity has occurred due to channel incision.

The county groundwater basins are composed primarily of shallow alluvial deposits, the fractured sedimentary and metamorphic rock of the Franciscan Formation, and the Clear Lake volcanic deposits. Significant information is available for the major alluvial deposits; however, there is very little information available for fractured bedrock and volcanic aquifers. The geologic and hydrologic characteristics of each groundwater basin differ with respect to many factors including the distribution of aquifer materials of varying permeability and material composition, sources of recharge, distribution over area and depth, and presence of boundaries or faults that limit groundwater flow.

The Big Valley groundwater basin borders the south side of the Upper Arm of Clear Lake and contains two aquifer systems. The floodplain system contains two principal aquifers. These aquifers consist of relatively more permeable floodplain and channel alluvium carried into the basin mainly by the flow of Adobe, Highland, and Kelsey Creeks. The lower aquifer is mostly confined or semi-confined, with an intervening clay-rich layer between it and the upper aquifer. The upper aquifer is largely unconfined except to the north where it is covered by lake deposits. Recharge of these aquifers occurs mostly from Kelsey and upper Adobe Creeks, with some downward percolation of rainfall, frost control water in early spring, and mid-summer to early fall irrigation. The other aquifer system occurs to the south where the uplifted Kelseyville formation contains two aquifers. The upper aquifer consists of stream deposits and is largely unconfined.

It is recharged by the surface flow of Kelsey Creek south of Kelseyville and by percolation of rainfall. The lower aquifer is a narrow volcanic ash aquifer. Recharge of the volcanic ash aquifer is poorly understood, but is likely to be by underflow from adjacent uplands (Christensen Associates Inc. 2003).

The Upper Lake groundwater basin underlies the level portion of Clover Valley, Middle Creek Valley south of Hunter Bridge, and the Rodman Slough. Most of the basin is confined, with free ground water in limited areas in the upper portions of the basin and at the mouths of canyons around the periphery of the basin. Most groundwater recharge occurs through the channels of Middle Creek, Alley Creek and Clover Creek in the unconfined portions of the groundwater basin (CDM and DWR 2006c, Earth Sciences Associates 1978).

The Scotts Valley groundwater basin is separated from the lake by about a mile-wide terrace deposit on the west side of the lake. Most of the lower, or northerly, portion of the groundwater basin is confined. This confined area represents approximately 83% of the valley floor area. The southern portion of the groundwater basin is largely unconfined; however, some lenses of impermeable clay lake deposits extend into the free area. Groundwater recharge occurs principally along the channel of Scotts Valley in the unconfined groundwater area (CDM and DWR 2006c, Wahler 1970).

Little information is available for the smaller groundwater basins along the Lower Arm and Oaks Arm of the lake, which are recharged from small streams such as Burns Valley, Seigler Canyon, Copsey, Schindler, and Herndon Creeks.

The groundwater flow into Clear Lake is estimated to be about 1,100 acre-feet, a very small fraction (<0.3%) of the total flows to Clear Lake compared to the contributions from rainfall and stream runoff (Richerson *et al.* 1994). Much of the lake is bordered by fractured Franciscan and volcanic formations that contain groundwater, but information on their flow contribution to the lake is unknown. There are many groundwater springs in the lake, which are mainly associated with major geologic faults in the region. These springs are not believed to be a significant source of water to Clear Lake (Richerson *et al.* 1994).

Data on groundwater quality in the Clear Lake Watershed are limited. DWR has been measuring groundwater mineral constituents on a variable number of Lake County wells since 1944. For any given well, the sampling schedule has been intermittent, probably due to occasional lack of access to wells. Data from wells for public water supplies are also collected and are available from the California Department of Public Health. The only studies analyzing groundwater quality are for Big Valley and are discussed in the section below.

2.5 GROUNDWATER QUALITY

Background

Groundwater quality depends on the quality of water recharged to the aquifer, aquifer chemical properties, and specific natural or human-caused waste inputs such as fertilizer and pesticide applications, septic system leachate, or specific

waste disposal areas such as landfills, abandoned landfills, or illegal dumping. DWR has collected limited data on groundwater quality in the Clear Lake Basin, beginning in 1944. Data on groundwater quality from public water supply wells are available through the California Department of Public Health (CDPH).

The only extensive analyses of groundwater quality data available are for Big Valley. The dominant ions in Big Valley are magnesium, calcium, and bicarbonate. The ratio of magnesium to calcium (chemical equivalent ratio) ranges from 1.5:1 to 3:1. In most groundwater systems, calcium is present in greater amounts than magnesium. Sodium, chloride, and sulfate are present at lower concentrations than the dominant ions. Total dissolved solids content ranges from 350 to 1,200 milligrams per liter (mg/L) and averages 400 to 500 mg/L. This is elevated with respect to the secondary drinking water standard of 500 mg/L. Big Valley also occasionally has localized problems with hydrothermal features that contribute high levels of iron and boron and elevated ratios of magnesium to calcium. Boron, which is injurious to many agricultural crops at levels of 0.75 to 1.0 mg/L, is generally present in Big Valley at moderate levels ranging from 0.10 to 0.67 mg/L. Additional wells, however, contain boron concentrations from 0.67 to 2.5 mg/L, and one well had a concentration of 7.28 mg/L (SMFE 1967). In some areas of Big Valley, nitrate levels have been rising since the late 1950s suggesting nitrate loading from fertilizer or animal/human waste (Christensen Associates Inc. 2003). Nitrate is regulated for human health concerns and has an applicable primary drinking water standard of 10 mg/L N. Levels in some Big Valley wells are approaching 7.5 mg/L N, and one sample was 9.5 mg/L N.

In other aquifers or localized areas, elevated levels of iron, manganese, or hardness may be present (Richerson *et al.* 1994). These parameters do not pose health threats; however, they are associated with nuisance properties and regulated with secondary drinking water standards for such conditions as taste, odor, staining of clothing, and/or scale formation in plumbing fixtures. These minerals can also cause clogging of irrigation systems, especially micro-irrigation systems. Increased hardness levels require the use of additional soap or detergents and can increase treatment costs for either homeowners who use water softeners or municipal wastewater treatment plants that must treat the increased rate of waste load in the waste inflow stream. Water treatment systems, or frequent replacement of irrigation fixtures, may be required in agricultural systems.

A summary of DWR groundwater quality sampling of the Upper Lake and Scotts Valley aquifers for the period from 1945-2000 found only seven exceedances of primary drinking water standards and more numerous exceedances of secondary or agricultural water standards. Primary drinking water standards are legally enforceable standards to protect public health, which apply to public water systems. Secondary drinking water standards are non-enforceable guidelines that regulate contaminants that may cause aesthetic or cosmetic affects (USEPA 2009c). The DWR sampling was insufficient to detect geographic or temporal trends in water quality (WLRCD 2009a, 2009b).

Management

DWR has periodically monitored well physical and chemical parameters in Lake County since the late 1930s. Since 1983, California state and local agencies that sample wells for pesticides have been required to send their reports to the California Department of Pesticide Regulation (DPR). The DPR maintains a database on all pesticide detections in wells. No detections have been reported in Lake County (DPR 2003-2006).

Lake County Department of Health Services, Environmental Health Division (LCEHD), administers regulatory programs that include components designed to protect drinking water quality. They regulate water well installations, small public drinking water systems (having 5 to 14 connections and serving fewer than 25 people daily over 60 days of the year), on-site septic sewer systems, businesses generating hazardous material and waste, underground storage tanks, and solid waste facilities. Chapter 9, Article VIII of the Lake County Code sets minimum standards for the construction of new water wells, repair of existing wells, and destruction of abandoned wells based on California Water Code and DWR recommendations. Septic system standards are defined in Article III, Chapter 9 of the Lake County Code.

Regulation of large public drinking water systems is by CDPH. The California Drinking Water Source Assessment and Protection Program requires large public drinking water systems to complete a drinking water source assessment that includes an inventory of possible contaminating activities and a vulnerability ranking to potential contamination (CDHS 1999).

2.6 GROUNDWATER SUPPLY

Background

Groundwater levels typically decline during summer due to higher water extraction rates to meet increased demands, and they recover during winter when demands are much lower and rainfall leads to groundwater recharge. The 2006 Lake County water inventory and analysis estimates that full recharge of major aquifers would not occur on severe drought events, which occur approximately once every ten years. Nevertheless, the 2006 inventory found that long-term trends in well levels indicate that annual groundwater extractions are not exceeding annual groundwater recharge (CDM and DWR 2006c).

In years following insufficient groundwater recharge, impaired or unbalanced groundwater conditions across a groundwater basin can have serious economic consequences, particularly to domestic and agricultural water supplies. Reduced groundwater levels and storage volumes in the aquifers can lead to limitations on the quantities available for extraction and thereby directly reduce the intended uses for those supplies. Groundwater overdraft can lead to land subsidence and a permanent reduction in groundwater storage capacity. In general, when supplies become limited, the impacts are not distributed equally across a region because the physical changes in the aquifers vary from one area to another. Often, users located at the down gradient end of a groundwater basin will experience greater impacts because upstream users have the ability to withdraw the water first.

Reduced water supplies also tend to result in greater pumping costs because the vertical lift necessary to bring the water to the ground surface increases.

Reduced groundwater supplies may lead to water quality impairment. In some locations, water drawn from deeper in the aquifer may have higher mineral concentrations. Crops differ in their tolerance of boron, and increasing levels of boron would limit the crops that could be grown. Iron and other minerals clog micro-irrigation systems, requiring water treatment and replacement of drip emitters. Higher mineral concentrations would also increase water treatment costs for domestic use.

Even in years when complete groundwater recharge occurs in the fall, early drying of streams due to adjacent groundwater use can have significant consequences for maintenance and survival of aquatic, wetland, and riparian vegetation communities and directly affect aquatic fish and insect habitat and populations. As groundwater levels are reduced and streamflow recedes, water temperatures typically rise, in particular during the warmer periods of the year, and subsequently put stress on sensitive organisms. Earlier drying of streams in the spring and summer is considered to be one of the factors leading to a decline in the population of the Clear Lake hitch and possible extinction of the Clear Lake splittail, both of which have spring spawning migrations in tributaries to Clear Lake (Moyle 2002). Hitch is listed as a species of special concern by the California Department of Fish and Game (DFG). (Section 4.4)

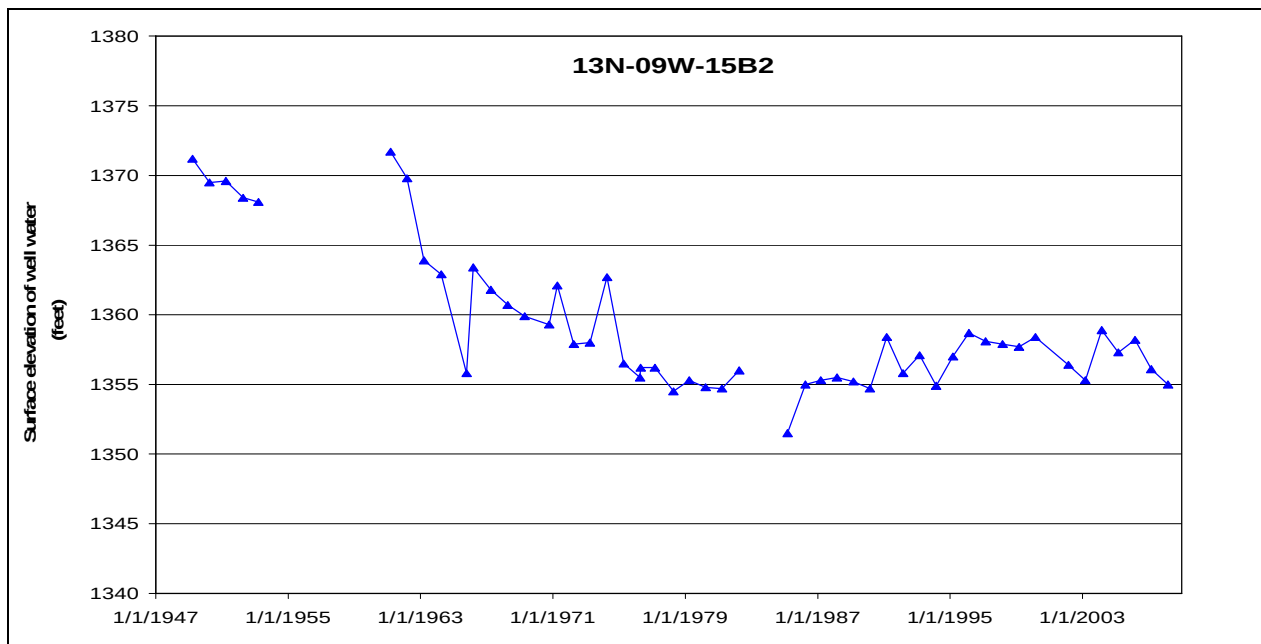


Figure 2- 6 Spring water levels for well number 13N-09W-15B2

A significant reduction in groundwater storage occurred as a result of channelization and mining gravel deposits in stream channels during the early and middle part of the 20th century. Channelization increases flow velocities and hydraulic scour, causing channels to down cut. Gravel removal in excess of recharge rates in Middle Creek, Scotts Creek, Kelsey Creek, and Adobe Creek caused the channels to down cut by hydraulic scouring. The reduced surface

elevation of the channel bottoms relative to the surrounding land surface and shallow underlying groundwater levels results in decreased groundwater storage and increased groundwater seepage to the stream channels and lower groundwater levels.

Kelsey Creek experienced the greatest drop in channel level due to straightening and deepening its mouth in 1962 and extensive gravel mining below the Main Street Bridge, which continued until 1980. The drop in the creek channel level after 1960, and the partial recovery following the moratorium on gravel mining in 1981, can be seen from water levels for well number 13N-09W-15B2, located approximately 600 feet north of Kelseyville Main Street and 320 feet laterally from Kelsey Creek. Spring well levels, shown in Figure 2.5, show an approximate 15 feet drop in the level of Kelsey Creek by the 1970s, and a rise of about 3 feet after 1987. In Scotts Valley, spring well levels indicate that channel incision of approximately 6 feet occurred near the Scotts Valley Road Bridge following large gravel mining operations in the late 1960s (WLRCD 2009b).

The 2006 Lake County Water Inventory and Analysis catalog the available estimates of groundwater in the Clear Lake Watershed (CDM and DWR 2006c). These are available only for the major alluvial groundwater basins; Big Valley, Upper Lake Valley and Scotts Valley, and High Valley (Table 2-5). Big Valley contains most of these groundwater resources, 85% of the safe yield capacity of the four basins.

Table 2- 5 Estimated groundwater total storage and safe yield for several basins of the Clear Lake watershed (acre-feet).

Groundwater Basin	Total Storage	Safe Yield Capacity
Big Valley	105,000	60,000
High Valley	9,000	900
Scotts Valley	5,900	4,500
Upper Lake Valley	10,900	5,000

Source: CDM and DWR 2006c

The inventory was based on the DWR 2000 land use survey that had been updated to 2004 conditions based on stakeholder feedback. Although the inventory units (areas of the county) shown in Table 2-6 do not correspond directly with the extent of ground water basins, they appear to indicate that groundwater use does not exceed safe yield capacity. Groundwater use in Big Valley is 14,000-16,000 acre-feet per year, only 22-27% of its estimated safe yield capacity of 60,000 acre-feet. The groundwater use reported for the Scotts Valley inventory unit included 2,370 acre-feet per year from the Scotts Valley aquifer, and the remaining 2,000 acre-feet came from other areas in the unit. Therefore, groundwater use of the Scotts Valley aquifer was 53% of safe yield capacity, and in Middle Creek inventory unit, corresponding to the Upper Lake Valley groundwater basin, it was at 67% of its estimated safe yield. In addition, recent trends in agricultural crops have probably led to reduced groundwater use. For example, pear acreage in Lake County decreased 47% from 2000 to 2007 (LCAD various). In some cases pears have been replaced by irrigated crops; however, in many cases, land is fallow or un-irrigated pasture. Total groundwater use in the

Clear Lake Watershed was estimated to be 28,000 acre-feet for an average year and 33,000 acre-feet in a dry year (CDM and DWR 2006c).

Table 2- 6 Groundwater use during average and dry years for Big Valley, Scotts Valley, and Upper Lake inventory units (acre-feet).

Inventory Unit	Groundwater Use In Average Year	Groundwater Use In Dry Year
Big Valley	13,390	15,902
Scotts Valley	4,373	5,018
Middle Creek	3,380	3,870

Source CDM and DWR 2006c Tables 4-4 and 4-7

The 2006 water demand forecast estimated current (2000) and future (2040) agricultural, and urban water use for average and dry years (CDM and DWR 2006b). Urban water use includes residential, commercial, industrial and landscape water use. It is forecast to increase approximately 62% by 2040 (Table 2-7). Three different scenarios for agricultural water use were used to predict agricultural demand. All three of these scenarios assume that countywide wine grape acreage would more than double by 2040, and that pear and walnut acreage would decline. The three scenarios assume a 56-70% increase in the areas of irrigated cropland. The increase in water demand declines slightly under scenario 1, increases slightly under scenario 2, and increases 21% (average year) to 24% (dry year) under scenario 3. Water demand is less than the increase in acreage because a substantial proportion of irrigated acreage is projected to be in wine grapes, which use substantially less water than do irrigated orchards or specialty crops.

Table 2- 7 Current and projected (2040) water demand in the Clear Lake watershed for average years and dry years (acre-feet).

Water Demand Category	Water Demand in Average Year	Water Demand in Dry Year
Current Urban	9,646	10,415
2040 Urban	15,765	16,865
Current Agriculture	32,367	38,073
2040 Agriculture- Scenario 1	29,985	36,748
2040 Agriculture- Scenario 2	33,101	40,633
2040 Agriculture- Scenario 3	39,185	47,543

Scenario 1: Large decreases in pears and walnuts, increases in vineyards and ranchettes.

Scenario 2: Moderate decreases in pears and walnuts, increases in vineyards and ranchettes.

Scenario 3: Conversion of pears and walnuts to specialty crops, increases in vineyards and ranchettes.

Source: CDM and DWR 2006b.

Management

Currently, DWR monitors water levels in 23 wells in Lake County and samples these wells periodically for mineral constituents. Lake County monitors spring and fall water levels in 54 wells in the Clear Lake Watershed and monthly water levels in an additional 15 wells in Big Valley.

A Groundwater Management Plan for Big Valley was adopted in 1998, and a countywide Groundwater Management Plan was adopted in 2007 (LCFCWCD 1999, CDM and DWR 2006a). Stakeholder meetings were held around Lake County to identify basin management objectives for the 2007 plan. Objectives common to all the groups included preventing long-term declines in groundwater levels and increased monitoring of groundwater levels and quality. Objectives for the Big Valley basin were more specific than for the other basins, reflecting the history of groundwater management planning in this area. The more specific Big Valley basin objectives included determining a safe yield of groundwater and establishing quantitative limits on groundwater extractions for particular areas.

Both the Big Valley and Lake County Groundwater Management Plans contained similar components to achieve groundwater protection. These include:

- Monitoring groundwater levels and quality.
- Updating well construction and abandonment policies.
- Expanding and/or managing groundwater recharge and conjunctive use projects.
- Implementing cooperation among local, state, and federal agencies.

Lake County regulates groundwater export by a 1999 ordinance, Chapter 28, “Regulation of the Extraction and Exportation of Groundwater from Lake County.” This ordinance outlines the process for obtaining a permit to export groundwater in excess of 1 acre-foot per year. The application must include a California Environmental Quality Act compliant environmental review and hydrogeologic analysis. The application is reviewed by the Planning Department and presented in a public hearing before the Planning Commission. The permit is granted only if the Planning Commission finds that the extraction will not cause or increase overdraft and will not result in adverse effects on reasonable and beneficial uses of overlying water.

In order to protect Lake County’s groundwater resources, the Lake County General Plan (2008) has policies to:

- Promote land use that allows for continued recharge of groundwater basins.
- Manage groundwater resources to ensure an adequate, safe, sustainable, and economically viable groundwater supply.
- Monitor behavior of groundwater source areas.
- Identify and monitor potential groundwater pollution sources.
- Support additional studies on groundwater sources.
- Implement and update the Groundwater Management Plan.
- Limit the export of groundwater outside its originating basin.
- Manage streams and watersheds to maintain groundwater recharge functions.

Lake County adopted the Creek Management Plan in 1981 to control gravel-mining operations in stream channels. Most in-channel gravel mining ceased by the late 1980s, and the Creek Management Plan was replaced by the Aggregate Resource Management Plan in 1992. As a result of lowered groundwater levels, the Kelsey Creek Detention Structure was constructed in 1987 to promote increased groundwater recharge rates and improve groundwater levels and storage in the adjacent aquifers. Located approximately 1.5 miles north of Kelseyville, the structure consists of radial gates in the channel that can be used to detain water in the channel during low flows and increase groundwater recharge rates. During drought years, it has proven effective at maintaining higher groundwater levels in its area of influence than in the remainder of Big Valley. Between 1989 and 1995, four drop structures were built for gravel retention between the detention structure and Renfro Crossing. These structures have filled in with gravel, restoring some of the groundwater storage lost to channel down-cutting.

Lake County and cooperating governments/agencies are working to develop an Integrated Regional Water Management Plan (IRWMP), which will be an important planning document for management of both ground and surface water ([Section 2.3](#)).

2.7 WATERSHED EDUCATION AND OUTREACH

This section summarizes all watershed-related education programs available in the watershed. Some of these programs include education on water quality and water supply, and many cover other aspects of watershed functioning and management. Watershed education and outreach are vital to increasing public understanding and involvement of water resource and watershed issues. Currently, there are numerous agencies and organizations providing watershed education in the Clear Lake Watershed.

The Lake County Water Resources Division (LCWRD) has pursued a program since 1969 to determine the causes and potential controls or management of algae and aquatic plants. An important component of this program has been to convey the research results to the public. LCWRD has funded and/or pursued grant funding for two significant UC Davis research efforts, the Clear Lake Algal Research Unit from 1969-1976 and the Clean Lakes Report from 1994-1995. UC Davis researchers also investigated mercury in Clear Lake from 1995-2001.

When aquatic plants became a more significant issue for boating in Clear Lake, LCWRD conducted a demonstration project to compare the effectiveness of several methods of aquatic plant control (CLAPMP 2002). With the severe *Lyngbya* algal bloom in 2009, LCWRD has provided public outreach and education including demonstration of management techniques.

As part of the Lake County Clean Water Program (LCCWP) being implemented by the City of Lakeport, City of Clearlake and County of Lake ([Section 3.6.2](#)), numerous education and outreach materials have been developed and distributed. Brochures for home and business owners and construction workers/builders have been developed. These include several posters and a full color brochure on the many potential sources of water pollution in the watershed, brochures on proper

concrete waste clean-up, mercury disposal, and erosion control BMPs (Best Management Practices). Brochures are distributed at the cities, the Lake County Community Development Department (LCCDD) counter, and at public events such as the Lake County fair. The Cities of Clearlake and Lakeport have also initiated storm drain stenciling programs as part of the LCCWP.

The Hinthel Environmental Resource Community (HERC) is an organization of the 5 Tribes in Lake County that has been in existence since 2002. HERC holds monthly meetings to discuss environmental issues on Indian Lands. These meetings also bring in local, county, state or federal representatives for technical presentations or general outreach to Tribes on environmental topics and issues.

Local watershed groups, organized under the State of California's Coordinated Resource Management and Planning (CRMP) guidelines, hold monthly meetings where they frequently invite watershed resource specialists to give presentations. Many of these groups hold annual creek clean-up events. The watershed groups sponsor watershed information booths at local events such as the Kelseyville Pear Festival. Active watershed groups in the Clear Lake Watershed are the Big Valley Watershed Council, Lower Lake Watershed Council, Middle Creek CRMP, Nice Watershed Council, Schindler Creek/High Valley CRMP, and Scotts Creek Watershed Council.

A variety of school curricula, both specific to the Clear Lake Watershed and related to general environmental and natural resource topics, have been developed locally. "A Child's Place in the Environment" is a curriculum for first through sixth graders developed in 1989. It covers topics such as "Preserving and Restoring Ecosystems" and "Caring for Aquatic Systems." A Lake County Watershed Curriculum Guide with lessons outlined for grades K-3, 3-6, 6-9, and 9-12, was developed from 1996 to 1998. This curriculum includes lessons on watersheds, erosion, Lake County ecosystems, and aquatic studies. Currently, lessons in earth, life, and physical sciences for grades 4-6 are being developed as part of the Learning Activities through Kelseyville's Exemplary Science Collaborative (Lake Science Collaborative). These lessons are being designed to meet California grade-level content standards.

The Carle Continuation High School in the Konocti School District has an Environmental Technology class in which students learn about watershed function, monitor Seigler Canyon Creek, participate in creek clean-up projects and stream team monitoring, have completed the first phase of a stream bank restoration project, and continue to maintain and monitor the trees at the restoration site.

The East and West Lake RCDs, organize an annual "Kids in the Creek" Day in cooperation with numerous other agencies such as DFG, BLM, USFS, Natural Resources Conservation Service and local Tribes. This event brings local fourth graders to a creek-side location to learn about and try hands-on activities on a variety of natural resource topics.

The local University of California Cooperative Extension (UCCE) office offers education to farmers on water management and erosion control. This program includes information on using plant and soil water monitoring tools, and using

historical or real-time evapotranspiration (crop and soil water loss) information to schedule irrigation. UCCE offers a series of publications on “Reducing Runoff from Irrigated Lands,” several of which have information specific to Lake County.

The Lake County Winegrape Commission supports an education program for wine grape growers that includes workshops and demonstrations to improve plant and soil water monitoring and irrigation efficiency.

The Lake County Weed Management Area (LCWMA) holds an annual Invasive Weed Tour to educate residents and local government officials about this issue in Lake County.

LCWRD has done significant outreach to prevent the introduction of invasive mussels to Clear Lake, which includes holding public meetings, giving presentations to service clubs, organizing a poster competition at local schools, and posting public service announcements at the local television station and movie theaters.

Clear Lake State Park, located on the shores of Clear Lake in Big Valley, has a visitor center offering interpretive displays on the natural, cultural, and recreational resources of Clear Lake. The Clear Lake State Park Interpretive Association (CLSPIA) supports the park and visitor center through fund raisers and gift shop sales to provide docent training programs, maintain the visitor center exhibits, and fund the summer Junior Ranger Program. The Junior Ranger Program has been providing outdoor education to children since 1975. Following a four year fund raising effort, the CLSPIA has signed contracts to begin construction of an Outdoor Education Pavilion to support the park’s education mission in 2009. During the summer Park Rangers offer weekly campfire talks on environmental topics and support the educational programs discussed above. Clear Lake State Park also offers miles of trails, excellent wildlife viewing and fishing, boating, swimming, and camping facilities.

The local chapter of the National Audubon Society holds the Heron Festival at Clear Lake State Park every spring. This is a two-day event with numerous wildlife and nature exhibits and activities such as boat tours to view wildlife. From September through May, the local Audubon chapter holds monthly field trips for bird viewing, many of which are located in the Clear Lake Watershed, and guest speaker’s present nature topics at monthly Audubon meetings. Audubon also sponsors the Christmas Bird Count in December and Great Backyard Bird Count in February, and they support school bird and nature education programs.

The Big Valley Band of Pomo Indians holds an annual Tule Boat Race. Local Tribes gather to learn about traditional ways of building tule boats and their significance to Pomo culture. The Tribes build boats and compete in a series of races in an event that is open to the public.

Located at the north end of Clear Lake, the Rodman Slough Preserve is managed by the Lake County Land Trust (LCLT). At the preserve, LCLT provides guided weekly nature walks and quarterly lectures on nature topics, and they are

developing a nature center at a small house on the property. The emphasis of their programs is on the wildlife of Rodman Slough and Clear Lake.

At the opposite end of the lake, near Lower Lake, Anderson Marsh State Historical Park offers monthly nature walks and held six school programs in the spring of 2009. Limited funding from the state has reduced park staffing, and the Anderson Marsh Interpretive Association is working with park rangers and the local Children's Museum of Art and Science to develop a visitor center and provide training for volunteer docents. Plans for the visitor center include education on watershed ecology and Native American and European cultural heritage.

The Sierra Club Lake Group hosts five open meetings on environmental topics each year. Many of these meetings relate directly to watershed health.

2.8 WATER RESOURCES ACTIONS

2.8.1 Overall Strategy

This plan uses a watershed approach that recognizes the physical connections between surface and ground water. Surface and ground water are also linked in their use, management and regulation. Therefore, many of the actions proposed in this section concern both surface and ground water resources, and all recommended water resources actions are combined in one section.

Due to the importance of water resources to Lake County's economy, quality of life, and environment, the 2008 Lake County General Plan includes a new chapter devoted to water resources. The goals and policies in this chapter provide a sound basis for water resource management and direction in the county. In summary, the goals are:

- Groundwater supply protection to provide for current and long-range water needs.
- Protection of ground and surface water quality to meet the needs of all beneficial uses.
- Ensuring a sustainable, affordable long-term water supply.
- Using a watershed management approach that includes development of new surface water supplies and enhanced groundwater recharge.
- Encouraging water conservation and reuse.

Protection of Clear Lake water quality is specifically addressed. "The County should ensure that development around Clear Lake and along major tributaries occurs in a manner which minimizes the potential impact of land disturbance and erosion on the water quality of the lake, and minimizes the potential for pollution discharge from sewage disposal systems and other potential polluting sources. Whenever possible, the County should require that older developments without adequate sewage and stormwater disposal systems upgrade these systems to conform to current standards" (LCCDD 2008).

Other policies to protect water quality include requiring “the use of feasible and practical best management practices (BMPs) to protect surface water and groundwater from the adverse effects of construction activities and urban runoff” and ensuring “the design of facilities and management of stormwater runoff in a safe and environmentally sustainable manner” (LCCDD 2008).

Specific policies to augment water supplies include working cooperatively with other local, state, and federal agencies; developers to provide for development of additional water supplies; efficient use of stormwater runoff for groundwater recharge; participation in all appropriate local, regional, and state water resources planning efforts; and encouragement of water conservation and water use efficiency.

Increased water use efficiency will be achieved by requiring use of water conservation techniques and water-conserving appliances in new development, retrofitting existing development, and encouraging water conservation education. Use of agriculture and forestry best management practices for efficient water use is encouraged as is use of reclaimed wastewater for groundwater recharge, agricultural and landscape irrigation, geothermal recharge, and environmental restoration projects (LCCDD 2008).

Public facilities related to water resources are addressed in the General Plan. Lake County recognizes the need to provide an affordable, adequate, and safe water supply and to provide for adequate wastewater collection and treatment. Stormwater drains should be sufficient to protect people and property while maintaining the quality of receiving waters (LCCDD 2008).

Lake County Water Resource Management policies recognize the need for continued monitoring and enforcement to control non-point source water pollution according to the USEPA National Pollutant Discharge Elimination System (NPDES) program. In addition, the county evaluates land use and development plans for their potential to cause an exceedance of TMDL waste load allocations. To the maximum extent possible, the county ensures that projects don’t contribute to water quality impairment.

The IRWMP, currently under development, will address water quality and water supply issues in great depth at the regional level ([Section 2.3](#)).

2.8.2 Complete the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project (Middle Creek Project)

Background: Since 1995 LCWPD has been pursuing the Middle Creek Project, a project to acquire 1,650 acres of reclaimed land at the north end of Clear Lake and restore it to wetlands. This project has been identified as the single largest recommended water quality improvement to Clear Lake. It would restore the largest damaged wetland area around the lake, and the restored wetlands would filter water from the Scotts Creek and Middle Creek Watersheds, which contribute an estimated 57% of the inflow and 71% of the phosphorus loading to the Upper Arm of Clear Lake (USACE 1997). The United States Army Corps of Engineers (USACE) estimates that phosphorus and sediment inputs from Scotts and Middle Creeks would be reduced 40% by the Middle Creek Project, which

amounts to an estimated 28% reduction for the Upper Arm of Clear Lake. They estimate that chlorophyll (an indication of algal biomass) would decline approximately 34% from a historical average of 92µg/l down to 61µg/l. These reductions in the Upper Arm are significant because over 75% of the Clear Lake Watershed drains into the Upper Arm, because it accounts for over 65% of Clear Lake's surface area and volume, and due to prevailing wind direction, it is a source of much of the algae in the Lower and Oaks Arms. The Middle Creek Project includes purchase and removal of 18 homes and purchase of a large area of agricultural land that are at risk of flooding. It would also restore approximately 1,400 acres of wetlands, provide valuable fish and wildlife habitat, and increase the current area of wetlands around Clear Lake by 73%.

The USACE completed a feasibility study and environmental documentation (EIS and Environmental Impact Report [EIR]) for the Middle Creek Project in 2002. LCWPD has received \$5.714 million in grants from DWR to begin land acquisition in the area, and as of December 2007, 134 acres had been acquired (CLTSC 2008, LCWPD 2007). In November 2007, authorization for the USACE to participate in the Middle Creek Project was passed as part of the Federal Water Resources Development Act. Additional federal legislation appropriating money for the project and transferring USA in trust properties (held in trust for the Robinson Rancheria Band of Pomo Indians) outside of the project boundaries is required. The Lake County Board of Supervisors, LCWPD, and Robinson Rancheria has been lobbying federal representatives to pass this legislation. California Assembly Bill 74, authorizing state participation for the Middle Creek Project, passed in October 2009.

Project Description: The Middle Creek Project involves acquisition of approximately 1,650 acres of land that would be restored by breaching the levees and allowing the land to flood. Approximately 1,400 acres of the land is below the normal high water level of Clear Lake and would become wetlands and open water. The levees in the area, some of which were constructed more than 100 years ago, are sub-standard, and neither the state nor federal governments are authorized to participate in their repair because the reconstruction costs would exceed the benefits received due to reduced flood damage. Eighteen homes and a large area of agricultural land would be purchased as part of the Middle Creek project, and the homes would be removed. These properties would therefore no longer be subject to economic risk of flooding. In addition to the project authorization passed in 2007, federal legislation to appropriate money for the project is required. The USACE is also working with the Robinson Rancheria Band of Pomo Indians to transfer "USA in trust" parcels outside the project area.

Key Participants: USACE, LCWRD and Robinson Rancheria Band of Pomo Indians.

Timeframe: 0-10 years.

Technical Resources Required: Design services.

Cost Estimate: \$48,000,000.

Milestones: Complete project design, complete property acquisition, and construct project.

Effectiveness Criteria: Establishment and growth of aquatic and riparian vegetation in restored area and approximately 30% reductions in sediment and phosphorus loads to, and chlorophyll concentrations in, the Upper Arm of Clear Lake.

2.8.3 Implement Site Remediation at the Sulphur Bank Mercury Mine

Background: Declared a USEPA Superfund Site in 1990, the SBMM is estimated to contribute 97% of mercury loads to Clear Lake. A project to control erosion from mine tailings along the lake and a project to remove mine wastes in adjacent roads and residential areas have been completed. One access road still has mercury contaminated road base, and clean-up of the terrestrial portion of the mine site (USEPA Operable Unit 1, OU1) and mine wastes in the lake and adjacent wetland (USEPA Operable Unit 2, OU2) have not been completed. The terrestrial portion of the mine site includes the open mine pit, now filled with water, and surrounding mine waste. Water in the impoundment is contained by a waste rock dam. Flow of acidic water from the pit to Clear Lake through the waste rock dam is considered to be a significant source of mercury to Clear Lake.

The USEPA has completed a Remedial Investigation and Feasibility Study for OU1, however negotiations with the State of California to determine water treatment and discharge requirements for water from the Herman Impoundment must be completed before a remediation alternative can be implemented. USEPA has begun remedial investigations for OU2. However, pilot studies to determine the feasibility of remediation efforts in the lake depend on the elimination of continued mercury inputs from the terrestrial portion of the Superfund site (Richard Sugarek, personal communication).

Project Description: Clean-up and site remediation of OU1 and OU2 should be pursued as rapidly as possible to remove the majority of mercury inputs to Clear Lake.

Key Participants: USEPA, Elem Pomo Tribe, Clean Lake Environmental Action Network (CLEAN), LCEHD, and LCWRD.

Timeframe: 0-10 years.

Technical Resources Required: USEPA staff and consultants.

Cost Estimate: To be determined.

Milestones: Clean-up of OU1 and OU2.

Effectiveness Criteria: Reduction of mercury loads from SBMM to Clear Lake of 95% and reduction of fish mercury content.

2.8.4 Improve Understanding of Clear Lake Limnology

Background: Clear Lake was listed as impaired due to excessive nutrients in 1986 under Section 303(d) of the Federal Clean Water Act. The amendment to the CVRWQCB Basin Plan for the control of nutrients in Clear Lake was adopted in June 2006. This Clear Lake Nutrient TMDL requires the responsible parties (Lake County and others) to develop and implement a plan which includes

“studies to assess the current limnological conditions and to determine the appropriate measures for Clear Lake to meet the Basin Plan objectives” (CVRWQCB 2006).

The Clean Lakes Report was completed for LCFCWCD (now LCWPD) in 1994, and using the data available attempted to determine the cause of the nuisance blue-green algal blooms in Clear Lake (Richerson *et al.* 1994). Just as the Study was starting, Clear Lake changed significantly with reduced blue-green algal blooms, increased clarity (transparency depth essentially doubled), and more prolific aquatic macrophytes. Insufficient data and funds were available to fully understand the factors that caused these blooms and subsequent increased water clarity. The study concluded that phosphorus was a major cause of the algal blooms and could be reduced; however, other factors such as iron availability and internal nutrient cycling probably play a major role in algal productivity.

Analysis of the water quality data through 2002 by LCWPD staff indicates that while phosphorus levels in the lake have not decreased significantly below the levels measured during the 1980s, the increased clarity has continued. No major changes in lake chemistry were noted during this analysis. It has been the LCWPD’s position that this indicates that phosphorus reduction is not the only action required to improve water clarity and quality. This, and subsequent data, need to be analyzed to determine what changes have occurred that have led to the increased clarity.

Subsequent studies on the lake by UC Davis researchers have indicated the sulfate budget was increased significantly concurrent with mining activities at SBMM, which may have affected the iron cycle and the internal phosphorus loading in the lake, potentially causing increased algal productivity (Richerson *et al.* 2008). Other hypotheses proposed as the cause for the high blue-green algal populations are changes to the Clear Lake food chain caused by species introduction, i.e. largemouth bass, catfish, threadfin shad, and silversides. Data are limited on food chain changes and have not been analyzed as they relate to algal productivity (Dr. Alex Horne, personal communication; Norman Anderson, personal communication). Additional research is necessary to evaluate these hypotheses.

Project Description: LCWPD has contacted Dr. Geoff Schladow, UC Davis and Tahoe Environmental Research Center, about conducting additional Clear Lake studies, including analysis of recent DWR data and additional experiments to confirm or disprove several hypotheses that have been proposed as the cause of the high algal productivity in Clear Lake. Dr. Schladow expressed interest in assisting the county in its efforts to determine the cause of the high productivity and nuisance algal blooms and recent improved conditions. As numerous researchers from UC Davis have conducted recent research on the Clear Lake ecosystem and developed several hypotheses, there are benefits to contracting with UC Davis for updating the Clean Lakes Report. In April 2009, the LCWPD contracted with UC Davis to begin the analysis of existing data. The initial analysis should be complete by June 2010. It is likely that additional studies and funding will be required to fully understand Clear Lake’s limnology.

Following a more complete understanding of Clear Lake limnology, additional recommendations of the CLTSC are to establish a baseline of Clear Lake’s natural

water quality conditions, to determine actions needed to improve lake water quality once the cause of water quality deterioration is identified, and establish criteria defining when Clear Lake is no longer impaired for nutrients.

Monitoring programs by a variety of agencies and organizations contribute to the understanding of Clear Lake limnology. Improved coordination of these efforts could help to reduce the costs and increase the effectiveness of Clear Lake monitoring ([Section 2.8.6](#)).

Key Participants: LCWRD, UC Davis, DWR, and TMDL Stakeholders.

Timeframe: Analysis of recent DWR data, one year. Additional studies 5-10 years.

Technical Resources Required: Limnology specialists.

Cost Estimate: \$500,000.

Milestones: Determine causal factors in Clear Lake water quality deterioration, determine natural, baseline water quality conditions, define target water quality conditions, determine actions to achieve these conditions.

Effectiveness Criteria: Completion of milestones.

2.8.5 Create a Water Resources Metadata Library for Lake County

Background: There are numerous agencies and organizations that have collected and continue to collect information on Lake County's water resources. This information comes in many forms from paper documents to recently developed databases, and in many cases the availability of the data is not known outside the agency or organization where it originated.

Project Description: Compiling a metadata library that describes the information that is available, how it is stored, and where it is available will assist government agencies in coordinating their programs and better understanding resource issues, and it will assist private citizens in accessing this public information. Developing the library should include a process for systematic update of the library by participants. While the Clear Lake Watershed should be the first priority in compiling the metadata library, it should be extended to water resources in the entire county because it would be a valuable resource for all county residents and because much of the available information is on a countywide or statewide level. LCWRD has begun this process by posting an on-line database of documents within its library.

Key Participants: Local CRMPs, East Lake Resource Conservation District, (ELRCD), West Lake Resource Conservation District (WLRCD), LCWRD, LCEHD, LCVCD, Sacramento Valley Water Quality Coalition (SVWQC), Tribes, Regional Board, DWR, and CDFA.

Timeframe: 0-3 years.

Technical Resources Required: County staff.

Cost Estimate: \$20,000.

Milestones: Project completion.

Effectiveness Criteria: Improved accessibility of water resources data, and increased understanding of watershed and water resource conditions by government agencies and public.

2.8.6 Develop and Implement a Comprehensive Clear Lake Watershed Monitoring Program

2.8.6.1 Coordinate Current Watershed Monitoring Programs

Background: Currently, water quality monitoring activities within the Clear Lake Watershed are conducted by several government agencies, local Tribes, and the SVWQC. For the most part, these activities are not coordinated. Surface water quality monitoring programs are described in Appendix B. The level of Clear Lake is monitored by the USGS with a gage at Lakeport, and outflow is measured by a USGS gage on Cache Creek below the Cache Creek Dam. There are three DWR stream gages within the watershed, on Scotts, Middle, and Kelsey Creeks, and a USGS gage on Kelsey Creek. Groundwater is monitored by the county and DWR. Currently, DWR monitors water levels in 23 wells in Lake County and samples these wells periodically for mineral constituents. Lake County monitors spring and fall water levels in 54 wells in the Clear Lake Watershed and monthly water levels in an additional 15 wells in Big Valley.

Program Description: Meetings of agencies, Tribes, and organizations currently monitoring water quality in the Clear Lake Watershed will be held to coordinate monitoring activities and reduce overlap when possible. Possible changes in methods of data acquisition and storage will be explored that could also lead to improved capacity to share data.

Key Participants: Local CRMPs, ELRCD, WLRCD, LCWRD, LCEHD, LCVCD, SVWQC, Tribes, Regional Board, DWR and CDFG

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: Regular staff time.

Milestones: Project completion.

Effectiveness Criteria: Improved monitoring program with potentially reduced overall workload for monitoring participants.

2.8.6.2 Review and Improve Clear Lake Watershed Monitoring to Meet TMDL Objectives

Background: The cause(s) of Clear Lake's nutrient impairment leading to excessive algal growth is(are) not well understood. Although the Nutrient TMDL focuses on phosphorus load reductions, lake phosphorus concentrations are poorly correlated with water clarity, and other possible

causes have been proposed. Additional studies to improve understanding of Clear Lake limnology are on-going ([Section 2.8.3](#)).

Project Description: Based on the results of additional Clear Lake limnological studies, it may be necessary to re-direct and/or increase monitoring efforts to better determine the causes of Clear Lake water quality deterioration. Once these causes are better understood, it may be necessary to change objectives and methods to monitor load reductions and water quality improvement.

Key Participants: LCWRD, UC Davis, DWR, and TMDL Stakeholders.

Timeframe: On-going.

Technical Resources Required: Limnology specialists, Staff of participating agencies.

Cost Estimate: To be determined.

Milestones: On-going modifications to monitoring program to effectively monitor water quality improvement.

Effectiveness Criteria: Clear Lake Watershed monitoring program that improves understanding of lake limnology.

2.8.6.3 Continue and Expand Volunteer Monitoring Programs

Background: There have been a variety of watershed monitoring programs in the county. In 2004-2006 local volunteer “stream teams” monitored several local creeks using the California Stream Bioassessment procedure which includes basic chemical and physical measurements, habitat rating, and counts of benthic macroinvertebrates. The 319h grant that funded the stream monitoring also provided training for the volunteers. Volunteers with the Chi Council have been monitoring and recording Clear Lake hitch numbers in tributaries of Clear Lake during the spawning season since 2004.

Project Description: Expanding volunteer environmental monitoring programs can provide valuable data while increasing interest and involvement in watershed activities. The commitment of Chi Council volunteers to hitch monitoring remains strong. Local Tribes have received grant funding to monitor stream chemical and physical characteristics during the spawning season, and to develop an adaptive management plan for the hitch. The Kelsey, Middle, and Scotts Creek Watershed Assessments identified a variety of volunteer monitoring programs to monitor watershed health and increase interest in watersheds. Potential additional monitoring programs could be ground water level monitoring and Clear Lake secchi depth monitoring. Both of these would provide valuable data on county water resources and use relatively simple equipment and methods.

Key Participants: Local CRMPs, ELRCD, WLRCD, Tribes, and LCWRD.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: To be determined.

Milestones: Expanded and new volunteer monitoring programs.

Effectiveness Criteria: Increased information on watershed processes and local involvement and understanding of watershed processes.

2.8.7 Support and Increase Clear Lake Watershed Education and Outreach

2.8.7.1 Support Current Programs

Background: Watershed education and outreach are vital to increasing public understanding and involvement. Many of these programs also enrich the experience of visitors from outside the county. Currently, there are numerous agencies and organizations providing watershed education in the Clear Lake Watershed ([Section 2.7](#)).

Project Description: The many excellent education and outreach programs currently available in the Clear Lake Watershed provide a wide variety of education, outreach, and ecotourism opportunities that should be supported and continued.

Key Participants: Local CRMPs, local non-governmental organizations (NGOs), local schools, ELRCD, WLRCD, City of Lakeport, City of Clearlake, LCWRD, LCOE, LCCDD, HERC, Tribes, DFG, UCCE, State Parks, BLM, and USFS.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies, volunteers, and educators.

Cost Estimate: To be determined.

Milestones: Continued and expanded education and outreach programs.

Effectiveness Criteria: Number of visitors and participants in watershed education and outreach, and improved public understanding of watershed processes and involvement in watershed preservation.

2.8.7.2 Algal bloom Mitigation Education

Background: During the period leading up to the 1990s, when nuisance algal blooms were a frequent occurrence on Clear Lake, a group of volunteers formed from the Algae Abatement Committee worked in partnership with LCWRD to offer assistance to shoreline property owners impacted by algal blooms. The 2009 *Lyngbya* bloom, which created persistent noxious algal mats in sheltered lake locations, led to reactivation of the Algae Volunteer Network for Clear Lake.

Project Description: LCWRD will continue to provide education and outreach to assist private property owners with mitigating nuisance algal blooms and reducing nutrient inputs to the lake. Possible education topics include techniques to mitigate algal blooms, reducing fertilizer and pesticide use, use of native plants in landscaping, and restoration of tules and other native aquatic plants on the shoreline. Education/outreach approaches include workshops and meetings, equipment demonstrations, media notification, website information, and brochures. LCWRD staff will make available county-owned boats and pumps to the Algae Volunteer Network. Much of this equipment has been in storage since the 1990s. In addition, the county has authorized the purchase of additional boats, pumps, and associated equipment for the control of algae in the amount of \$100,000.

Key Participants: LCWRD, City of Clearlake, City of Lakeport, Clear Lake Advisory Subcommittee (CLAS), Algae Volunteer Network, Clear Lake resort owners and operators, Greater Lakeport Chamber of Commerce, Clearlake Chamber of Commerce, marina and other shoreline business owners, and shoreline residents.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies, volunteers, and educators.

Cost Estimate: To be determined.

Milestones: As needed, workshops, meetings and demonstrations, and use of county equipment to mitigate algal blooms.

Effectiveness Criteria: Reduction in nuisance algal blooms, and, shoreline property owners and businesses informed about techniques to mitigate algal blooms.

2.8.7.3 Create a Watershed Discovery Center

Background: Representatives of twenty Lake County organizations, local Tribes, government agencies, civic leaders and business groups joined together to pursue the Clear Lake Discovery Center. With funding from a USFS grant and in-kind contributions from the community, the LCPWD contracted for a feasibility study for the Center. The planning process resulted in a conceptual plan for the Discovery Center at Rodman Slough County Park, and a financial plan to pursue funding for its implementation. The study included a market analysis, which found that Lake County is under-served in the availability of museums relative to counties with similar tourism spending (LSA Associates, Inc. 2005).

Project Description: The goal for the Discovery Center is to develop resources to educate and interpret the natural habitat and cultural history of the region, to provide a destination attraction for visitors, and to provide a venue for on-going research and monitoring of the Lake County ecosystem. Grant funding for project design and environmental review

was unsuccessfully pursued. However when the opportunity arises, funding for this important project should be pursued.

Key Participants: Local CRMPs, local NGOs, local businesses, local schools, ELRCD, WLRCD, LCWRD, CLAS, LCOE, Tribes, DFG, UCCE, State Parks, BLM, USFS.

Timeframe: 0-10 years.

Technical Resources Required: Staff of participating agencies, and consultants.

Cost Estimate: To be determined.

Milestones: Environmental study, design, construction, and established education events..

Effectiveness Criteria: Number of visitors and public that is better informed about Clear Lake and its watershed.

2.8.7.4 Develop a Watershed Outreach Program for Off-highway Vehicle (OHV) Users

Background: OHV use is a popular recreational activity in the Clear Lake Watershed that occurs both on public and private lands. In public lands such as the BLM Cow Mountain Recreation Area and the Mendocino National Forest (MNF), OHV travel outside designated trails and roads and in stream channels contributes to erosion and sedimentation and damage to wildlife and aquatic habitats. Off-trail OHV use on private lands can cause similar damage, and in some cases it occurs without permission of the property owner.

Project Description: Watershed outreach for OHV users could be offered through a variety of channels such as public meetings, informational pamphlets, presentations to OHV user groups, public service announcements (radio, television, and newspapers), and curriculum for or presentations at public schools.

Key Participants: ELRCD, WLRCD, LCWRD, local schools, LCOE, BLM, and USFS.

Timeframe: 0-5 years.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: Regular staff time.

Milestones: Meetings, pamphlets, public service announcements, and school programs.

Effectiveness Criteria: OHV users who are aware of and avoid ecosystem damage.

2.8.8 Develop and Implement an Interagency Communication and Coordination Strategy

Background: Lake and watershed management inherently encompass a wide variety of topics including environmental, economic, and social issues. Therefore, a number of federal, state, and local agencies, two cities, local Tribes, RCDs, and CRMPs are involved in the management of Clear Lake and its watershed. Federal agencies include BLM, NRCS, USACE, USEPA, USFS, and United States Fish and Wildlife Service (USFWS). State agencies include California Department of Forestry and Fire Protection (CAL FIRE), Caltrans, CDFA, CVRWQCB, DFG, DWR and UCCE. Local agencies include YCFCWCD, the Lake County Agriculture Department (LCAD), LCCDD, LCPWD, LCVCD, LCWMA, LCEHD and Lake County Special Districts Department (LCSDD). The two cities are Clearlake and Lakeport. Local Native American Tribes are the Big Valley Band of Pomo Indians, the Elem Pomo Tribe, the Habematolel of Upper Lake, Robinson Rancheria Band of Pomo Indians, and the Scotts Valley Band of Pomo Indians. There are two Resource Conservation Districts in the Clear Lake Watershed, ELRCD and WLRCD. Active CRMPs in the Clear Lake Watershed include the Big Valley Watershed Council, Lower Lake Watershed Council, Middle Creek CRMP, Nice Watershed Council, Schindler Creek/High Valley CRMP, Scotts Creek Watershed, and the Chi Council. Public and private water purveyors also have an interest in Clear Lake management (Section 2.8.8.1). Along with coordinating monitoring activities (described in Section 2.8.6), establishing regular communication would improve coordination of other activities. Communication need not be limited to face to face meetings. Webinars and conference calls reduce travel and time demands, and a variety of forms of electronic communication such as automated email list subscription services, facebook pages, blogs, websites, and wiki sites offer different advantages for communication.

Project Description: Agencies, Tribes, cities, and organizations involved in developing this interagency communication and coordination strategy would use meetings or other forms of communication to:

1. Describe the role and involvement of each entity in management of Clear Lake and its watershed and the communication tools they currently have available.
2. Identify areas of common interest, overlapping responsibilities, and/or opportunities to coordinate programs. For example, many of these agencies/tribes/organizations have common experiences to share in addressing changing Clear Lake chemistry and biology. This step would potentially divide the larger group of agencies and organizations into sub-groups based on areas of interest/involvement.
3. Identify the most effective (suitable, simple, cost effective, readily available) methods for communication and cooperation among the whole group or sub-groups.
4. Implement the methods identified.

Key Participants: See agencies and organizations listed in Background above.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies and organizations.

Cost Estimate: To be determined.

Milestones: Complete steps 1 through 4 in the above Project Description.

Effectiveness Criteria: Improved interagency communication with possibly reduced workloads, and improved Clear Lake and watershed management.

2.8.8.1 Improve Communication among Water Purveyors

Background: Past attempts have been made to organize regular quarterly meetings of all water purveyors in Lake County. While these efforts have been discontinued, a combination of direct meetings with alternative modes of communication could prove useful to participants. It may be valuable to organize communications among surface water purveyors (those using Clear Lake) separately from those using groundwater, because many of the issues facing these two groups are distinct. A priority of regular communication among water purveyors would be to improve emergency preparedness. Examples of potential emergency situations include drought conditions, toxic blue green algae blooms, and invasive mussel infestations. Regular communications could include an educational component, so that all water purveyors are better aware of water quality and supply issues.

Project Description: Initial face to face meetings would be held to identify areas for cooperation and modes of communication (e.g. face to face meetings, webinars, conference calls, electronic communications). Regular communication and cooperation would follow.

Key Participants: Public and private water purveyors who withdraw Clear Lake water including but not limited to Clearwater Mutual Water Co., Crescent Bay Improvement Co., Richmond Park Resort, Westwind Mobile Home Park, Cache Creek Mobile Home Park, Konocti Harbor Resort and Spa, Riviera West Mutual Water Co., Buckingham Park Water District, California Water Service- Lucerne, Nice Mutual Water Co., Clearlake Oaks County Water District, Mt. Konocti Mutual Water Co., Highlands Water Co., Konocti County Water District, City of Lakeport, Golden State Water Company- Clearlake, LCSDD, LCWRD, LCEHD, CDPH.

Timeframe: On-going.

Technical Resources Required: Staff of participating purveyors.

Cost Estimate: Regular staff time.

Milestones: Establishment of system for regular communication and planning among water purveyors.

Effectiveness Criteria: Water purveyors improving coordination, understanding of water issues, and emergency preparedness.

2.8.9 Complete the Integrated Regional Water Management Program (IRWMP)

Background: The IRWMP is a multi-county, regional planning process. It is intended to provide a comprehensive approach to addressing water supply as a component of the California Water Plan. Stakeholder meetings gathering input from Lake County residents, agencies, and organizations on the IRWMP have been held since May 2007. The region that the IRWMP will encompass is the Cache and Putah Creek Watersheds as well as most of the remaining area of Yolo County. The tentative name for the region is the Westside Region. Currently, meetings are being conducted among the cooperating governments; Lake, Napa, Yolo, and Colusa Counties and the Solano Water Agency.

Project Description: Representatives of the entities listed above will hold regular meetings to develop the IRWMP. Lake County will finalize goals and objectives by the end of 2009 and complete its contribution for a planning grant by the first quarter of 2010. Over the next two years Lake County and other participating governments/agencies will work with a consultant to develop the plan which will be completed by the end of 2012.

Key Participants: LCWRD, LCCDD, LCSDD, Tribes, Cities of Lakeport and Clearlake, Independent Water Purveyors, Napa County, Yolo County, Colusa County, and Solano Water Agency.

Timeframe: 0-2 years.

Technical Resources Required: Staff of participating agencies, consultants.

Cost Estimate: \$1,000,000.

Milestones: Finalize Lake County goals and objectives by the end of 2009, complete Lake County contribution to planning grant application by March 31, 2010, and complete IRWMP by end of 2012.

Effectiveness Criteria: Development of a comprehensive plan for water supply management in the Westside Region.

2.8.10 Increase Reuse of Treated Wastewater

Background: Reuse of treated municipal wastewater for groundwater recharge or to irrigate agricultural fields or greenways such as parks, recreational fields, and golf courses has the potential to reduce demands on available water supplies in the watershed. This reuse requires compliance with California Code of Regulations Title 22, and the increasingly stringent treatment requirements of this code have the potential to make wastewater reuse quite costly.

As part of a Lake County Sanitation District (LACOSAN) project, a large portion of wastewater in the watershed is currently being transported to the Geysers to recharge steam fields ([Section 3.10.6](#)). To maintain pipeline capacity, makeup water is currently drawn from Clear Lake. As local communities grow, and as a third phase of the pipeline is completed, additional effluent flows will displace the makeup water. The 2008 General Plan contains policies to expand the use of recycled water for uses such as groundwater recharge, agricultural and landscape irrigation, geothermal recharge, and environmental restoration.

The City of Lakeport recently completed a wastewater reuse feasibility study, and is exploring the possibility of constructing a tertiary treatment facility adjacent to their existing wastewater treatment facility for the treatment and distribution of wastewater.

Project Description: As population and water demand increase, water supplies in the watershed could be increased by replacing irrigation water with recycled water. This would require construction of water storage ponds because wastewater flows are greatest in winter while irrigation water demand occurs during summer months. Use of treated wastewater for groundwater recharge (following tertiary treatment with nitrogen removal) may be feasible in the Big Valley area.

Key Participants: LACOSAN, LCCDD, Clearlake Oaks County Water District, Kelseyville County Water Works District No. 3, City of Lakeport, and potential water consumers.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies and consultants.

Cost Estimate: To be determined.

Milestones: Completion of projects to use recycled water for irrigation.

Effectiveness Criteria: Amount of freshwater supplies that are replaced with treated wastewater.

2.8.11 Increase Water Conservation

Water conservation will be an important component of the IRWMP, which is currently being developed ([Section 2.8.9](#)). Water conservation not only reduces potential vulnerability to drought, it also reduces loads to wastewater treatment facilities.

2.8.11.1 Water Conservation in New Developments

Background: The Lake County 2008 General plan requires the use of water conservation techniques in new development. These techniques include the use of low flow plumbing fixtures, water-conserving appliances, high efficiency irrigation systems, gray-water for landscaping, and drought tolerant vegetation. In addition, design to capture stormwater runoff for groundwater recharge is encouraged.

Project Description: Continue current program requiring water conservation techniques in new development and update requirements as new technology and strategies become available.

Key Participants: LCCDD, Cities of Lakeport and Clearlake, Lake County Redevelopment Agency (LCRDA), all water purveyors and purchasers.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: Regular staff time.

Milestones: Construction of water use efficient buildings and landscapes.

Effectiveness Criteria: New development that achieves high standards of water use efficiency.

2.8.11.2 Water Conservation Improvements During Re-modeling

Background: Many older residences and buildings have fixtures and appliances that require large amounts of water for operation. Water use efficiency is increased when these are replaced with units that comply with the higher standards of current state code. Retrofitting with low water use plumbing fixtures is required for structures that are re-modeled, reconstructed, or added on to, and upon the change of ownership or use within LACOSAN.

Project Description: Continue to enforce requirements for water use efficient fixtures and appliances during re-modeling.

Key Participants: LCCDD and Code Enforcement Division of LCCDD.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: Regular staff time.

Milestones: Continue to update and enforce standards.

Effectiveness Criteria: Increased proportion of water efficient residences and buildings.

2.8.11.3 Increase Water Conservation Education

Background: Education programs for farmers on improving agricultural water use efficiency are being provided by UCCE and the Lake County Winegrape Commission (Section 2.7). Water purveyors provide information to their customers on water conservation. In many cases, adoption of water conservation leads to reduced utility bills for farms, businesses, and residences from reduced pumping or water service costs.

Project Description: Additional education on water conservation in homes, businesses, agriculture, and landscaping could be provided by government departments and agencies such as the NRCS, UCCE, LCSDD and others, and it can be taught in local school systems. Education and outreach could include workshops, classes, and pamphlets.

Key Participants: LCSDD, LCCDD, UCCE, Lake County Winegrape Commission, NRCS, LCOE, and local schools.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: To be determined.

Milestones: Classes and workshops completed and educational materials developed and distributed.

Effectiveness Criteria: Public that understands and practices water conservation.

2.8.12 Complete the Adobe Creek Conjunctive Use Project

Background: In 1964, the Soil Conservation Service (SCS) constructed the Adobe Creek Flood Control Project. The Project consisted of construction of the Adobe Creek and Highland Springs Reservoirs for the purpose of providing flood control along Adobe Creek in Big Valley. A water supply component was not included in the reservoir design. Channel modifications to Adobe Creek downstream of the reservoirs to the creek mouth further reduced the flood risk. The project functioned as designed, resulting in significant flood damage reduction.

The flood control project resulted in channel incision because of increased flow velocities due to channelization and because the dams precluded gravel recharge to lower Adobe Creek. Channel incision was further aggravated by gravel extraction after construction of the dams. The resulting channel incision reduced storage in the aquifer by lowering the maximum water table level (LCWRD 2000).

In 1995, NRCS provided a Hydrologic Unit Planning (HUP) team to evaluate the practicality of modifying the Highland Springs Reservoir to increase storage for later release for groundwater recharge. The HUP team determined that modification of the primary spillway would be practical and would have minimal adverse impacts. The Lake County Flood Control and Watershed Conservation District (LCFCWCD), now called the Lake County Watershed Protection District (LCWPD) used Zone 1, Adobe Creek Flood Control District funds to contract with Christensen Associates Inc. for a detailed feasibility study. The 2002 Adobe Creek Conjunctive Use Project Feasibility Study describes the project, which is intended to increase groundwater recharge and improve fish spawning success by increasing stream flows during late spring (Christensen Associates Inc 2002). LCFCWCD applied unsuccessfully for a Proposition 13 Groundwater Recharge Construction Grant in 2001 and 2002 to fund construction of the conjunctive use project. In 2005, a benefit assessment to fund the Adobe Creek Conjunctive Use Project and other projects was placed on the ballot for property owner approval; however, the assessment was not approved by voters.

Project Description: The proposed Adobe Creek Conjunctive Use Project would provide benefits of increased groundwater storage and improved spring stream flows for spawning migration of Clear Lake hitch and other fish species. The project would consist of adding sluice gates to the Highland Springs Reservoir principal spillway to provide for increased storage of winter inflow that is normally spilled to Clear Lake and reduce draw-down of the reservoir in the fall. Modifying reservoir operation would increase water availability by 986 acre-feet. About 200 acre-feet of this increased storage would be used to increase spring

stream flows, a small amount would be lost due to evaporation, and approximately 750 acre-feet would be available for groundwater recharge during the summer and fall. The 2002 feasibility study estimated the capital cost of the project to be \$800,000 and with increased operation, maintenance, and water purchase costs, the project was found to be economically feasible at a cost of \$70/acre-foot (Christensen Associates Inc. 2002).

A final design for the project needs to be completed, and additional environmental review will be required. LCWPD has initiated and needs to complete the process of applying for water rights because this project will result in storage of water for more than 30 days.

Key Participants: LCWRD and NRCS.

Timeframe: 0-10 years.

Technical Resources Required: Staff of participating agencies, and consultants.

Cost Estimate: \$1,000,000.

Milestones: EIR, project design, water rights permit, and construction.

Effectiveness Criteria: Increased groundwater storage, and improved spring flows for spawning fish.

2.8.13 Update the Cost-Benefit Analysis of the Lakeport Dam

Background: Potential benefits of construction of a dam and reservoir above Scotts Valley include flood control, groundwater recharge, recreation, water supply for irrigation and municipal use, and sustained stream flows that would benefit spring fish spawning conditions and aquatic habitat.

Construction of Lakeport Lake on Scotts Creek above Scotts Valley was first authorized by the United States Congress in 1965. In addition to the project's primary purpose of flood control, it was also designed and evaluated for benefits of municipal water supply, irrigation, recreation, and fish and wildlife enhancement. With these benefits considered, the project was considered to have a positive benefit to cost ratio (USACE 1965). Studies on project design and environmental impacts were continued into the 1970s; however, the project was not completed. A scaled down dam and reservoir for flood control were found not to be economically feasible in a 1984 study by the SCS (USDA SCS 1984). Lake County pursued and received water rights for the project; however, these rights were later lost after the project was deauthorized by Congress.

Project Description: As conditions change that may impact costs and benefits of the Lakeport Dam and reservoir, an updated cost-benefit analysis should be considered. Results of this analysis would determine whether the project should be pursued further

Key Participants: LCWRD and NRCS.

Timeframe: Initiate project in about 2020, two years for completion.

Technical Resources Required: Staff of participating agencies and consultants.

Cost Estimate: \$20,000.

Milestones: Complete cost benefit analysis.

Effectiveness Criteria: Completion of milestones.

2.8.14 Other Actions

- 3.10.2 Review and Revise County Wetland Policies and Ordinances
- 3.10.3 Encourage Wetland Mitigation Bank Development
- 3.10.4 Restore Stream Channel Hydrology and Associated Habitats
- 3.10.5 Fully Implement the Lake County Clean Water Program
- 3.10.6 Complete the Full Circle Wastewater Reuse System
- 3.10.7 Expand Wastewater Capital Improvement Programs
- 3.10.8 Improve Wastewater Treatment Options for Un-Sewered Areas
- 3.10.9 Create a Mandatory Trash Pick Up Ordinance
- 3.10.10 Implement the Lake County Community Wildfire Protection Plan
- 4.6.3 Protect and Restore Lake and Shoreline Wildlife Habitat
- 5.5.4 Develop Boat Pumpout Stations around Clear Lake
- 5.2.7 Improve Public Access at Blue Lakes
- 5.4.7 Protect Open Space
- 7.5.2 Pursue the Cache Creek Flow Enhancement Project
- 8.12.2 Update the Shoreline Ordinance (Chapter 23 Lake County Code)



Clear Lake Integrated Watershed Management Plan

Chapter 3

LAND USE IMPACTS

3.1 INTRODUCTION

This chapter begins with a description of Native American land use prior to European Settlement. It then briefly describes Lake County General Plan land use designations. This is followed by sections on major land uses, agriculture, rural lands, residential and commercial land use, and public lands. These sections include an overview of the land use and issues that occur primarily within the land use designation. These are followed by sections describing two major land use issues that occur throughout the watershed; soil erosion and sedimentation, and fire hazard and management. The final section describes proposed actions to improve resource management.

3.2 NATIVE AMERICAN LAND USE PRIOR TO EUROPEAN SETTLEMENT

At the time of European contact, Native Americans had been living in the vicinity of Clear Lake for at least 10,000 years. There were six major tribes; the Northern, Eastern and Southeastern Pomo, Lake Miwok, Patwin, and Wappo. Each tribe had a distinct language, and had a territory within or including some part of the Clear Lake Watershed. In some cases, these major tribes were divided into smaller tribes within the watershed. While Native Americans used a variety of natural resources for food, clothing, shelter, and tools, it appears that they lived in balance with the ecosystem, which supported abundant fish and wildlife, and clean air and water.

A description of the way of life for the Eastern and Southeastern Pomo around Clear Lake gives an idea of Native American resource use immediately around the lake (McLendon and Lowy 1978). Both tribes used tules, native rushes growing around the lake, to build boats and houses and make clothing. While fish from the lake were available year round, fishing activities were concentrated on the spring spawning season when vast numbers of fish filled the creeks surrounding the lake. Fish were dried and stored to be eaten for the rest of the year and were traded with other tribes. Other foods that were stored and eaten year round included acorns (made into bread and mush), grains, pepperwood nuts, and buckeyes. When available, fresh meat, water fowl, fresh greens, roots, bulbs, berries, and fruits were also consumed. Obsidian from volcanic deposits near Clear Lake was used for tool making and for trading with other tribes that needed this important resource. One way that Native Americans actively modified the

environment was through the use of fire. Fire was used to improve acorn harvests, travel, or hunting, and to increase food availability for prey animals (Williams, G.W. 2003).

With the arrival of Europeans in the Clear Lake Watershed, many new land use practices were introduced with substantial and often measurable effects on watershed processes. This chapter covers past and current land uses and their effects on water resource quality and quantity.

3.3 GENERAL PLAN LAND USE DESIGNATIONS

Lake County General Plan land use designations are summarized in Table 3-1 on the following page and shown in Plate 7. These designations and accompanying land use regulations and zoning ordinances are important tools to foster economic and social growth while maintaining quality of life and sustainable natural resources. By clearly defining areas for higher intensity urban services and land uses from areas emphasizing rural or resource use, they provide for sustainable management, conservation, and utilization of natural resources. The general plan land use designations do not correlate directly with the land uses discussed in sections below, however. For example, the agriculture section discusses both crop and livestock production. While large scale commercial crop production occurs primarily on lands designated in the general plan as agriculture, livestock grazing occurs on lands designated as agriculture, rural lands, rural residential, and resource conservation. Nevertheless, Plate 7, which shows General Plan land use designations in the Clear Lake Watershed, gives a broad idea of where land uses occur. Plate 8 shows federal, state, county, and private lands in the Clear Lake Watershed.

Table 3-1 Lake County 2008 General Plan land use designations, minimum lot sizes, residential densities, and typical and conditional uses.

Land Use Designation	Label	Minimum Lot Size	Residential Density (dwelling units/acre)	Typical Uses**	Conditional Uses***
Rural Residential and Agriculture					
Agriculture	A	40 acres	1 DU/40 acre	active or potential crop production, wineries, agricultural products processing	
Rural Lands	RL	20-60 acres	1 DU/20-60 acres	agricultural production, single family homes, game preserves, fisheries	recreational facilities, manufacturing, mining
Rural Residential	RR	5-10 acres	1 DU/5-10 acres	large lot single family homes, small-scale agriculture	agriculture-related services, recreational facilities
Urban					
Suburban Residential Reserve	SR	40,000 sq.ft.	1 DU/1-3 acres	single family homes	
Low Density Residential	LDR	6,000 sq. ft.	1-5 DU/acre	single family homes	
Medium Density Residential	MDR	8,000 sq.ft.	6-9 DU/acre	duplexes, triplexes, mobile home parks	
High Density Residential	HDR	10,000 sq.ft.	10-19 DU/acre	where adequate urban services are present, allows duplexes, townhouses, apartments	
Commercial					
Local Commercial	CL	8,000 sq.ft.		small, localized retail, recreational, and service businesses	
Community Commercial	CC	10,000 sq.ft.	10-19 DU/acre	full range commercial, retail, and service establishments	
Service Commercial	CS	20,000 sq.ft.		auto and equipment sales and services, construction sales and services, warehousing	
Resort Commercial	CR	10,000 sq.ft.		recreation, dining, hotels, motels	
Industrial					
Industrial	I	20,000 sq.ft. or 1 acre*		geothermal service yards, large construction yards, mills, lumber yards, welding and fabrication shops	
Resource Conservation					
Resource Conservation	RC	None specified	1 DU/20-40 acres	significant habitats, waterways, wetlands, parks, public lands (e.g. US Forest Service, State)	resource utilization operations and facilities
Public/Institutional					
Public Facilities	PF	None specified		parks, public marinas, schools, hospitals, water and wastewater treatment facilities	

*20,000 sq.ft. in areas with public water and sewer, 1 acre in areas lacking public water and/or sewer. **Not all typical uses are included. See Lake County General Plan (2008) for all typical uses. ***Conditional uses require permitting. Not all conditional uses are included. See Lake County General Plan (2008) for all conditional uses.

3.4 AGRICULTURE

3.4.1 Overview

Since the mid-1800s, when European pioneers arrived in the region, agriculture has been an important land use component and socioeconomic factor in the county. Today, events like the Kelseyville Pear Festival and the Lake County Wine Adventure continue to celebrate agriculture's important role in the county. Agriculture also provides open space and contributes to the rural character of Lake County. Although agricultural fields and orchards have replaced native wildlife habitat, they still provide habitat and food sources for many birds and animals. Many livestock grazing lands retain much of their natural character and are important wildlife habitat. Because the county recognizes the importance of agriculture, it has included a new Agricultural Resources Element in the 2008 General Plan with the goal of preserving and maintaining a viable and diverse agricultural industry in Lake County (Lake County 2008).

Early settlers in Lake County practiced subsistence level agriculture based on livestock and dairy. Wheat was the first crop to be exported in the 1870s to 1890s followed by wine grapes, pears, hops, walnuts, and "Blue Lake" beans (UCCE 1998). Over the decades, the mixture of crops and livestock produced in Lake County has changed considerably. For example, there were over 30,000 head of sheep in the county in the 1930s, while today there are no significant numbers of sheep raised in the county. Cattle numbers have declined in recent decades, but remain an important component of Lake County agriculture (Figure 3.1). A significant decline in pear acreage occurred due to pear fire blight disease and the Great Depression in the 1930s and 1940s. After rebounding to become the most economically important crop in the county in the 1970s and 1980s, recent market forces have led to a decline in pear acreage. Wine grape production died out following the Prohibition Act of 1920, but today wine grapes are the most valuable agricultural commodity in the county.

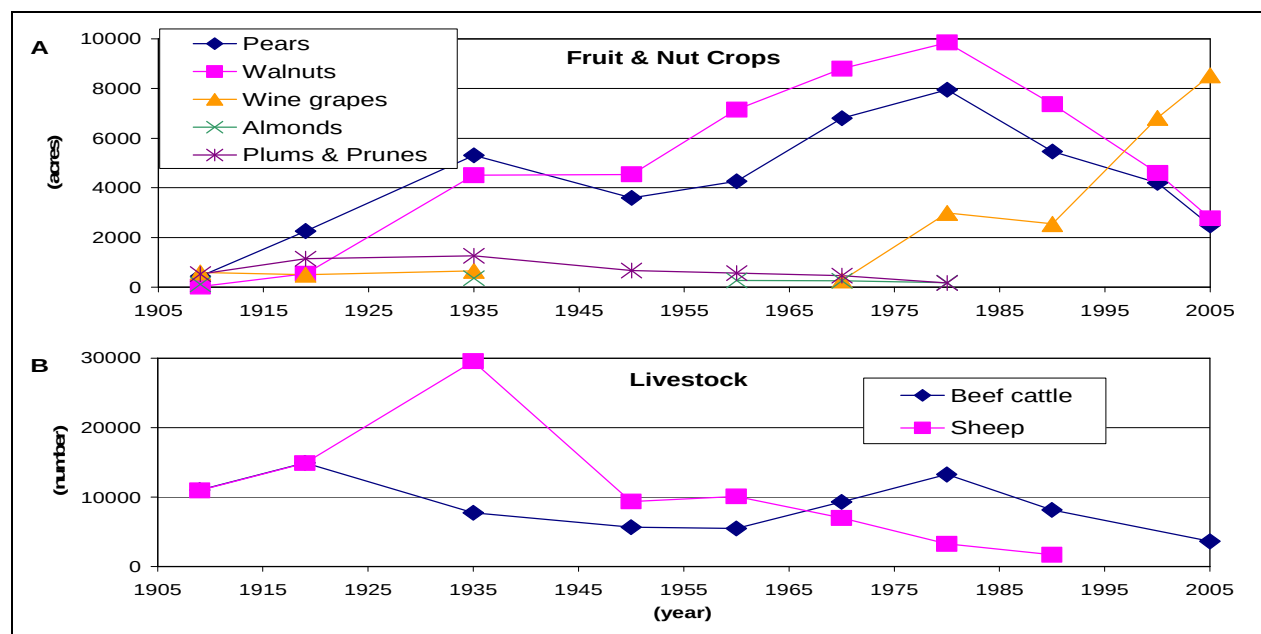


Figure 3-1 Changes in agricultural commodities in Lake County, 1910-2005.

Source: Annual Agricultural Crop Reports, Lake County Agriculture Department

As of 2007, there were 90,000 acres of rangeland, 3,900 acres of irrigated pasture, hay and wild rice, 13,479 acres of fruit and nut crops, 77 acres of nursery crops, and 50 acres of vegetables in the County (LCAD 2007). The value of total gross agricultural production was almost \$73 million in 2007, of which, wine grapes and pears were by far the most valuable commodities, comprising 60% and 19% of total agricultural sales in 2007 (LCAD 2007). The wine grape industry has become an important draw for tourists to Lake County. The number of wineries and tasting rooms in Lake County has increased from about five in 2000 to 24 in 2008.

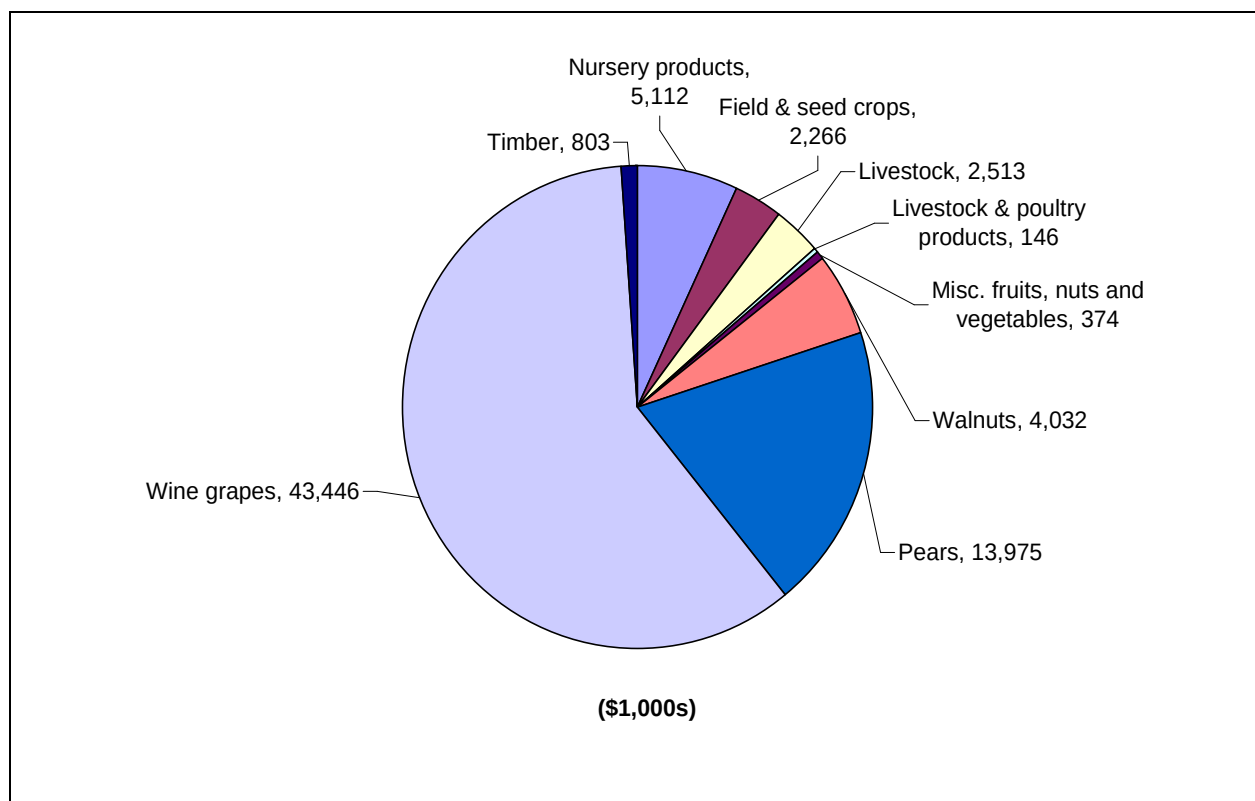


Figure 3-2 Gross agricultural production value, Lake County, 2007.



Figure 3-3 Big Valley vineyard (with alternating cover crop) in foreground, pear orchard in background. Photo taken in spring prior to vines leafing out. Photo courtesy of Lake County.

Since the arrival of European settlers in the county, most of the cropland in Lake County has been in the Clear Lake Watershed in and adjacent to Big Valley, Scotts Valley, and the community of Upper Lake. In recent years, substantial areas of vineyard have been developed on sloping terrain surrounding the Oaks and Lower Arms of Clear Lake. Some of these vineyards replaced walnut orchards, while others were developed in areas with native vegetation.

Raising livestock was the most common form of agriculture practiced during the early European agricultural settlement of the watershed. Today, the combined area of range land, irrigated pasture, and hay fields still dwarfs the area of other agricultural crops in the county (Section 3.8.2). A substantial portion of the lands used for livestock production lie within the Clear Lake Watershed. Privately owned rangeland and pasture are spread throughout the watershed but are concentrated primarily on the rolling uplands adjacent to Big Valley, Scotts Valley, and the communities of Upper Lake, Clearlake, and Clear Lake Oaks. There are also three publicly owned grazing allotments in the watershed in Mendocino National Forest (MNF).

Livestock grazed on publicly and privately owned lands in the watershed includes cattle, sheep, and horses. Because permits are not required to raise livestock on privately owned rangeland, there are no detailed records listing livestock populations or grazing intensities in the watershed. The United States Agricultural Census lists 3,270 cattle and calves, 694 hogs and pigs, and 1,239 sheep in Lake County in 2007 (USDA 2009).

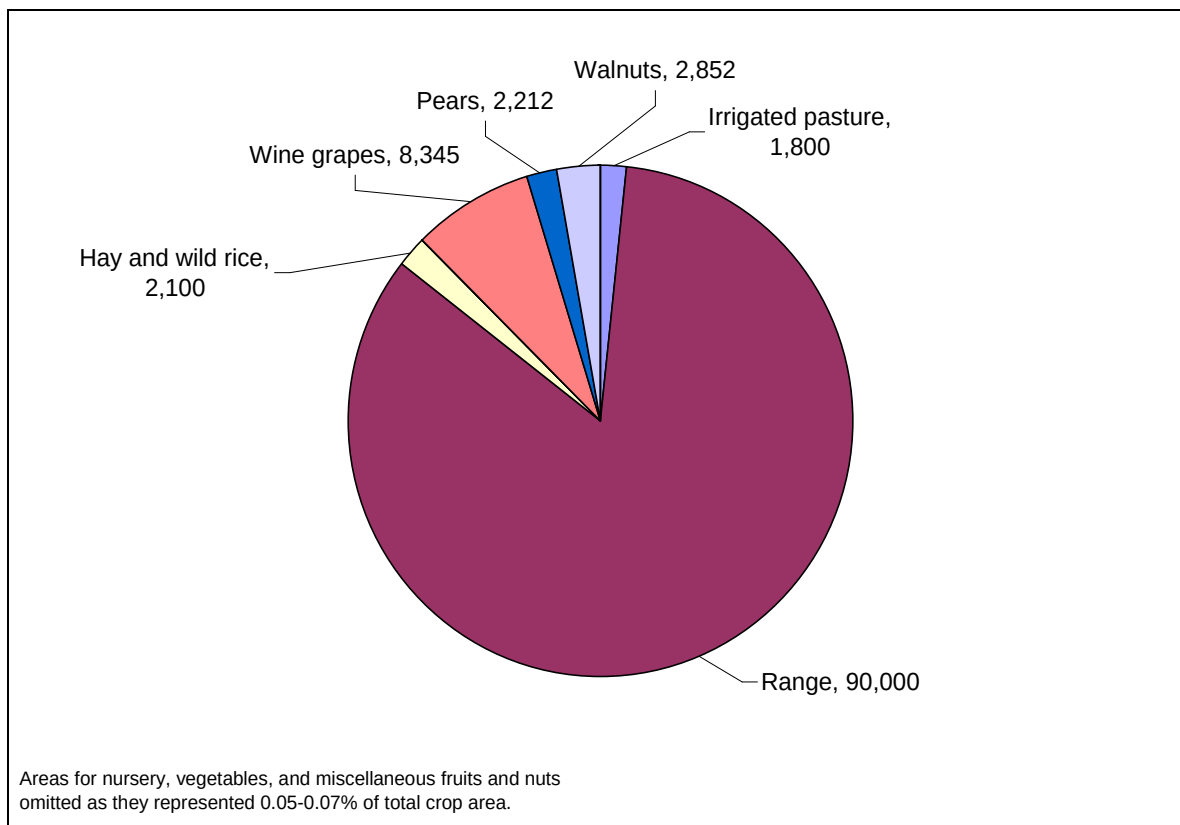


Figure 3- 4 Area of crops, rangeland, and pasture in Lake County, 2007.

The recent market conditions that have forced many pear farmers in the watershed to remove their orchards may have a substantial impact on agricultural land use. Between the years 2000 and 2007, approximately 2,000 acres, or 47%, of Lake County pear orchards were removed. Pear orchards are located on level ground that is generally well-suited to urban development or subdivision into small parcels for rural residential development. Much of the land that was or still is in pear orchards may be zoned Agriculture with a minimum lot size of 40 acres “to prevent development that would preclude its future use in agriculture” (LCCDD 2008). However, where orchards are comprised of one or more parcels smaller than 40 acres, the parcels can be sold individually, creating ownership patterns that may be too small for viable commercial agriculture. While walnut acreage has also decreased substantially since the 1980s, much of this land was on hillsides and was not prime farmland.

Another recent change in agricultural land use is the increase in vineyard acreage from approximately 2,550 to 8,350 acres from 1990 to 2007. Current weaker market conditions for wine grapes have led to a near cessation of vineyard expansion in the county. Many of the new vineyards were developed on former walnut orchards both in hillside and valley locations. Some areas formerly planted to pears are less well-suited because of heavy soil conditions. In some areas grasslands, oak woodlands, or chaparral were converted to vineyards. Potential erosion and sedimentation impacts from vineyard expansion are discussed in the erosion section ([Section 3.8.2](#)).

There has been a recent trend to increased organic farming in Lake County. As of 2007, there were 109 farms totaling 1,934 acres under organic production in the county. Walnuts make up the majority of organic acreage in the county at 1,708 acres (LCAD 2007).

Four issues of concern associated with agricultural development and land use in the watershed are:

- Wetland reclamation.
- Floodplain encroachment and stream channelization.
- Pesticide and fertilizer contamination of surface and/or ground waters.
- Reductions in the quantity and quality of groundwater.

3.4.2 Wetland Reclamation

Background

Wetlands are unique ecological systems that provide several crucial watershed functions. They provide floodwater storage, groundwater recharge capacity, and fish and wildlife habitat, and they retain, transform, and inactivate substances that might otherwise have deleterious effects on humans and the environment. Of the estimated 9,000 acres of wetland present at the time that European settlers arrived, an estimated 79% of wetlands surrounding Clear Lake have been lost, and more than half of that loss is attributable to agriculture.

Wetlands are highly productive ecosystems, providing food, water, and cover for over 160 species of birds and numerous amphibians, mammals, and reptiles (CDFG 2008a). They are a vital fisheries habitat providing increased food supplies and cover. Week (1982) found that most fish, both native and introduced in Clear Lake, preferred tule habitat. He emphasized the importance of wetlands as nursery areas for juvenile fish and shelter for spawning largemouth bass. Declines in the population of a subspecies endemic to Clear Lake, the Clear Lake hitch, *Lavinia exilicauda chi*, have prompted the formation of a local Coordinated Resource Management and Planning (CRMP) group, the Chi Council, dedicated to restoring hitch populations. Wetland vegetation may be important to the survival of juvenile hitch, which remain along the shoreline for approximately 80 days of their life cycle.

Large freshwater wetlands, like those formerly in the reclamation area adjacent to Rodman Slough and Tule Lake, have considerable capacity to filter sediment and nutrients from influent streams. Tule Lake still serves as a natural settling basin during high flows of Scotts Creek and is used for seasonal pasture and rice growing during the summer. Although the estimate of 70% reduction of the sediment and phosphorus content of Scotts Creek by Richerson *et al.* (1994) is probably an overestimate, Tule Lake is still likely to provide significant sediment and phosphorus retention (USACE 1997). A model used to determine phosphorus loading and potential reductions for the Clear Lake Nutrient Total Maximum Daily Load (TMDL) found that land use best management practices (BMPs) alone would not be sufficient to achieve sufficient reductions in sediment associated phosphorus to meet the TMDL target. In addition, wetlands restoration would be necessary (Tetra Tech 2004).

Tule Lake and the wetlands adjacent to Rodman Slough at the north end of Clear Lake were reclaimed for agricultural purposes from the early 1900s to 1940s. Together they represent 41% of the original wetland area and 51% of the area of wetland lost. Other large losses of wetlands included an early 1900s landfill on wetlands adjacent to the City of Lakeport that extended the shoreline lakeward several hundred yards, and conversion of a wetland in Clearlake Oaks to man-made peninsulas in the 1960s (known as the Clearlake Keys). The 1962 channelization of Kelsey Creek at its mouth at the State Park and the 1964 channelization of Adobe Creek as part of the Adobe Creek Flood Control project also reduced shoreline wetlands in these areas. All around the lake, smaller areas of shoreline tules and other wetland vegetation have been replaced by bulkheads, docks, marinas, and boat ramps (Week 1982).

Management



Figure 3- 5 Rodman Slough, view toward north east.
Photo by Tom Smythe.

Recognizing an important opportunity for wetland restoration at the outlet of the two largest tributaries to Clear Lake, Lake County has been pursuing the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project (Middle Creek Project) since 1995 (USACE 2003). The project would restore approximately 1,650 acres of land by breaching levees and allowing the land to flood. About 1,400 acres of this land would become wetlands and open water, which would double the current area of wetlands around Clear Lake (CLTSC 2008). A

detailed description of this project and its status is given in [Section 2.8.2](#).

To prevent further destruction of tules and other native emergent aquatic vegetation around Clear Lake, Section 23-15 of the Clear Lake Shoreline Ordinance was adopted in 2003. The ordinance states that “On residential properties, within the nearshore and foreshore of littoral parcels, management activities that result in the death of woody species (i.e. willow, cottonwood, buttonbush) and tules (scirpus sp., bulrushes) is prohibited. The above types of vegetation may be mowed, pruned or trimmed so long as it does not result in the death of the plant.” For commercial, resort or public properties, a lakewide, no-net-loss program is in place that requires replacement planting for any new areas of beach cleared.

3.4.3 Floodplain Encroachment and Stream Channelization

Background

Floodplains provide important ecological services, dissipating flood waters, settling out sediment and nutrients, and contributing to groundwater recharge. Riparian vegetation along streams and creeks is important to stream function, provides vital bird and wildlife habitat, and benefits adjacent aquatic habitat. Beginning with the arrival of European settlers, large changes in floodplain and stream channel morphology and functioning have occurred that impair many of these ecological benefits.

Most naturally occurring streams and rivers in floodplains have a meandering (sinuous) pattern. This pattern creates an alternating series of pools at the bends of the watercourse and riffles (shallow, gravelly areas) in between the bends. The stream form is dynamic with the meanders migrating over the floodplain. Large woody debris contributes to pool formation and supports high densities of aquatic macroinvertebrates that are an important food source for fish (Leopold, L.B. 1997, NRCS 1998). In their natural state, many stream banks are heavily vegetated. This vegetation moderates water temperatures, is an important source of food to aquatic systems, and is valuable terrestrial wildlife habitat.

Stream channelization caused by direct stream modifications, flood control projects, and gravel mining has multiple effects on stream hydrology and riparian habitat. Straightening disrupts the pool and riffle sequences that are important components of aquatic habitat. It also increases the velocity of water moving through the stream channel, which can lead to increased scouring and channel deepening. These unstable conditions may increase streambank and channel erosion and therefore sediment loads. Reservoirs prevent downstream movement of gravel that could replace gravel removed by mining. Construction of floodwalls and levees can increase stream velocity by constraining high flows to a narrower channel and allowing greater flood heights. Construction of levees also involves removal of riparian vegetation that is an important component of aquatic and terrestrial habitats. Large woody debris, which contributes to pool formation and aquatic habitat, is removed for flood protection (Leopold, L.B. 1997, NRCS 1998).

Valleys with wide floodplains and meandering streams are often well-suited for agriculture because they have fertile soils, level topography and readily available water for irrigation. Beginning in the 1850s, European arrivals in Lake County began to settle the large floodplains around Clear Lake in valleys such as Big Valley, Scotts Valley, and the valleys around Upper Lake. Along with scattered farm houses, towns such as Kelseyville and Upper Lake were constructed in these same flood-prone areas.

In order to prevent flooding and improve agricultural efficiency, it is likely that stream channel alterations began soon after settlers arrived. Deacon describes channelization of Scotts Creek in Scotts Valley in the 1870s to 1890s (Deacon 1948). Significant modifications to the courses of Middle and Clover Creeks near the town of Upper Lake were apparent on a 1916 United States Geological Survey (USGS) map (USACE 1997). By 1940, when the first set of countywide aerial photos were taken, most of the channel straightening still visible today had already occurred (ELRCD, WLRCD and LC 2009a, 2009b and 2009c). The effects of a major channel alteration were documented when the mouth of Kelsey Creek was straightened and deepened at Clear Lake State Park in 1962. Along with in-stream gravel mining occurring during this same time period, this channel alteration led to down-cutting of up to 10-15 feet in the lower Kelsey Creek channel, and the down-cutting continued upstream to what is known as the canyon, 7.5 miles above the mouth of Kelsey Creek (ELRCD, WLRCD and LC 2009a). In Eight Mile Valley in the upper portion of the Scotts Creek Watershed, re-routing of stream channels has created gullies up to 12 feet deep (ELRCD, WLRCD and LC 2009c). Other sections of stream channel with serious streambank erosion and channel incision that were identified in the Middle Creek and Scotts Creek Watershed Assessments are Scotts Creek in the vicinity of the confluence of the main and south fork and Middle Creek in the vicinity of the confluence of the east and west forks and downstream to the town of Upper Lake.

Flood control projects to reclaim land for agriculture and protect residential areas often include straightening stream courses. They also include levee building, channel maintenance to remove vegetation and debris, and building reservoirs to retain floodwaters. Private landowners and local reclamation districts built numerous levees to reclaim land in the Middle Creek wetland area from approximately 1900-1940 and along Scotts, Middle, Clover, and Adobe Creeks to prevent flooding. Levees on Scotts Creek from the south end of Hendricks Road to 1.5 miles past Eickhoff Road separate Scotts Creek from its floodplain, potentially increasing downstream flows (Tom Smythe, personal communication).

A major expansion and improvement of levees around the Middle Creek Reclamation Area and the town of Upper Lake, the Middle Creek Flood Control Project, was begun by the United States Army Corps of Engineers in 1959 and completed by 1966. It consisted of a by-pass to divert excess flows of Clover Creek above the town of Upper Lake to Middle Creek as well as 7.5 miles of new or improved levees along this by-pass and portions of Middle and Scotts Creek in the vicinity of Upper Lake and the Reclamation Area (USACE 1957). Immediate effects of this project could be seen following the floods of 1964-1965. Channel

scouring occurred in the project area, and bank erosion continued upstream from the project to the vicinity of the Hunter Bridge (LCFCWCD 1965).

In 1962, two reservoirs for flood control and recreation, Adobe and Highland Springs Reservoirs, were built (Christensen Associates Inc. 1993), and portions of Adobe Creek downstream of Highland Springs Reservoir were channelized to reduce flooding. The combination of channelization, elimination of gravel recharge by the dams, and gravel mining has lowered the channel of Adobe Creek up to six feet in some areas (Tom Smythe, personal communication).

Multi-purpose reservoirs, for flood control, groundwater recharge, augmentation of surface water supplies, and recreation have been proposed for Kelsey and Scotts Creek as well (SMFE 1964, Tudor Engineering Company 1981, USACE 1963, 1972a, 1972b). Feasibility studies found these projects to be cost prohibitive, and they have not been pursued.

With the arrival of European settlers, livestock use of stream channels began. Without proper management, livestock can significantly reduce riparian vegetation through over-grazing and trampling. Over-grazing reduces vegetative cover leading to potential soil erosion. Trampling and trailing can lead to soil compaction and break down stream banks, contributing to erosion and sedimentation (NRCS 1998). The placement of corrals, barns, and other animal confinement facilities near streams may contribute fecal contaminants to water. In some instances, landowners raising small numbers of animals with improper management and/or limited confinement area can cause severe overgrazing or stream damage in localized areas.

In-stream gravel mining, while not directly related to agriculture, contributed to channel straightening and deepening and to removal of riparian vegetation. Large-scale use of aggregate for road paving in Lake County began in the 1920s while use of aggregate in concrete foundations of buildings began in the 1930s. Prior to the availability of automobiles and trucks and the development of an improved road system, aggregate mining came from small local sources. By the 1920s, large, centralized operations along creeks began to operate (LCPD 1992). In the areas where large-scale in-stream gravel mining occurred in Scotts, Middle, and Kelsey Creeks, 1940-1941 aerial photos show wide gravel stream courses that were nearly bare of vegetation, possibly due to gravel mining that had already occurred. New sections of Highway 20 from Blue Lakes to Upper Lake and Highway 29 from the Nice Lucerne cut-off to Kelseyville were built from the 1960s to early 1970s. This created a very large demand for gravel from Scotts, Adobe, and Kelsey Creeks. It is estimated that 500,000 cubic yards of gravel were removed from Scotts Creek alone (SVWCD 1988).

Channel incision causes reduced groundwater storage (Section 2.6). Lower groundwater tables due to channel incision have been documented for Scotts, Middle, Adobe, and Kelsey Creeks (ELRCD, WLRCD and LC 2009a and 2009c, LCWRD 2000). A description of Kelsey Creek illustrates the kinds of changes that occurred:

“Formerly, the channel was only a few feet below the general level of the plain, and the stream flowed in any, or all, of several courses, which shifted back and forth over an area of up to 1,500 feet width. This condition frequently led to flooding of the area around and within Kelseyville, but it also provided a much larger area for the first stages of infiltration from the creek to the aquifers of the Kelseyville Basin” (LCFCWCD 1999).

While the channelization of Kelsey Creek has been detrimental to groundwater recharge, it has substantially benefited residents of Kelseyville by reducing flooding. Likewise, the reservoirs and channelization on Adobe Creek and the levee system around Upper Lake provide valuable flood protection to residents at considerable cost for continuous levee maintenance.

Management

Concerns that gravel mining was lowering the creek bed and reducing groundwater levels in Kelsey Creek led to the adoption of a Creek Management Plan for Lake County in 1981 (updated and renamed the Aggregate Resources Management Plan [ARMP] in 1994) and a moratorium on gravel mining in several creeks tributary to Clear Lake. Areas where moratoriums were designated include Kelsey Creek below the canyon three miles south of Highway 29 north to Clear Lake, Adobe Creek, Scotts Creek, and portions of Middle Creek. The ARMP has led to significant improvements in stream conditions. “Implementation of gravel mining regulations has significantly reduced in-stream



Figure 3- 6 Large areas of open space and agriculture flooded in the New Year’s Eve storm, 2005-2006 in Scotts Valley with relatively little property damage. Photo by Greg Dills.

gravel mining in Lake County, with no major in-stream gravel mining operations permitted at this time. The reduction of in-stream gravel mining has reduced in-stream channel and bank erosion below historic levels and riparian habitat has been increasing, restoring the natural and beneficial functions of streams” (CLTSC 2008).

To improve groundwater recharge, the Kelsey Creek Detention Structure was built in 1987. Located approximately 1.5 miles north of the Main Street Bridge in Kelseyville, it forms a 10 feet high dam when control gates are closed. This raises the level

of Kelsey Creek upstream to increase groundwater recharge. Operation of the detention structure is constrained by requirements to open the gates to permit

spring migration of spawning Clear Lake hitch and maintenance of bypass flows. Between the detention structure and Renfro Crossing, four drop structures were created for gravel retention between 1989 and 1995.

On Middle Creek, four rock weirs were placed downstream of the Rancheria Road Bridge (2005-2006) to retain gravel and permit passage of the Clear Lake hitch. Stream down-cutting required building of a footing that makes an approximate 4 foot barrier across the creek at the bridge. Gravel retention in the rock weirs will create a series of steps up to the bridge that lowers the height of the barrier and permits fish passage.

Today planners and resource managers in Lake County recognize the benefits of restricting land use in floodplains. Critical facilities are not permitted in the 100 year flood zone, and any residential construction in this zone must be developed to minimize flood risk and ensure safe access during floods (LCCDD 2008). Passive recreation activities, such as hiking and horseback riding, and agriculture are land use activities compatible with floodplains. For the Middle Creek Project, 18 flood-prone residences would be purchased along with the land purchase, and sub-standard levees would be breached allowing restoration of approximately 1,400 acres of wetland (USACE 2002).

3.4.4 Pesticide Use

Background

Pesticides are used to improve crop yields, to reduce and/or eliminate invasive species and vector-borne diseases, and to maintain infrastructure such as roads and buildings. Pesticides have the potential to adversely affect aquatic and terrestrial organisms, including humans. Pesticides applied directly to water bodies are covered in [Section 2.2.4](#). Pesticides applied on land are covered here. On land pesticides are used in agriculture, along roadsides, to control disease vectors such as mosquitoes, and in residential and commercial settings. Land-applied pesticides have the potential to enter water through drift, run off into surface waters, or leaching to groundwater. Where the applications are distant from water bodies, however, they are likely to be degraded, absorbed, or assimilated before potential contamination can occur.

The great majority of pesticides in Lake County reported to the state Department of Pesticide Regulation (DPR) are used in agriculture. Wine grapes and pears, which accounted for 83% of total Lake County agricultural commodity value in 2005 (Figure 3.2) used 96% of the total weight of pesticide use in Lake County in 2006 according to Pesticide Use Report data compiled by the DPR. However, the potential environmental threat posed by wine grape and pear pesticide use is mitigated by the types of chemicals used. Sulfur, both elemental and lime sulfur, and petroleum oil account for 83% and 93% of the weights of pesticides used in pears and wine grapes, respectively. Both sulfur and oil are acceptable for organic farming, and both have low toxicity. These materials present a hazard when proper protective gear is not used because direct contact with these chemicals can cause irritation of lung passages, skin, or eyes.

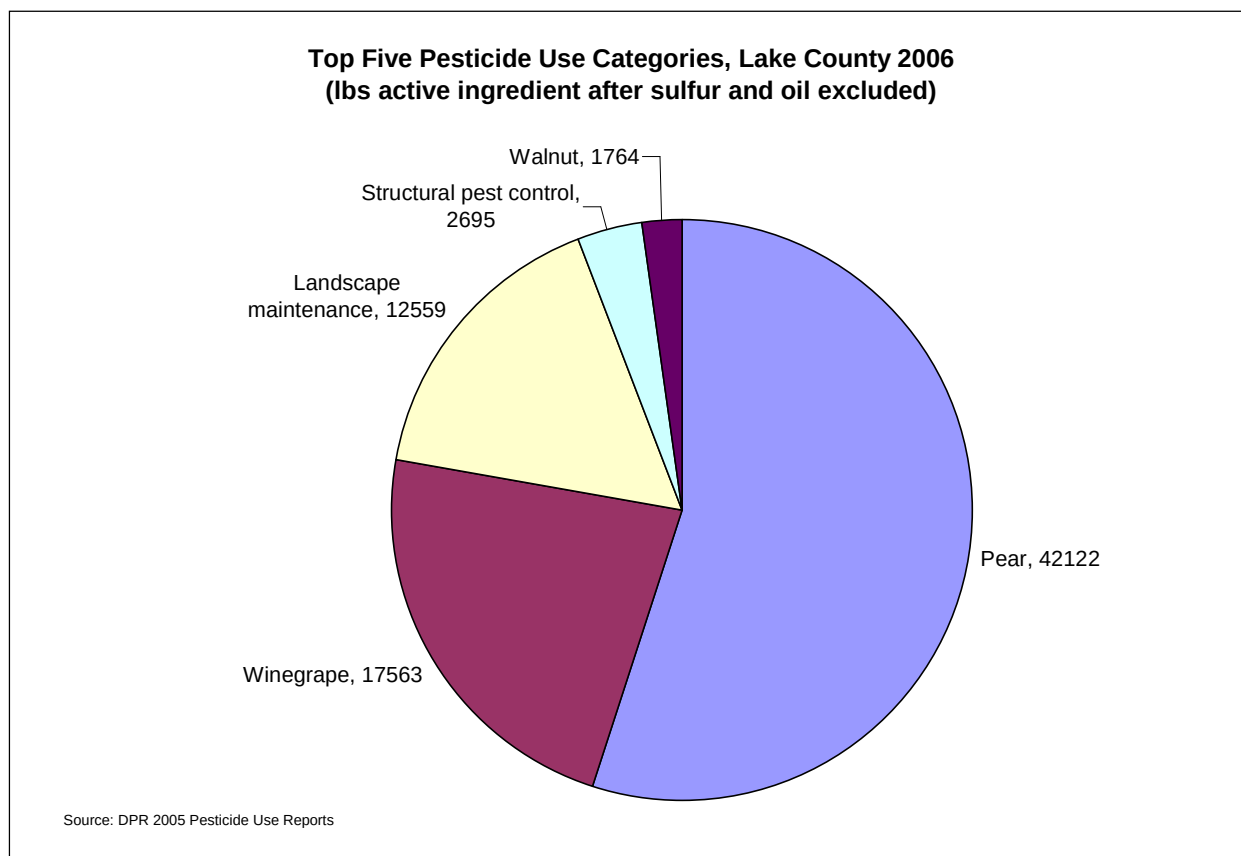


Figure 3- 7 Pesticide use for the top five user categories in Lake County, 2006.

Two pesticides, simazine and ziram, were highlighted as concerns in the Clear Lake Watershed Sanitary Survey 2007 Update (CLWSS), a report made by Clear Lake water utilities to the California Department of Public Health (CDPH).

Simazine is a persistent herbicide with the potential to leach to groundwater or persist in surface waters. Farmers have become aware of its potential environmental effects and are using less of it. Simazine use declined significantly from 2001 to 2005 for wine grapes and pears. However, its use increased significantly for landscape purposes during this time period (Forsgren Associates, Inc. 2007). In 2005, use by commercial landscapers accounted for 64% of reported simazine use in Lake County, and the CLWSS recommends that future monitoring “should include monitoring near storm drains servicing residential and urban areas.” The next highest reported use category was wine grapes with 25% of simazine use. The CLWSS also noted that drinking water providers have not detected simazine in Clear Lake water samples since 2000.

Ziram is a persistent fungicide used on apples and pears. Its use on pears increased four-fold from 2001 to 2005. Although it is not a regulated drinking water constituent, the Clear Lake Watershed Sanitary Survey recommends that a request be made to the Office of Environmental Health Hazard Assessment to evaluate whether ziram in drinking water might be a public health concern.

Management

Pesticide use for food crops and some other uses is highly regulated by the United States Environmental Protection Agency (USEPA) and by the DPR. Under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the USEPA sets strict standards for testing, licensing, and labeling pesticides. Pesticide labels are legal documents that prescribe how a pesticide must be used. Label information defines the crops or other uses for which the pesticide can be used, use rates, required protective equipment, and whether the chemical is for general or restricted use.

In 1972, the U.S. Congress passed amendments that greatly strengthened FIFRA, and since then many pesticides have been taken off the market or have had their use restricted (Aspelin 2003). The 1996 Food Quality Protection Act (FQPA) expedited the process to re-evaluate pesticides for cumulative exposures and safety to infants and children. It also facilitated registration of reduced-risk pesticides.

Like the USEPA, DPR evaluates all pesticides to be used in California for safety and effectiveness. DPR oversees licensing and certification of pesticide dealers, pest control businesses, pest control advisors, and pesticide applicators. County Agricultural Commissioners and their staff provide local enforcement of pesticide regulations. Restricted use pesticides can be purchased and applied only by certified commercial or private applicators under a permit issued by the county Agricultural Commissioner. Since 1990, DPR has required pesticide use reporting of all applications made to food crops and for many non-agricultural applications as well. Pesticide user groups not required to report pesticide use include residents applying pesticides to homes or landscapes, pet groomers and kennels, and facility managers of commercial, industrial or institutional facilities (Wilen *et al.* 2005).

Not only is agricultural pesticide use highly regulated, local Lake County pear and wine grape growers have made significant strides toward reducing pesticide use. Beginning in the mid-1990s, Lake County pear growers began to adopt the use of pheromone mating disruption to control the main pear pest, codling moth. Use of mating disruption greatly reduced the use of organophosphates for codling moth control, eliminated the need for fall spider mite control, and reduced the need for in-season mite control. Growers have also switched to reduced-risk pesticides such as insect growth regulators and bacterial products in place of organophosphates and other pesticides (Varela and Elkins, 2008).

Wine grape growers in Lake County support a marketing order, the Lake County Winegrape Commission, which markets their grapes and provides sustainable wine grape production education. Since 2002, over 70% of Lake County wine grape growers have participated in workshops where they assess the sustainability of their vineyard operations (Lundquist 2005). Numerous meetings on topics in sustainable pest management and other aspects of sustainable viticulture have also been offered. A study comparing pesticide use in wine grapes in Lake County with other North Coast counties, a Central Valley county and a Central Coast

county from 2002-2004, showed that Lake County had the lowest rates of pesticide use of all these counties (Lundquist 2006).

A majority (63%) of Lake County walnuts are grown organically. The National Organic Standards Board defines organic agriculture as “an ecological production management system that promotes and enhances biodiversity, biological cycles, and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain, and enhance ecological harmony,” and “‘organic’ is a labeling term that denotes products produced under the authority of the Organic Foods Production Act” (Organic Trade Association 2008). While the organic acreage of Lake County crops other than walnuts is still limited, organic acreage appears to be increasing, especially of wine grapes.

In the past, agricultural pesticide contamination of surface waters was not regulated or monitored; however, recent regulatory changes require monitoring of potential discharges from irrigated agricultural lands to waterways. On December 31, 2002, the Central Valley Regional Water Quality Control Board (CVRWQCB) adopted a “Conditional Waiver for Irrigation Return Flows and Storm Water Runoff from Irrigated Lands.” This conditional waiver requires dischargers to apply for individual Waste Discharge Requirement Permits or to participate in a watershed group that assists in monitoring and achieving water quality objectives. Due to the permit and monitoring expense for individual permits, almost all irrigated agricultural landowners in Lake County have joined the SVWQC to comply with the conditional waiver requirements.

As part of the SVWQC water quality monitoring plan submitted to the CVRWQCB, monitoring is carried out in Lake County three times a year. The first sample occurs with the first stream flow during the rainy season, the second occurs during the time when dormant oil sprays are applied to pears in the winter, January-February, and the third occurs in spring, May-June, during the irrigation season and before streams have dried up. Monitoring includes water and sediment toxicity tests, physical water quality parameters, and levels of pesticides, metals, and nutrients. If pesticides are detected, evaluations are made of pesticide use in the area by the Agricultural Commissioner (SVWQC 2004).

The SVWQC locations for monitoring in the Clear Lake Watershed were prioritized based on the percentage of agriculture in the sub-watershed. In 2005 and 2006, McGaugh Slough in Big Valley was monitored. The only exceedance found in McGaugh Slough was for the bacteria species *E. coli*; however, there has been no determination as to whether the source of the *E. coli* was from livestock, birds, humans, or another source. Monitoring shifted to Middle Creek in 2007. No exceedances were found, but DDT (dichloro- diphenyl- trichloroethane) was detected below drinking water standards. DDT has not been used in the United States for more than 30 years, but it is a very persistent chemical that binds to soil particles. Activities in or around the creek may have disturbed contaminated sediments leading to the detection. Location of the source is unknown (Tom Smythe, personal communication).

In 2010, the SVWQC will begin developing a management plan for *E. coli*. The plan will include gathering information at the local level on potential sources of *E.*

coli from irrigated lands and defining management practices to reduce potential E. coli contamination. Examples of management practices could include exclusion of livestock from stream areas and use of vegetation buffers to ensure that manure applied in agricultural operations does not reach surface water.

There have been no reported detections of pesticides in Lake County groundwater. Since 1983, California state and local agencies that sample wells for pesticides have been required to send their reports to DPR, and no detections have been reported in Lake County (DPR 2003-2006).

3.4.5 Fertilizer Use

Fertilizer use in agriculture has the potential to impact surface and ground waters. University of California Cooperative Extension (UCCE) cost studies for pears and walnuts indicate that nitrogen is the only nutrient applied at significant rates (UCCE 2003, 2005). The typical range in application rates for pears and walnuts is from 100-250 lbs N/acre/year (Rachel Elkins, personal communication). Nitrogen is applied at lower rates (0-100 lbs N/acre/year) to wine grapes, along with calcium and potassium (UCCE 2008a and 2008b). Nitrogen fertilizer has the potential to leach to groundwater as nitrate, and nitrate at high levels in drinking water is a health concern. A discussion of nitrate levels in groundwater is found in the Water Resources Chapter ([Section 2.5](#)) and in [Section 3.4.6](#) below. Calcium and potassium are readily bound to soil particles, and therefore do not easily leach. They could potentially be transported to surface waters attached to sediments; however, they are already plentiful and do not stimulate algal growth in Clear Lake Watershed surface waters. Phosphorus is applied to wine grapes in areas with volcanic soils at rates of 20-30 lbs P/acre/year. Phosphorus is tightly bound to soil particles, so soil erosion would be the main way in which fertilizer phosphorus could reach the lake. For several reasons, however, vineyard phosphorus fertilization is unlikely to contribute significantly to Clear Lake phosphorus loads. The amount of phosphorus applied is small relative to the amount found naturally in sediments. Thirty lbs P/acre of phosphorus applied to six inch depth would give a soil phosphorus content equivalent to about 2% of the average total phosphorus measured in sediments in Clear Lake Watershed streams (LCWPD 2009). In addition, not all applied phosphorus remains in the soil. A portion of the applied phosphorus is taken up by the vines and removed from the site at harvest. Vineyards occupy 2.6% of the land area in the Clear Lake Watershed, and only a fraction of these vineyards are located on volcanic soils. Finally, vineyards use a variety of practices to minimize soil erosion ([Section 3.8.2](#)).

Fertilizer is also applied to residential and commercial landscaping. Nitrogen fertilizers have the greatest potential to leach to groundwater; other fertilizers may move in surface runoff contributing to stormwater pollution ([Section 3.6.2](#)).

3.4.6 Groundwater Quality and Quantity

Background

Agriculture accounts for a significant majority of water use in the Clear Lake Watershed, 82% according to a recent water use inventory (Table 3-2). Since agriculture relies primarily on groundwater, it is also the biggest user of groundwater.

Table 3-2 Summary of water use in the Clear Lake Watershed in an average year (acre-feet).

Agriculture*	Municipal and Industrial	Conveyance Losses	Total Water Use
45,103	8,971	1,019	55,093

Source CDM and DWR 2006c.

*Agricultural water use described in the CDM and DWR 2003 study does not include water for frost protection; therefore their estimate has been increased by 39% based on the report by Christensen Associates Inc. (2003) which estimated the contribution of frost protection water to total agricultural water use for Big Valley.

Potential detrimental effects of groundwater overdraft listed in the Big Valley Ground Water Recharge Update (2003) include:

- Water shortages during droughts that impact agricultural production and local domestic water supplies.
- Drying up of wells during droughts, requiring deepening of wells or new sources of water supply.
- Increases in energy needed for pumping water from deeper levels.
- Deterioration of groundwater quality due to intrusion of hydrothermal water containing iron and boron.
- Ground subsidence which potentially reduces available groundwater storage and changes surface drainage patterns.
- Impacts on fish, wildlife, and riparian vegetation due to reduced streamflow and earlier drying up of creeks due to lowered water table (Christensen Associates Inc. 2003).

There is anecdotal or verifiable evidence for many of these impacts. During past droughts, water levels have dropped significantly, and in some cases wells have gone dry. Figure 3-7 shows a hydrograph from Big Valley. Well levels fluctuate from high in spring to low in fall, and the lowest levels were measured in 1977, a year of extreme drought and 1992, after a prolonged period of drought. The most significant ground subsidence has occurred in Scotts Valley where up to 3.5 feet of subsidence has occurred over the confined aquifer portion of the valley (SVWCD 1988). In Big Valley, ground water subsidence of 3.6-5.8 inches has been documented for a well near Finley.

There is no conclusive evidence that groundwater overdraft has led to intrusion of hydrothermal waters. An analysis of groundwater quality data are available only for Big Valley (Christensen Associates Inc. 2003). This analysis found chemistry indicating the presence of hydrothermal waters in some areas of Big Valley; however data were insufficient to relate water quality to changes in water levels

(Section 2.5). Increasing nitrate levels are found in some areas of Big Valley, potentially from fertilizer, livestock, or human waste. However, there is insufficient information to identify the source. As stated in the section above, pesticides have not been detected in Lake County wells.

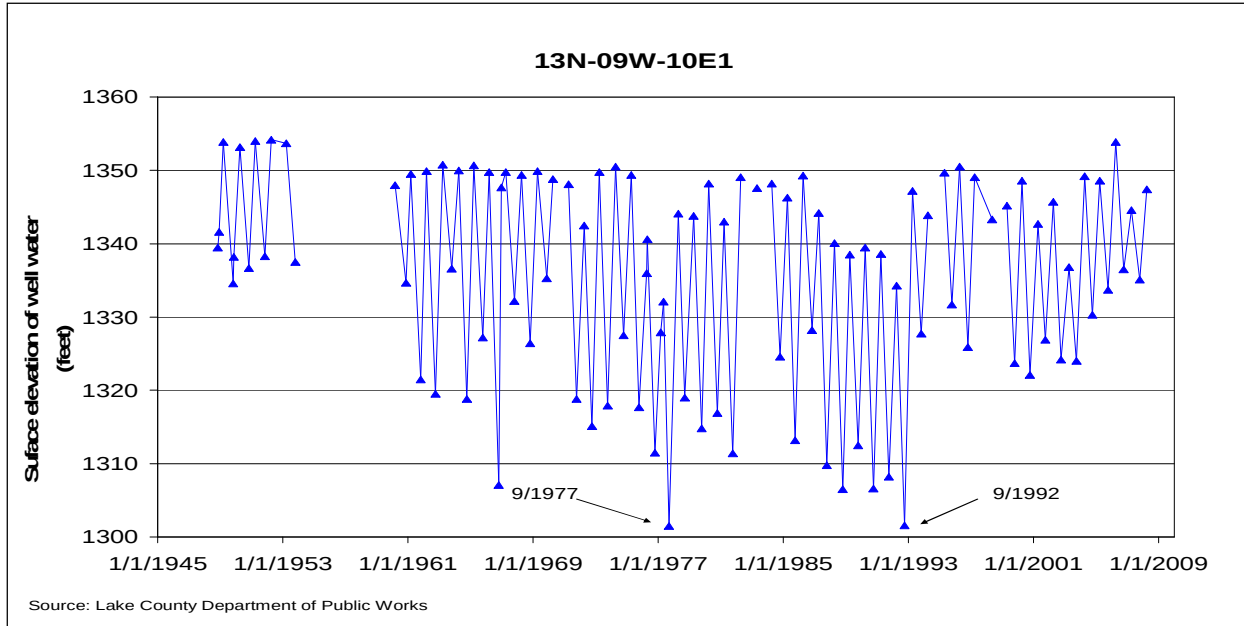


Figure 3- 8 Spring and fall water levels in well 13N-09W-10E1 located 0.6 miles west of Kelsey Creek on Big Valley Road.

Recent changes in the crops grown in the watershed have reduced the demand for groundwater, especially in the major valley groundwater basins such as Scotts Valley, Upper Lake Valley, and Big Valley. Pear acreage has declined from a peak of about 8,000 acres in 1980 to about 2,200 acres in 2007 (LCAD various). Most pear orchards were and are located in valleys, and much of the acreage formerly occupied by pear orchards is not currently in agricultural production. Wine grape acreage more than tripled to 8,300 acres from 1990 to 2007 (CASS 1998, CDFA 2008); however, a significant proportion of this increase was in mountainous areas using groundwater resources local to these areas. In addition, pears require 2-5 times as much irrigation water as do wine grapes on an area basis (CDM and DWR 2006c, Christensen Associates, Inc. 2003).

The monitors well water levels, and there is some evidence for recent reductions in groundwater use. Preliminary analysis of 16 wells in Big Valley showed lower than average draw-down in 2008, even though it was a lower than average rainfall year (Tom Smythe, personal communication).

While it is impossible to predict future cropping patterns, the past has shown large changes in cropping patterns combined with a steady increase in the population of the county. The three scenarios for agricultural water demand in the Lake County Water Demand Forecast (CDM and DWR 2006b) predict a 7% decrease, 2% increase, or 21% increase in agricultural water demand by 2040 depending on the

mixture of crops by that time (Table 2-7). During this same time, urban water use is predicted to increase as much as 39%.

Management

UCCE and the Lake County Winegrape Commission continue to provide education on improved water monitoring and irrigation methods, and farmers have adopted a wide variety of tools to improve irrigation water use efficiency that were not available in the past. Wine grape growers and some walnut growers use low flow irrigation systems that reduce the area of wet soil surface, and therefore reduce evaporative water loss. Farmers use a variety of instruments to measure plant and soil water status, and farmers and local agencies support a network of weather stations with internet accessible weather data, so farmers can match water use to current weather conditions (Lake County Weather Page 2008).

The Big Valley Groundwater Management Plan (1999) and the Lake County Groundwater Management Plan (2006) provide guidance on managing groundwater resources. These plans have been adopted by the Lake County Board of Supervisors. Objectives of the Lake County Groundwater Management Plan include maintenance of a sustainable high quality water supply for agricultural, environmental, and urban uses, facilitation of projects to replenish groundwater, and improved understanding of groundwater resources. Goal WR-3 of the Lake County General Plan (2008) is “to provide a sustainable, affordable, long-term supply of water resources to meet existing and future domestic, agricultural, industrial, environmental, and recreational needs within the county, so as to maintain sustainability between new development and available water supplies.” Implementation measures include designating and managing groundwater recharge areas, managing groundwater resources to ensure sustained yields, working with public agency water providers and local stakeholders to develop groundwater management partnerships, identifying critical water resource areas, and participation in local, state, and regional water resource planning efforts.

Lake County is in the process of developing an Integrated Water Resource Management Plan (IRWMP). The proposed planning area for the IRWMP will encompass the Clear Lake Watershed and is comprised of the Cache and Putah Creek Watersheds as well as most of the remaining area of Yolo County. More details on the IRWMP are given in the Water Resources Chapter ([Section 2.3](#)).

3.5 RURAL LANDS

Background

The rural land use category in Lake County is intended “to allow rural development in areas that are primarily in their natural state” (LCCDD 2008). It is used largely for lands that are remote or have steep topography, and typical uses include “animal raising, crop production, single family residences, game preserves, and fisheries.” The importance of rural lands for watershed functions

such as groundwater recharge, collection, and filtering to improve water quality is also recognized in the Lake County General Plan. Many of the uses of rural lands are covered elsewhere in this document. Residential land use is covered in the following section, and livestock grazing was covered in the preceding section on agricultural land use. Wildlife habitat and recreation are covered in separate chapters. A limited amount of timber production occurs on private lands in Lake County, primarily in rural lands.

Another land use that occurs primarily in rural lands in Lake County is geothermal energy production. Geothermal energy generation uses steam, produced by groundwater exposed to molten rock near the earth's surface, to drive turbines that generate electricity. Although geothermal energy is considered a renewable energy source, over-production from the steam fields has led to declining steam and energy production. To maintain current levels of geothermal energy production treated wastewater from Lake County and the City of Santa Rosa is now injected into the steam fields (Section 3.6.4). The Geysers steam fields extend across northeastern Sonoma County and southern Lake County. The portion of the Geysers steam fields that occur within the Clear Lake Watershed lies along the southern edge of the watershed, almost entirely within the Kelsey Creek sub-watershed. There are currently approximately 60 geothermal wells and one geothermal power plant in this area.

Management

The Lake County Geothermal Resource and Transmission Element, now consolidated into the 2008 General Plan, sets out goals, policies, and implementation measures for geothermal resource management (LCCDD 2008). Other Lake County General Plan policies guiding geothermal development include siting to avoid residences, resorts, and impacts on scenic views. Geothermal projects must ensure that water needed for other beneficial uses is not adversely impacted, and the county coordinates with the geothermal industry and other agencies to determine long-term water needs to maintain sustainable geothermal energy production. Erosion control and soil stabilization are required for geothermal projects. To address public concerns over disruption of the viewshed by geothermal facilities, the county has designated a setback around Clear Lake and Mt. Konocti from which geothermal development, with the exception of direct use of geothermal energy⁴, is excluded. This setback extends 1-2 miles from the lake around most of the lake, and reaches a width of 5 miles from the lake in the vicinity of Mt. Konocti (Figure 3.9).

⁴ In direct use of geothermal energy, low to moderate temperature water provides direct heat for residential, commercial and industrial uses.

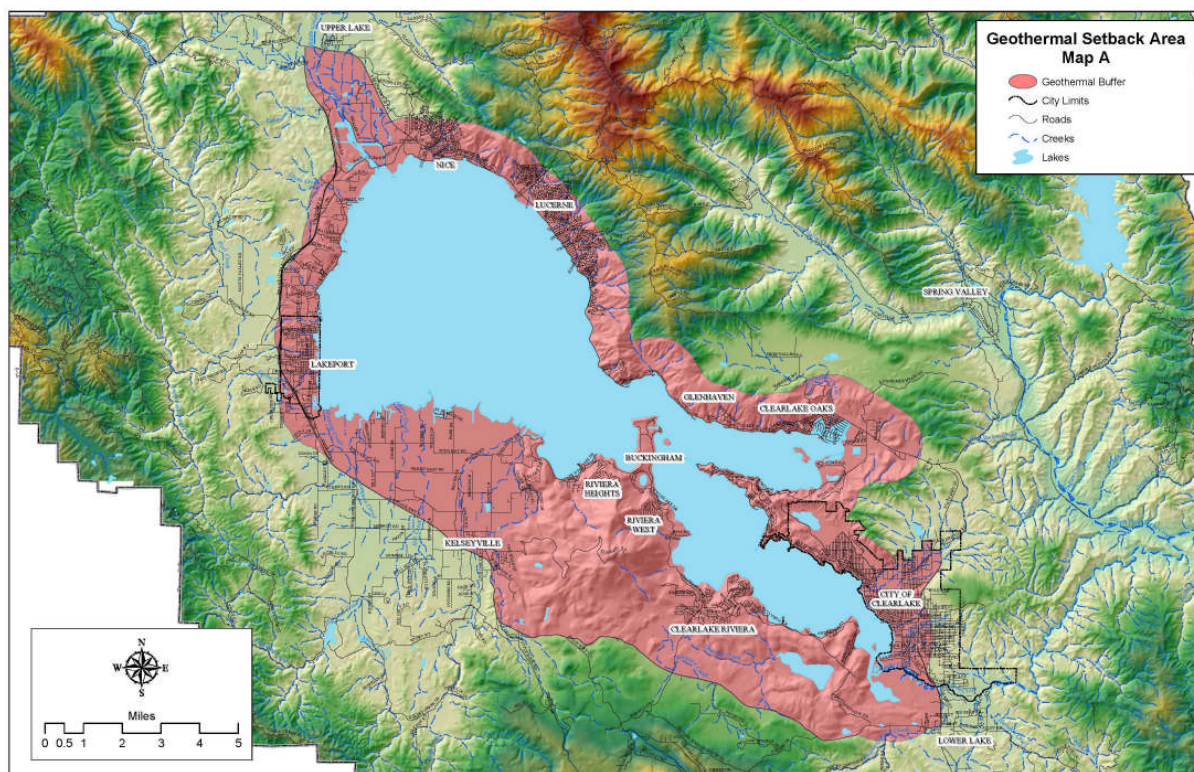


Figure 3- 9 Geothermal setback area around Clear Lake.

3.6 RESIDENTIAL and COMMERCIAL LAND USE

3.6.1 Overview

More than 70% of the county's population of 68,332 resides within the Clear Lake watershed. The majority of the population is in or adjacent to the incorporated cities of Lakeport and Clearlake. Additional population centers are found in the communities of Upper Lake, Nice, Lucerne, Glenhaven, Clearlake Oaks, Lower Lake, the Rivas, and Kelseyville. High-density residential developments (more than one housing unit per acre) are concentrated in the cities of Lakeport and Clearlake and along the lakeshore. Dispersed (rural and semi-rural) residential developments are spread throughout the watershed.

The first towns to be settled in the Clear Lake Watershed were Lower Lake, Upper Lake, Lakeport, and Kelseyville in the 1850s and 1860s. The town of Clearlake was laid out as the town of Highland in 1888, and Clearlake Highlands was developed in 1924-25. When Highway 20 from Ukiah to Lake Tahoe was completed in the 1920s, communities on the north shore of Clear Lake were developed. Lucerne was laid out in the 1920s and Nice was formed in 1930 (Lake County, no date, Simoons 1952). The Clear Lake Oaks Keys were built in the 1960s, and the Rivera's were built in the late 1960s.

Population growth rates in the county have fluctuated considerably since 1980. Population growth was greatest between 19890 and 1994 with 2-4.5% annual increases and was relatively high again from 2000-2003 when annual growth was 1.4-2.6%. In intervening years, it has ranged from 0.3-1% per year (CDFDRU 2008). Projections based on the 2000 U.S. Census data estimate that the 2007 Lake County population is 68,332, and the population in the county is projected to reach 101,557 by 2030 (LCCDD 2008). These projections include a population increase of approximately 81% in most of the watershed, but only 25% is dispersed in residential areas.

Three major issues of concern are associated with residential and commercial development in the watershed: urban stormwater runoff, municipal wastewater collection and treatment, and on-site wastewater treatment. The following sections describe the current understanding of these issues and the manner in which they adversely affect the environment in the watershed.

3.6.2 Urban Stormwater Runoff

Background

The conversion of farmland, forests, and grasslands to rooftops, roads, engineered fill, and parking lots has significantly reduced permeable surface area in the watershed, causing a proportionate increase in the rate and volume of stormwater runoff during and shortly after precipitation events (Hydro-Envirosphere 1996; Lake County 2000). In areas of commercial and residential development, stream channelization, and where necessary, levee building for flood control, are common practices. Stream channelization reduces aquatic and riparian habitats, contributes to more rapid stream water velocity, and reduces groundwater recharge (Section 3.4.3).

As stormwater runoff washes over impervious and slowly permeable urban surfaces and construction sites, it picks up a host of substances including heavy metals, pesticides and other synthetic organic compounds, oil and grease from vehicles and roads, fertilizers, sediment and nutrients, and pathogens. Because of reduced contact with soil, there is less opportunity for breakdown or absorption of toxic substances. When stormwater is discharged into surface waters via overland flow and municipal stormwater drains, urban stormwater can impair water quality, threaten beneficial uses, and degrade aquatic habitat. In a recent national water quality inventory conducted by the USEPA, urban runoff was found to be a source of pollution in 13% of impaired rivers; 21% of impaired lakes, ponds, and reservoirs; and 45% of impaired estuaries (USEPA 1998). Although no such relationship has been established between urban stormwater runoff and surface water bodies in the watershed, urban stormwater runoff quality is an issue of concern with regard to water quality in Clear Lake.

Numerous potential stormwater pollutants are toxic to aquatic organisms and have the potential to contaminate drinking water supplies. Heavy metals such as lead, zinc, cadmium, copper, chromium, and nickel are commonly found in stormwater. They come from artificial surfaces such as galvanized metal, paint, and preserved

wood and are released due to corrosion, flaking, dissolving, or leaching. Synthetic organic compounds such as adhesives, cleaners, sealants, and solvents are widely used and may be disposed of improperly. Some of the compounds in oil and grease are toxic to aquatic organisms at low concentrations. Sources of oil and grease include leakage, cleaning and spills from vehicles, restaurants, and waste oil disposal (CASQA 2003).

Pesticides, another potential toxic stormwater pollutant in residential and commercial areas, are a concern for several reasons. Home owners and business owners/managers are not required to receive pesticide use training or report pesticide use, as are other user groups. A recent study of residential pesticide use in California found that about half of residential pesticide users do not follow pesticide labels precisely, and almost half disposed of pesticides improperly (Flint 2003). In addition, commercial landscape maintenance providers, who are required to report pesticide use, account for a significant proportion of pesticide use in Lake County (Figure 3.7), and this use is likely to occur in residential and urban areas. Impervious surfaces in residential and urban areas cause larger and more rapid discharges of stormwater, and there is less opportunity for potential breakdown or adsorption of toxic substances by soils.

Nutrients in stormwater harm aquatic ecosystems by stimulating algal growth. Fertilizers used for lawns and gardens typically contain nitrogen and phosphorus (CASQA 2003). Sediments are major sources of phosphorus and iron. Accelerated erosion occurring on disturbed construction sites may account for a significant proportion of the sediment load contained in urban stormwater runoff. Erosion on construction and excavation sites was estimated to account for approximately 4% of the erosion and total average sediment yield to Clear Lake (USDA SCS 1994).

Management

Storm Water Management Plan: Federal water quality regulations require local government entities to reduce pollution from municipal stormwater run off. The government regulates stormwater discharge by requiring National Pollutant Discharge Elimination System (NPDES) permits under the federal Clean Water Act. Lake County government entities (Cities of Clearlake and Lakeport and the county) fell under this requirement in 1999 when USEPA regulations required small Municipal Separate Storm Sewer Systems (small MS4s) to acquire NPDES permits for stormwater discharges. An MS4 is defined as a conveyance or system of conveyances designed or used for collecting or conveying stormwater that is not a combined sewer or publicly owned treatment works. It can include road drainage systems, municipal streets, ditches, man-made channels, or storm drains (40 CFR 122.26).

The State Water Resources Control Board (SWRCB) and Regional Water Quality Control Boards have responsibility for water quality regulation in California and adopted an NPDES General Permit to comply with EPA small MS4 regulations. Several areas of Lake County fall within the small MS4 designation because of high population density (greater than 1,000 residents per square mile) and because

of discharge to a sensitive water body. Clear Lake is defined as sensitive because it is on the 303(d) list as impaired due to nutrients, and constituents of urban runoff can contribute to this impairment. The portion of Lake County within the Eel River drainage does not fit the small MS4 designation. The County of Lake, City of Clearlake, and City of Lakeport have joined together as co-permittees for the NPDES stormwater discharge permit (CL, CC and CL 2003). The NPDES permit covers a portion of the Upper Cache Creek drainage within which the Clear Lake Watershed lies, and the Upper Putah Creek drainage. The permit includes a provision that the co-permittees are separately liable for violations. The permit was for a five year period, ending in July 2008. The SWRCB is drafting guidelines for permit renewal.

The NPDES permit requires permittees to maintain, implement, and enforce a Storm Water Management Plan (SWMP). The SWMP must identify, assign, and implement control measures and BMPs, must demonstrate effectiveness, and must be modified as necessary and appropriate to reduce pollutants in stormwater to the maximum extent practicable. The SWMP must fulfill the requirements of six minimum control measures, which are:

- Public education and outreach on stormwater impacts and how to reduce them.
- Public involvement and participation.
- Illicit discharge detection and elimination.
- Construction-phase stormwater run off control.
- Post-construction stormwater management in new development and redevelopment.
- Pollution prevention/good housekeeping for municipal operations.

The Lake County SWMP has been named the Lake County Clean Water Program (LCCWP). There are three organization and management components of the LCCWP. The Program Advisory Council is made up of representatives from each co-permittee as well as Board of Supervisors members, City Council members, and other staff from the co-permittees. This council meets on a quarterly basis to oversee management and implementation of the LCCWP. In addition, four Program Workgroups oversee specific elements of the LCCWP. Finally, each co-permittee designates a stormwater program coordinator to provide administrative, financial, and management support to implement the LCCWP and to stay abreast of changes in stormwater management technology and regulations. They provide coordination among the co-permittees and other county agencies, the Program Advisory Council and Workgroups, regional and state agencies such as the CVRWQCB and SWRCB, and the California Storm Water Quality Association (CASQA).

The co-permittees continue to work to achieve full compliance with the requirements of the SWMP. Following the LCCWP Fiscal Year 2007/2008 Annual Report, the co-permittees received a Notice of Non-compliance.

However, they quickly responded to the Notice of Non-compliance to the state's satisfaction.

Prevention of erosion from construction sites is covered in the LCCWP and the 2007 Lake County Grading Ordinance. The goal of the LCCWP for construction sites is to reduce discharge of stormwater pollutants including sediment, litter, concrete, and other wastes to the maximum extent possible. Construction site BMPs are to be implemented and evaluated for their success in reducing discharges (CL, CC and CL 2006). The 2007 grading ordinance requires erosion control and sediment detention plans with all grading permit applications. It defines watercourse setbacks as a function of erosion hazard rating and stream classification. Grading is classified as "simple," "standard," or "complex" based on erosion hazard rating and the size and complexity of the project, and these classifications are subject to different levels of review (LCCDD 2007).

3.6.3 Illegal Waste Disposal

Background

Illegal waste disposal ("illegal dumping") occurs in and adjacent to stream channels and along isolated roads throughout Lake County. In many cases, it occurs on vacant private property. This dumping causes potential ground and surface water contamination, health hazards, unsightly conditions, potential flooding, and significant costs associated with prevention and clean-up.

Management

Lake County combats illegal dumping in several ways. The Lake County Public Services Department (LCPSD) has contracted with two private franchise haulers to provide low cost curbside trash pick-up and recycling. These franchise haulers have exclusive areas that serve nearly all residents and businesses in unincorporated county areas. This program is successful with a voluntary usage rate of 85% (Kim Clymire, personal communication). The program includes free pick up of two bulky items (i.e. furniture, mattresses,) per year, and low cost pick up of other bulky items (appliances). The City of Lakeport has a mandatory refuse service, and the City of Clearlake is developing a mandatory service program. The county also sponsors a free mobile household hazardous material program that is available to residents about once a month to dispose of paint, chemicals, small propane tanks, fluorescent lights, and unusable prescription drugs. This program is also available to businesses, but there is an associated cost.

The Lake County Community Development Department (LCCDD) maintains an abatement process for clean-up of illegal dumpsites, and CRMP groups hold annual clean-ups in many creeks that are tributary to Clear Lake.

LCPSD, and the Code Enforcement Division of the Lake County Community Development Department (LCCED), have a prevention program that encourages residents to use an authorized garbage service and use low cost or free disposal and amnesty programs. LCPSD also educates the public about low-cost/no-cost

options for waste disposal through such means as brochures, flyers, a recycling website, newspaper articles, and radio announcements.

Chapter 9 of Lake County Code prohibits trash hauling for pay, unless the hauler has a contract with the county. In addition, contractors can haul refuse produced as part of the work (demolition, tree trimming, clean-up). The penalty for illegal trash hauling and dumping (a misdemeanor) is a fine of up to \$100 and up to 30 days in jail, or both. State law has penalties for littering on roadways of up to \$1,000, for illegal dumping from \$250-\$2,500, and for illegal dumping in commercial quantities (greater than or equal to 1 cubic yard) from \$1,000-\$10,000 (California Vehicle Code Sections 17300, 23111-23115, 420017, California Penal Code Section 374). Barriers or gates are installed to prevent access to widely used illegal dump sites on public lands, and landowners are encouraged to post signs and erect barriers on private property. As an example, in 2009, LCPSD, in cooperation with the California Department of Forestry and Fire Protection (CAL FIRE), installed two gates above the towns of Nice and Lucerne to prevent access to illegal dumpsites.

Illegal waste clean-up on private property is enforced by LCCED. However, when the clean-up involves a health and sanitation issue, the Lake County Environmental Health Division (LCEHD) is involved in the clean-up. LCEHD has funding for clean-up of drug lab chemicals. They have grant funding to ensure that local businesses properly dispose of tires, and this funding includes some money for clean-up of illegally dumped tires.

LCCED, LCEHD, and the Lake County Sheriff's Department (LCSD) investigate reports of illegal dumping. Enforcement is difficult, due to a lack of state guidance on what constitutes sufficient evidence to prove that illegal waste disposal has occurred. Therefore, the Sheriff's Office gets involved when there is prosecutable evidence, such as an eyewitness to the illegal dumping. The California Department of Fish and Game (DFG) enforces state law that prohibits dumping within 150 feet of a water body.

3.6.4 Wastewater Collection and Treatment

Background

A collateral effect of residential and commercial development is the generation of substantial quantities of wastewater. Untreated wastewater can contain high concentrations of nutrients, organic carbon, human pathogens, and a variety of organic and inorganic contaminants. It can therefore pose a significant threat to water quality and human health when discharged into surface or groundwater. Wastewater collection and treatment system operators must have permits, called Waste Discharge Requirements, which specify the conditions under which they operate. Although wastewater discharge is prohibited under the CVRWQB Basin Plan and Lake County ordinance, due to aging and inadequate infrastructure, spills sometimes occur. Systems are most frequently overloaded during wet weather. "Inadequate hydraulic capacity is the major culprit, either through undersized pipelines, inadequate pump capacity at lift stations, and/or treatment

plants that are not designed to handle the demands of wet weather flows. Wet weather also often results in rising groundwater levels and increased soil saturation which reduces the percolation rates of disposal ponds” (Forsgren Associates Inc. 2007).

All major and some smaller communities around Clear Lake are sewered, and as of 2007, there were five municipal and two private wastewater treatment plants serving these communities. For the period from 2002-2006, both facility improvements and unauthorized releases from these plants are detailed in the Clearlake Watershed Sanitary Survey (Forsgren Associates Inc. 2007).

The extent of water quality impacts caused by unauthorized wastewater discharges from municipal wastewater treatment plants in the watershed is unknown. Richerson *et al.* (1994) addressed this concern in part when they examined the contribution of municipal treatment plants to the annual phosphorus budget of Clear Lake. Their calculations indicate that unauthorized wastewater discharges from municipal treatment facilities contribute only a small proportion of the total amount of phosphorus entering the lake each year. However, these researchers were not able to completely dismiss the phosphorus contributions from treatment plants as insignificant, primarily because the phosphorus from sewage treatment plants tends to be in a dissolved, and therefore bioavailable form, whereas the majority of phosphorus entering the lake is adsorbed to sediment, and is therefore less bioavailable.

Management

A major project to collect treated wastewater from around the lake and inject it into the Geysers geothermal steam fields has been implemented to reduce wastewater storage capacity problems in the watershed. The first two phases of the “Full Circle” effluent pipeline have been completed, and the system now serves the north and eastern sides of the lake including the communities of Clearlake, Lower Lake, Clearlake Oaks, Paradise Valley, Kono Tayee, Nice, Lucerne, Upper Lake, and North Lakeport. It also serves Middletown, outside the Clear Lake Watershed. The third and final phase of the “Full Circle” effluent pipeline will completely encircle the lake with a link to the communities of Lakeport and Kelseyville. Injection of water from this system supports approximately 100 Megawatts of power generation capacity in the Geysers steam fields. Currently, water from Clear Lake is used to keep the pipeline at capacity. As local communities grow and when phase three of “Full Circle” is completed, the increased effluent flows will displace the makeup water (Dellinger and Allen 2004). The Lake County Sanitation District (LACOSAN) is currently pursuing funding to upgrade the Kelseyville wastewater treatment plant, the first step in phase 3 of the Full Circle project (Mark Dellinger, personal communication).

3.6.5 On-Site Wastewater Treatment

Background

Households in the watershed that are not serviced by municipal or privately owned wastewater treatment facilities use on-site wastewater treatment systems (OWTS or septic systems), usually consisting of a septic tank and associated leachfield(s), to store, treat, and dispose of domestic wastewater. As of 1996, there were approximately 12,300 septic systems operating in the watershed (Hydro-Envirosphere 1996). These systems are concentrated in communities surrounding the Lower and Oaks Arms of Clear Lake, and to a lesser extent, the Upper Arm. The communities include Glenhaven, North Drive on the south shore of the Oaks Arm, along Lakeshore Drive on the east shore of the Lower Arm, Jago Bay, Clear Lake Riviera, Konocti Bay, Riviera West, Buckingham, Riviera Heights, Soda Bay, and the Kelseyville floodplain (Archibald and Wallberg MWH 2002).

Contamination of surface waters such as Clear Lake with septic tank wastewater can occur in two ways. One is percolation of the wastewater through soil into groundwater that enters the lake. This can occur where the septic systems are in close proximity to the lake on unsuitable soils and/or steep slopes. The other is surfacing of this wastewater during wet weather. This can occur through poor design and/or maintenance of the septic system. Groundwater contamination from septic systems can occur due to leaching of septage to the water table. Appropriate site selection, design, and maintenance of septic systems can prevent most contamination problems.

In 1988, the County commissioned wastewater pollution studies that examined the relationship between water quality and on-site wastewater disposal in the communities of Jago Bay, Soda Bay, and Blue Lakes (Questa Engineering Corp. 1990a, 1990b, 1990c). The studies found septic system failure rates of 10% at Jago and Soda Bays and 23% at Blue Lakes. In the former two communities on Clear Lake, there was no evidence to suggest that on-site wastewater disposal was significantly impairing ground or surface water quality. At Blue Lakes, however, the study found evidence of fecal contamination of surface and groundwater and localized evidence of elevated nitrate concentrations in groundwater. At all three locations, the studies cited lack of suitable land area for construction of new septic systems that could meet current standards of practice. For Clear Lake, the conservative or “worst case scenario” calculations made by Richerson *et al.* (1994) suggested that septic systems were not a significant source of phosphorus to Clear Lake.

The findings of the above studies did not indicate problems severe enough to qualify for state funding in the 1990s, and no follow up was made to improve these areas (Ray Ruminski, personal communication). Recent (2002-2006) water quality monitoring offshore of areas served by septic systems has not found fecal coliform levels above drinking water standards (Forsgren Associates Inc. 2007).

Management

Lake County has an ordinance that sets design criteria for new septic systems and repairs of existing systems in order to prevent surface and groundwater

contamination. The ordinance was first adopted in 1961 and has since been revised numerous times. The ordinance requires a site evaluation and approval of an area sufficient for complete replacement. LCEHD enforces the ordinance, reviewing and approving design and construction plans and conducting site inspections. LCEHD makes public education materials available on septic system maintenance; however, it does not currently inspect for maintenance of septic systems (Archibald and Wallberg MWH 2002). LCEHD is in the process of developing an operating permit for advanced treatment systems. These systems are used in areas unsuited for standard systems, and they require periodic maintenance by qualified service providers in order to operate properly (Ray Ruminski, personal communication).

The SWRCB has proposed regulations for OWTS that were to go into effect by July 2010. These regulations were required under Assembly Bill 885 (2000 Jackson), and a draft Environmental Impact Report (EIR) for the regulations is currently under review. Because of the large number of public comments received, the State Water Board is extending the period for public comment, and will be revising the regulations in light of the comments received. As originally written, the regulations would require property owners to have their septic tanks inspected for solids accumulations every five years. If there is an onsite domestic well, it would have to be tested once every five years.

3.7 PUBLIC LANDS

The area of Clear Lake lakeward of Zero Rumsey is managed by the State of California in the Public Trust for the people of the State of California. A Public Trust easement overlies shoreline property between Zero Rumsey and 7.79 feet Rumsey. In 1974, the state transferred management of the Public Trust to Lake County, with the exception of mineral rights lakeward of Zero Rumsey. Management of Clear Lake and its shoreline are described in the Lake Management Chapter ([Section 8.9](#)).

Public land holdings in the Clear Lake Watershed surrounding the lake are extensive (Plate 8). The largest contiguous holdings are in the northern part of the watershed and consist of the Bureau of Land Management (BLM) owned 52,000 acre Cow Mountain Recreation Area to the west of Lakeport and a sizable portion, 29,000 acres of the MNF, located in the Middle Creek Watershed north of Upper Lake. There are two state parks, Clear Lake State Park and Anderson Marsh State Historic Park, located on the shores of Clear Lake. The State of California also owns Boggs Mountain Demonstration State Forest (BMDSF), a portion of which lies in the Clear Lake Watershed, and other lands scattered throughout the watershed. The County of Lake owns several parks and other properties where public facilities are located. Lake County recently purchased 1,520 acres of land on Mt. Konocti, and this land is adjacent to 821 acres owned by BLM. Public lands are an important resource for recreation and the tourism income associated with this use.

A major water quality impact of land use activities on public lands are soil erosion and sedimentation caused by road and trail construction and operation, Off-highway vehicle (OHV) use, and timber harvesting. These impacts are discussed in the Erosion and Sedimentation section below ([Section 3.8.4](#), [Section 3.8.5](#)).

Due to their extensive land holdings and their expertise as land managers for the public benefit, public agencies such as the USFS and BLM have a large role in fire hazard management ([Section 3.9](#)).

In remote areas of the watershed, illegal marijuana growing operations are having an increasing impact on water resources and wildlife habitat. Lake County has led the state's Campaign Against Marijuana Production, CAMP, in the number of plants seized from 2006-2008. In 2008, 500,000 plants were seized in Lake County, mostly from public lands. Marijuana growing operations frequently rely on water diversions from streams. During summer months these diversions may de-water small streams in the upper watershed and reduce flows or cause streams to dry earlier lower in the watershed (Figure 3.11). There have been observations of ponds built adjacent to streams for fertilizer mixing, which cause both sediment and fertilizer inputs to streams (Figure 3.10). Diesel spills from generators used to power pumps or other equipment have also contaminated waterways (Anderson 2008, Edmison 2007). These operations sometimes poison wildlife, and they leave behind large amounts of waste. Armed guards at marijuana growing operations pose a significant threat to people participating in back country recreation.



Figure 3-10 Water diversion from ephemeral stream at marijuana garden cleaned up in Upper Scotts Creek Watershed, 2008. *Photo courtesy of Gary Sharp, BLM.*



Figure 3-11 Pit built for fertilizer mixing and/or water diversion near Eight Mile Valley, 2008. *Photo courtesy of Gary Sharpe, BLM.*



Figure 3-12 Trash at marijuana garden clean-up site in Scotts Creek headwaters, 2008. *Photo courtesy Gary Sharpe, BLM.*

3.8 EROSION AND SEDIMENTATION

3.8.1 Overview

Background

Accelerated erosion from human activities occurs in several ways. Land surface disturbance and removal of vegetative cover, such as that due to agricultural tillage, over-grazing or clearing for construction, contribute to surface erosion. Concentrated water flows from development and road building, and stream channelization (deepening and/or straightening stream channels) increase stream volume and velocity. This in turn can lead to down-cutting, increased stream bank erosion, and increased potential for sediment transport. Concentrated flows can also lead to catastrophic events such as road failures.

Along with the economic impacts of events such as road failure or loss of topsoil, sedimentation of streams and lakes has major impacts on water quality. Sediment in streams can smother aquatic invertebrates and cover gravels needed for fish spawning. The organic matter and nutrients present in sediments may increase biological oxygen demand. Sediment is also the main source of iron and phosphorus that stimulate blue-green algal growth in Clear Lake.

Richerson *et al.* (2008) found that early agricultural activity in the watershed (1854–1927) did not substantially accelerate erosion and sedimentation rates above natural levels. Studying Clear Lake sediments, they found that “Our cores tentatively suggest that grazing, wood cutting and lumbering, agricultural clearing, and the development of small towns and recreation facilities, as conducted from 1854-1927, were relatively low-impact activities from a watershed mass-balance perspective” (Richerson *et al.* 2008). The authors also noted that during that time period “land clearance was focused on level ground with low erosion risk.”

After about 1927, Richerson *et al.* (2008) found that the rate of inorganic mass accumulation in Clear Lake increased approximately 26 times over background, or pre-European rates. The increase was attributed to the use of heavy earth-moving equipment in a variety of industries. This included wetland reclamation projects for agriculture, open pit mercury mining at the Sulphur Bank Mercury Mine (SBMM) in which tailings were pushed into the lake, streambed gravel mining, home building, and road construction.

This study also found that erosion rate slowed sometime during the period from 1927-2000. Inorganic mass accumulation rates from 1955 to 2000 were approximately five-fold lower than from 1927 to 1955. (Their ability to separate the two time periods was due to the presence of DDD applied to the lake from 1949-1957). The reduced erosion rate in the post 1955 time period may reflect recent regulations and actions to reduce erosion, and it may help to explain improved water clarity in Clear Lake since 1992.

Management

The USDA SCS (1994) estimated that sediment production in the Clear Lake Watershed is 348,300 tons per year (equivalent to 316,000 metric tons (metric tons) per year). This estimate is much higher than that of the Clean Lakes Report (110,000-156,000 metric tons per year) or that found in recent county studies (75,000-104,000 metric tons per year). The study is useful for the relative contribution of various sources of erosion and the potential to reduce these sources of erosion (Table 3-3). Sources of erosion with the greatest potential for sediment reduction were land, accelerated channel erosion, and roads accounting for 30%, 28% and 25% of the potential sediment load reductions, respectively.

Table 3-3 Contributions of various sources to sediment yield and potential sediment reductions through land treatments.

Source	Sediment Yield w without Treatment (Tons/yr)	Contribution to Total Sediment Yield without Treatment (%)	Potential Sediment Reduction (Tons/yr)	Contribution to Total Potential Sediment Reduction (%)
Background channel	55,500	16%	8,300	6%
Accelerated channel	61,900	18%	37,100	28%
Wildfire	14,100	4%	1,400	1%
Roads	44,100	13%	33,100	25%
Construction and Excavation	15,000	4%	11,300	9%
Land	157,700	45%	39,400	30%
Total	348,300		130,600	

Source: USDA SCS 1994.

The following sections describe how different land use activities contribute to soil erosion.

3.8.2 Agriculture

Background

Agriculture is one of several land uses contributing to “land” erosion in the table above. The “land” category is a miscellaneous category including all sheet, rill, gully, and landslide erosion not related to the other sources listed in Table 3-3 above. Therefore it is likely to include activities such as logging, OHV recreation, and agriculture.

Although the Richerson Clear Lake sediment study did not find increased erosion rates during the early years of Lake County agriculture (pre-1927), in the mid-1900s hillside development of walnut orchards became extensive, and since the 1990s development of hillside vineyards has become common. From 1990 to 2006, wine grape acreage more than doubled to approximately 8,300 acres in

Lake County. A large proportion of the increase was on hillside locations, in many cases on former walnut orchards. Much of this development occurred in the uplands north of the Oaks Arm along Highway 20 and south of the Lower Arm of Clear Lake along Highway 29. (A significant portion of this southern acreage drains to Thurston Lake and Putah Creek). Erosion control practices were inadequate on several of the new vineyard developments, leading to highly visible and significant erosion events. These events led to increased regulation and oversight of agricultural grading discussed in the management section below.

While vineyard development has the potential to increase short term erosion, it is likely that large scale conversion of hillside walnuts to vineyards in recent decades has reduced long-term erosion and sedimentation rates (Rachel Elkins, personal communication). Many hillside walnut orchards were dry farmed, and spring tillage was used over the entire orchard floor to reduce weed competition and conserve soil moisture. Therefore, not only was soil on the orchard floor bare when fall rains began, it was loosened to several inches depth, causing a significant potential for soil erosion. Hillside vineyards are typically maintained without tillage that would loosen soil. In between vine rows a permanent cover crop is maintained. Generally, this cover crop is comprised of winter annuals that dry out and are mowed in the spring. Herbicides are used in the vine row to keep it free of vegetation and reduce competition for available water and nutrients. Therefore, in vineyards at the time of fall rains, there is a relatively narrow strip of undisturbed bare soil, and a wider strip of undisturbed soil with herbaceous cover between the vine rows.



Figure 3-13 Vineyards on hillside terrain in the Clear Lake Watershed. *Photo courtesy of Lake County.*

Of the hillside walnut orchards that remain, an increasing number are converting to low flow irrigation. Maintenance of the drip lines for this type of irrigation precludes tillage in the tree row, about 1/3 of the orchard area. In the tree row, herbicides or hand crews are used to manage weeds, both of which leave a relatively

undisturbed soil surface. Other Lake County crops such as pears, hay, and rice are located on level ground where erosion is not a significant issue.

When livestock are allowed to over-graze, the reduced vegetative cover causes soil erosion on sloping ground. Trampling and trailing can lead to soil compaction and break down stream banks, also contributing to erosion and sedimentation (NRCS 1998). In some instances, small-scale animal production with improper management and/or limited confinement area can cause severe overgrazing or stream damage in localized areas.

Management

The Lake County Grading Ordinance was updated in 2007 (LCCDD 2007). Under the previous grading ordinance, agricultural conversions such as conversion of walnut orchards to vineyards were exempt from permitting requirements. In the updated grading ordinance, removal of previously cultivated trees and vines triggers grading permit requirements when the soil erosion hazard rating is moderate or severe. These ratings correspond to soils with a slope generally greater than 5%. In addition, all agricultural development that occurs on land that was previously covered with native vegetation requires a grading permit. Once grading permits are required, Erosion Control and Sediment Detention Plans are required that include temporary and permanent methods to prevent erosion.

The California livestock industry has developed a voluntary plan to protect water quality in order to avoid a regulatory approach to non-point source pollution prevention. The California Rangeland Water Quality Management Plan was approved by the SWRCB in 1995, and UCCE and the Natural Resources Conservation Service (NRCS) are providing education and technical support to assist livestock producers and rangeland owners/managers with implementation of the plan (UCCE 1996). Local UCCE and NRCS personnel have provided two water quality courses to Lake County livestock producers. In these courses, livestock producers learn about water quality and watershed management, and develop a letter of intent or plan that identifies water quality problems and an approach for management and monitoring on their property.

3.8.3 Construction and Post-Construction

Background

In construction vegetative cover is removed, and soil is disturbed. In addition, soil is compacted leading to increased runoff, soil and mud may be tracked from construction sites to road ways, and high-slope soil piles may be created. While construction was estimated to contribute only 4% of the sediment yield to Clear Lake, it was estimated that 75% of this erosion would be preventable (USDA SCS 1994). Numerous BMPs are employed to reduce potential erosion ranging from scheduling to allow BMP implementation before significant rainfall, to covering soil with mulch or mats, to use of dikes and drainage to convey concentrated flows without excessive erosion (CASQA 2003).

Long-term, “post-construction,” impacts from new developments or redevelopment include soil erosion due to stream bank scouring from channelization and/or increased impervious surfaces that create higher peak flows.

BMPs used to prevent these problems include site and landscape design planning, reduction of roof runoff, and use of pervious pavements and alternative building materials (CASQA 2003b).

Management

The updated Lake County Grading Ordinance (Lake County 2007) outlines permit requirements for clearing of vegetation and grading activities based on the size of the disturbed area, the amount of soil disturbed, the slope, soil erosion hazard, proximity to water courses, timing of the project and other factors. All permits include submission of an Erosion Control and Sediment Detention Plan, and as the size of the project and/or potential for environmental disturbance increases, the level of environmental review increases.

The LCCWP also requires the permittees (County of Lake, City of Clearlake, City of Lakeport) to develop and enforce programs to reduce stormwater runoff from construction activities and new and redevelopment projects that lead to disturbance of one acre or more of land (CL, CC and CL 2006). The updated grading ordinance helps the county to partially fulfill this requirement with regard to construction. The co-permittees have adopted stormwater ordinances that provide them with the authority to implement construction and post-construction programs. They have developed education and outreach materials, revised existing ordinances, and have completed, or are in the process of revising inspection and fee structures and providing employee training (CL, CC and CL 2009).

3.8.4 Road Construction and Operation

Background

Roads are an integral part of almost all major types of land use in the basin, including, but not limited to, agriculture, ranching, logging, recreation, and private land development. Road construction first gained momentum in the watershed when motorized earth-moving equipment became commonplace during the late 1920s. Today, the watershed supports an extensive system of surfaced and unsurfaced roads operated and maintained by federal, state, local, and private entities with an overall density of approximately 4.7 miles of road per square mile of land area.

Roads can be a major source of erosion and sedimentation in the watershed. Surface erosion from unpaved roads produces chronic sources of fine sediment, and road failures lead to sudden, large inputs of sediment. Many older roads were designed to drain water into ditches on the in-slope side of the road. This water is then channeled into natural draws where bridges or culverts allow water to pass under the road surface. This design transports road sediments directly to water channels, and it reduces water flow down slopes, increasing water volume into natural drainages. An additional drawback is that plugging of culverts during large storm events can lead to road failures and large erosion events. Other factors that increase the potential for road failure are the steepness of the slope that the road traverses and the amount of soil displaced by road construction. On

unstable slopes, road building can trigger landslides that can be very difficult to stop (McCashion and Rice 1983, USDA FS 1999).

A 1978 “Soil Erosion Study for Lake County” described a time when there was very little oversight and regulation of road building. It found that “the greatest single source of erosion is from road construction in the development of subdivisions,” and that “most of these roads are constructed without engineered plans or supervision or control of any kind” (GHDA 1978). The study highlighted the need for a county grading ordinance, and following this study, a grading ordinance was adopted in 1982. The grading ordinance has been updated several times since, most recently in 2007. A 1994 study estimated that roads contribute 13% of the sedimentation in the Clear Lake Watershed and that 75% of this sediment load may be preventable (USDA SCS 1994) (Table 3-3).

The county has mapped 2,157 miles of roads, trails and firebreaks in the Clear Lake Watershed, 1,500 of which are unpaved (Table 3-4). This mapping project was based on available GIS records and analysis of aerial photographs. From aerial photos it was not possible to distinguish among roads, trails, and firebreaks, so these are all lumped together as “roads” in Table 3-4. The lines showing the length of paved and unpaved state, county and city roads are all actual roads. The “other” category includes roads on public lands such as BLM, USFS, and BMDSF lands, roads on private lands, and trails and firebreaks. There are approximately 175 miles of paved and unpaved roads on BLM and USFS lands; therefore, the categorization (trail, road, firebreak) of a significant portion of the “other” unpaved category is not available.

Table 3-4 Road lengths in the Clear Lake Watershed (miles).

	Paved	Unpaved	Total
State Highways	107	0	107
County maintained	387	45	432
City of Lakeport	37	4	40
City of Clearlake	63	77	140
Other	63	1,375	1,438
Total	657	1,500	2,157

*Roads include roads, trails, and firebreaks.

Public lands make up approximately 24% of the total land area of the Clear Lake Watershed. The two major public landholdings are the BLM Cow Mountain Recreation Area to the west of Lakeport, and a sizable portion of MNF to the north of Upper Lake. These public lands contain extensive networks of roads, mostly unpaved, that traverse fairly steep and rugged terrain.

The BLM Cow Mountain Recreation Area, a portion of which is located in the Clear Lake Watershed, consists of two management units. North Cow Mountain is managed for non-motorized activities such as hiking, hunting, horseback riding, and mountain biking. It has 27 miles of roads that are open to motorized vehicles, and 21 miles of trails and fire breaks open to non-motorized uses. South Cow Mountain is managed primarily for OHV recreation, and as of 2006, there were 93 miles of roads and trails open to motorized vehicles, 7 miles open but planned

for closure, and 12 miles of roads and trails permanently closed to motorized vehicles (USDI BLM 2006).

An independent trail analysis of the South Cow Mountain area, conducted by the Lake County Public Works Department (LCPWD) (1997), identified numerous high priority trails in South Cow Mountain that were described as having a high potential to erode and adversely affect surface-water quality because of their poor design and/or proximity to watercourses. The study found that the high priority trails were constructed prior to BLM land management, and those constructed and designed by BLM technicians are well-designed to minimize erosion.

There are 52 miles of roads and 7 miles of OHV trails in the MNF lands in the Clear Lake Watershed. In 1999, the USFS completed a watershed analysis for this area which concluded that roads were a major contributor to soil erosion (USDA FS 1999). Many older roads were designed with in-slope drainage, causing sediments to directly enter water courses and leading to concentration of water flows in natural drainages. The report recommended decommissioning of unnecessary roads and reconstruction of necessary, but poorly designed roads.

Management

Construction of new roads on private lands is regulated by the Lake County Grading Ordinance (LCCDD 2007). For subdivisions, road design and construction must conform to the Subdivision Ordinance, Chapter 17 of Lake County Code, and is reviewed by the Lake County Public Works Department. Construction of roads on private property not meeting the definition of a subdivision must meet standards outlined in the grading ordinance with requirements to minimize road width and grade, to avoid in-stream crossings and roads that cross floodplains, landslide prone areas, and highly erodible soils when possible.

The County of Lake has a program to check, clear, and repair ditches, culverts, and other stormwater conveyance structures on county-maintained roads. In recent years county road crews have had a goal of maintaining stormwater systems on 10% of the roads each year. Lake County road crews clean all drop inlets every year. The sweeping program removes approximately 2,000 cubic yards of trash and sediment from paved roads each year. (Steve Stangland, personal communication).

Lake County Road Department personnel receive training on and use a variety of best management practices to prevent erosion and stormwater pollution during road construction and repair projects. The most recent version of Lake County Road Design and Construction Standards was adopted by the Lake County Board of Supervisors on January 14, 2004. These standards include requirements to:

- Prevent stormwater pollution with harmful materials such as fuels, oils, bitumens and calcium chloride.
- Control erosion in conformance with the current edition of the California Stormwater Quality Association Stormwater Best Management Practice handbook series.

- Install long-term stormwater runoff controls in areas with more than 1 acre of new development or redevelopment (DPW 2004).

The California Department of Transportation (Caltrans) maintains state highways within the Clear Lake Watershed. The current Caltrans guiding plan to prevent stormwater pollution from drainage systems serving highways and highway-related properties, facilities, and activities is the “Statewide Storm Water Management Plan” (Caltrans 2003). This statewide plan includes assignment of responsibilities to implement the plan; description, selection, and use of BMPs; training and public education; monitoring and research; program evaluation; and reporting.

In BLM and USFS lands, resource management plans call for road and trail maintenance and identification of roads that present a significant erosion risk. These assessments are followed by mitigation measures and/or closure and rehabilitation, and minimizing disruption of natural drainage patterns on new or alternate routes (USDA FS 1995, USDI BLM 2006).

Following up on the 1997 trail analysis of South Cow Mountain, the BLM now evaluates the soil erodibility factor when designing and constructing new roads and trails. In South Cow Mountain, BLM built three bridges from 2000-2001 to prevent OHV travel in creeks, and it proposes to develop up to 40 miles of re-routed trail to protect erodible soils and sensitive resources and expand recreational opportunities (USDI BLM 2006). The position of recreation planner for South Cow Mountain has not been filled by the BLM for the past three years. This deficiency leads to reduced trail monitoring and maintenance and a lack of planning to ensure safe OHV use while minimizing environmental impacts. The BLM is currently in the process of putting together a new recreation plan for the entire Cow Mountain unit, which will be completed by 2010.

The Upper Lake Watershed Analysis report⁵ completed by the USFS found that “the poor design and condition of many roads within the watershed contribute to high peak stream flows. Some of the roads on Forest land are no longer needed and should be decommissioned” (USDA FS 1999). Recent (2009) discussions with the MNF Westside Hydrologist confirm that poor road design and lack of maintenance funding are still the key issues in road contributions to sedimentation (Frank Aebly, personal communication). The MNF road crew, responsible for maintaining the 300-400 miles of road on nearly 1,000,000 acres of MNF land consists of two men and one backhoe. Outside contractors are hired as funds are available (Bruce Smith, personal communication). Currently, a forest hydrologic technician is inventorying road conditions, focusing on stream courses that are tributary to Middle Creek. These inventories will assist with prioritizing projects to improve road drainage and/or decommissioning. The USFS is applying for FY 2010 Legacy Road Maintenance funding for some or all of the roads identified in the survey.

⁵ The watershed area in this analysis is equivalent to the area in the Middle Creek Watershed Assessment (2009).

There is little information available on conditions and maintenance of roads on private land in the Clear Lake Watershed.

3.8.5 Other Sources of Erosion

Other activities and conditions contributing to erosion include off-road use of OHVs, logging, and the effects of wildfires and control efforts. The potential for wildfires to contribute to erosion is discussed in the section below, and the other two are discussed here.

Off-trail OHV riding is a problem both on public and private lands. On USFS lands, OHV use is allowed in campgrounds, staging areas, and trails that have been developed for OHV use. However, unauthorized OHV use occurs in stream beds, and on fire lines and trails. USFS personnel attempt to restrict use of unauthorized areas using natural brush barriers, hay bales, and fences (USDA FS 1999).

Unauthorized OHV use on private lands throughout the county causes erosion and problems with excessive noise and unsafe driving. Because of significant unauthorized OHV use on the north shore of Clear Lake the Nice Watershed Group led an effort that resulted in a revision to the Lake County Transportation Ordinance in 2006 (Lake County Code Section 19-52). The ordinance now requires OHV users on private lands to carry written permission from the landowner; however, this ordinance is difficult to enforce.

Timber harvest can contribute to soil erosion due to soil disturbance by heavy equipment, creation of roads, and removal of vegetative cover. Timber harvests are subject to state and or federal regulations, one purpose of which is to minimize erosion. Timber harvesting, especially in recent decades, has been limited in the Clear Lake Watershed.

Approximately 28% (968 of 3,432 acres) of the BMDSF lies within the Clear Lake Watershed. At the time of the state's purchase in 1950, all merchantable timber had been harvested with the exception of scattered seed trees and patches of old growth trees considered to be inaccessible at the time of purchase. BMDSF was purchased to study recovery from a completely cut over area. The average age of trees on the forest is 60 years, and the average age of younger trees is 50 years. The management goal of the forest is "to create an all-aged forest structure, with stands containing a variety of age and size classes" (CDFFP 2008). The near term harvest schedule for the harvest calls for 181-371 acres harvested every other year.

The current management prescription allocation for the Middle Creek area in MNF calls for limited timber harvesting. Of the 28,291 acres in this area, 1,515 are classified as "Timber Modified," allowing for timber production with other resource objectives such as "visual quality, watershed, rare and endemic species, and wildlife" (USDA FS 1995). In this management prescription, lower timber yields are expected due to increased rotation lengths and restricted harvest practices. USFS personnel found records of a total of 888 acres of timber harvested since 1983 (James Donahey, personal communication).

For timber harvest, vegetative manipulation, and fire suppression and fuels management, the USFS follows BMPs described in “Water Quality for National Forest System Lands in California Best Management Practices” (USDA FS 2000). The USFS designates riparian reserves along streams in which timber harvest levels are reduced. These reserves vary in width depending on the type of stream, whether ephemeral, intermittent, or perennial. Narrower equipment exclusion zones are located adjacent to streams.

3.9 FIRE HAZARD AND MANAGEMENT

Background

Wildfires are a natural occurrence in California’s Mediterranean climate, which has warm and dry summers. Because of policies that have emphasized fire suppression since the 1920s there has been a build up of fuel loads in many areas. The increased fuel load creates the potential for more severe wildfires that may cause greater erosion, sedimentation, and other effects on water quality. As California’s population has expanded, there are more people living and working in areas prone to wildfire, called the wildland-urban interface. This trend increases the potential losses to life and property due to wildfires and in some cases increases the complexity of carrying out prescribed burns for fuel load reduction.

Many local vegetation types such as chaparral, oak woodlands, and ponderosa pine forests, are adapted to fire. The severity of wildfires depends on the dryness of vegetation and ground cover, weather conditions such as wind speed, humidity, and temperature, and the amount of fuel available. In the 1920s, fire exclusion became a widely adopted policy in California, and the consequence has been a build up of fuels with the potential for more severe wildfires. In recent decades, the recognition that fire has an important place in maintaining the health of forests and other ecosystems has led to an increased emphasis on prescribed burning and other methods of fuel reduction (Agee 2006).

A major effect of wildfire on water quality is increased soil erosion and sedimentation. With high fire severity, more of the soil cover of grasses, herbaceous plants, and plant residues is removed, which exposes the mineral layer to raindrop impact and overland flow. When vegetation is removed, sliding of dry material and debris is more likely, especially on steep slopes. Fire can also increase water repellency of soil, which increases surface water runoff. Heavy equipment used to control wildfires can disturb soil and increase erosion.

Prescribed burning is less likely to contribute to soil erosion and sedimentation than is wildfire. Creation of water repellency is unlikely under prescribed fire conditions when initial soil conditions are usually wetter (Robichaud, P.R. 2000). Soil erosion potential increases with increasing slope length. Wildfires sometimes burn very large areas; however, prescribed burning is carried out under controlled conditions in limited areas. For example, buffers along water-ways are maintained. Heavy equipment use is generally unnecessary, or is carefully

controlled, in the case of prescribed burning. The timing of prescribed burning is regulated by the Lake County Air Quality Management District (LCAQMD). They help to ensure that prescribed burns are carried out under weather conditions that are not too windy, potentially leading to escape of the fire; too calm, leading to excessive deposition of airborne particulates in Clear Lake and its watershed; or too damp, leading to excessive smoke.

The USDA SCS (1994) study estimated that wild fires contribute 4% of sediment inputs to Clear Lake, and it estimated the potential for reduced sedimentation due to wildfires to be only 1% of the total potential sediment reduction. The estimate for wildfire contribution to sediment production was on an average annual basis, and large fires, occurring on an infrequent basis, could presumably have a large short-term impact.

An analysis of the 1996 Fork Fire, which burned approximately 30% of the Middle Creek Watershed, found that high-intensity burning occurred mostly in chaparral (USDA FS 1999). Accelerated rates of erosion were measured in chaparral areas, and higher sediment and phosphorus loads were measured in stream water samples (LCWRD 1999, USDA FS 1999). In January 1997, treatment plants in Lakeport, Nice, and Lucerne were unable to adequately treat water due to high turbidity from the Forks Fire (USDAFS 1999).

Additional post-fire effects may include water quality changes in acidity levels or increased levels of nitrogen compounds. Reduced stream cover can cause warmer water temperatures, which can deplete dissolved oxygen (USDA FS 2005). Water yield, the amount of water coming from a given watershed, may increase following a fire because of reduced plant water use. Increased surface runoff following fires will also change the timing of stream flows, causing flood peaks to arrive more rapidly and reach higher levels. The higher stream flows have the potential to move greater amounts of bedload and suspended sediment. Recovery to pre-fire streamflows may take from several years to decades (Robichaud, P.R. 2000).

Anecdotal evidence indicates that the east fork of Middle Creek carries higher sediment loads than the west fork (WLRCO 2009a). Most of the watershed of the east fork of Middle Creek was burned in the 1996 Fork Fire, while a largescale wildfire has not occurred in the watershed of the west fork since 1966. Other potential factors that may explain differences in sediment loads in the watersheds of the two forks include OHV use, road conditions, the impacts of past timber harvesting, or inherent differences in geology and soils.

As California's population has grown, increasing numbers of people have moved to fire-prone wildlands. This growing wildland-urban interface creates difficult institutional problems for fire management. "Most land is privately owned, myriad jurisdictional problems exist for zoning, building codes, fire protection, and attitudes persist that disaster will strike somewhere else, or will never strike twice" (Agee 2006). Given the experiences of California's 2008 wildfire season, the attitude that "disaster will strike somewhere else" is likely to be much less prevalent, and there is an opportunity to improve land use decisions and fire management locally and statewide

Management

Wildfire control in the Clear Lake Watershed is managed under cooperative agreements among CAL FIRE, resource management agencies such as the BLM and USFS, and local fire protection districts. Projects to establish fuel breaks along high-travel roadways and to reduce fuel loading help to prevent wildfires and subsequent damage to water quality. Prescribed burning to reduce fuel loads is carried out under cool, damp conditions, and is confined to specified areas. It therefore contributes much less to erosion and sedimentation and is a positive alternative to large-scale wildfire. Other methods for fuel load reduction include brush mowing and intensive livestock grazing.

In the MNF, extensive chaparral management using prescribed burning was initiated in 1985. In addition treatments to reduce logging slash are more stringent than in past years. While the USFS policy fire suppression policy since 1933 has been to minimize fire size using all-out fire suppression, strategies are being developed for allowing fires caused by natural ignitions, such as lightning, to reduce fuels to natural conditions in wilderness areas (USDA FS 1995). Recent records indicate significant use of prescribed burning in the Middle Creek Watershed. Since 2000, a total of 3,690 acres of MNF land in the watershed have received prescribed burn treatments. Most of this burning was under-burning and pile burning in tree plantations, however, and prescribed burning in chaparral areas was less than the goal of 5% per year (WLRCD 2009a).

On BLM lands such as Cow Mountain, the fire management approach is to “limit the intensity of fire suppression efforts to the most economical response consistent with human and resource values at risk” (USDI BLM 2006). Prescribed burning is used to manage noxious weeds and to manage chaparral for fuel hazard reduction, wildlife habitat improvement, and watershed enhancement. The goal for annual prescribed burning is up to 1,000 acres on Cow Mountain; however, the area of prescribed burning is usually less than 400 acres per year (Jeff Tunnell, personal communication).

On private lands, the State of California requires anyone owning, leasing, or otherwise responsible for buildings in wildfire hazard areas to maintain a defensible space around the building. CAL FIRE inspects new buildings for compliance with defensible space requirements, and they inspect other buildings when they receive complaints and when time permits. Landowners wishing to carry out prescribed burns must LCAQMD and CAL FIRE. CAL FIRE can provide technical advice on prescribed burning, and in some instances, when a large area of brushland is involved, CAL FIRE can cost share and provide expertise for prescribed burning.

The Lake County Fire Safe Council hired a consultant to complete a Community Wildfire Protection Plan (CWPP) for the entire county. Ten meetings were held around the county in October 2008 to gather local input on the CWPP. Local, state, and federal fire protection organizations and other interested parties were involved in developing and reviewing the plan. The plan includes chapters on wildfire behavior, fire ecology, Lake County community features, fire protection organizations, risk assessment, and an action plan. The action plan includes

sections on advancing defensible space, reducing fuels and structural ignitability, enhancing fire protection, evacuation planning, and fire safe education. The plan was approved by the Lake County Board of Supervisors in August 2009.

3.10 LAND USE ACTIONS

3.10.1 Overall Strategy

This strategy is based on the 2008 Lake County General Plan, which recognizes the importance of supporting the county's economy based on agricultural, industrial, recreational, and other commercial activities, while at the same time protecting the county's natural resources. General land use goals of the Lake County General Plan are "to encourage the overall economic and social growth of the county while maintaining its quality of life standards," and "to clearly differentiate between areas within Lake County appropriate for higher intensity urban services and land uses (i.e., high density residential, high density commercial and industrial) from areas where rural or resource use should be emphasized" (LCCDD 2008).

General plan open space policies call for limiting development in areas that are constrained by natural hazards. Development in the 100 year floodplain zones is strictly limited. Passive recreation activities such as hiking and horseback riding are permitted, and critical facilities should not be permitted in the 100 year floodplain. New development and divisions of land, especially residential subdivisions, shall be developed to minimize flood risk to structures, risk to infrastructure, and ensure safe access during flood conditions. In addition, septic system approval shall require stringent controls where there is a substantial likelihood of infiltration of floodwater into the systems, and/or discharge from the systems into floodwaters.

Stormwater pollution prevention is addressed through policies that require "the use of feasible and practical best management practices (BMPs) to protect surface water and groundwater from the adverse effects of construction activities and urban runoff" and "the design of facilities and management of stormwater runoff in a safe and environmentally sustainable manner" (LCCDD 2008).

Public facilities related to water resources are addressed in the General Plan. Lake County recognizes the need to provide an affordable, adequate, and safe water supply, and to provide for adequate wastewater collection and treatment. Stormwater drains should be sufficient to protect people and property while maintaining the quality of receiving waters (LCCDD 2008).

Wildlife habitat and resources are protected in the Lake County General Plan. The goal for biological resources is "to preserve and protect environmentally sensitive significant habitats, enhance biodiversity, and promote healthy ecosystems throughout the County" (LCCDD 2008). A variety of policies support this goal ([Section 4.6.1](#)).

To minimize the threats from urban and wildland fires, the county consults with appropriate fire management districts and agencies prior to approving development or issuing building permits, encourages cluster developments to provide for more effective fire protection in high hazard fire areas, and requires wildland fire management plans for projects adjoining areas with high fuel loads. The county has development guidelines for developments in high wildfire hazard areas to mitigate risk to life and property, including the use of fire resistant building materials for the exterior of residential units. The county supports fuel modification and reduction programs and requires fuel breaks based on fire hazard conditions (LCCDD 2008).

3.10.2 Review and Revise County Wetland Policies and Ordinances

Background: The Lake County General Plan recognizes the values of wetlands for recreation, groundwater recharge, wildlife habitat and scenic enjoyment. In the section on Clear Lake, the plan emphasizes the importance of the lake's wetlands. "Preservation of all remaining wetlands areas is imperative" (LCCDD 2008). Open space buffers between developments and wetlands are recommended. General Plan implementation measures include requiring wetland delineations, insuring compliance with federal, state, and local statutes concerning jurisdictional wetlands and special-status species habitat, and restoring wetlands in the area proposed in the Middle Creek Project.

Article 29 of the Lake County Zoning Ordinance, "Wetlands Combining District" describes exempt activities, uses requiring minor or major use permits, and management plan requirements.

The Shoreline Ordinance (Chapter 23, Lake County Code) prohibits removal of beach vegetation on residential properties and has a no net loss requirement for commercial, resort, and public properties.

Lake County has a Wetlands Policy adopted by the Board of Supervisors on February 28, 1995, which describes county wetlands goals and recommendations to achieve them.

The SWRCB is currently developing a Wetlands and Riparian Area Protection Policy (WRAPP) that will likely necessitate changes in county wetland policy. The state policy is being developed in three phases. The Phase 1 policy will ensure no-net-loss of wetlands. It involves developing a wetlands definition for California, a policy to provide protection from dredge and fill activities, a regulatory mechanism with a watershed focus, and assessment methods to monitor wetland protection effectiveness. Phase 2 will protect wetlands from other activities affecting water quality. Phase 3 will expand the policy's protection to riparian areas. Stakeholder meetings for Phase 1 were held in 2008, and Phase 1 policy is currently being written (SWRCB Resolution No. 2008-0026, SWRCB 2009b).

Project Description: The county wetlands policy, Zoning Ordinance and Shoreline Ordinance need to be updated to ensure wetlands protection and compliance with General Plan goals and state and federal regulations.

Key Participants: LCCDD and Lake County Water Resources Division (LCWRD) of the Public Works Department.

Timeframe: 0-3 years.

Technical Resources Required: Staff of participating agencies and USACE.

Cost Estimate: \$5,000.

Milestones: Complete revisions and Board of Supervisors approval.

Effectiveness Criteria: Revision of policies and ordinances will prevent future wetlands loss.

3.10.3 Encourage Wetland Mitigation Bank Development

Background: The USACE and USEPA have recently made changes to rules guiding mitigation for loss of wetlands and other aquatic resources that have been lost due to unavoidable impacts authorized through issuing section 404 USACE permits (33 CFR Parts 325 and 332). Wetland mitigation banks are one method of providing mitigation for loss of wetlands due to development. These banks are set up by a public or private sponsor securing a site for wetland mitigation, and restoring and/or preserving wetlands on the site. The bank then sells compensatory mitigation credits to permittees to satisfy their wetlands mitigation obligations. The site must have long-term protection through real-estate instruments and/or other methods.

Project Description: There has been a coordinated effort between county agencies and a private environmental consulting firm to investigate development of a wetland mitigation bank in Lake County. This effort should be continued until a bank is successfully developed.

Key Participants: LCWRD, USACE, and private firms.

Timeframe: 0-5 years.

Technical Resources Required: Staff of participating agencies, USACE, California Environmental Protection Agency (CalEPA), and DFG.

Cost Estimate: Regular staff time.

Milestones: Identify interested landowner(s) and identify wetland mitigation bank sponsor, complete application to establish bank, and obtain approval for wetland mitigation bank establishment.

Effectiveness Criteria: No net loss of wetlands.

3.10.4 Restore Stream Channel Hydrology and Associated Habitats

3.10.4.1 Restore Stream Channel Hydrology and Riparian and Aquatic Habitats

Background: Stream channels, especially in the level valleys in the lower elevations of the Clear Lake Watershed, have been heavily altered by channel straightening and clearing, levee building, and gravel mining. This process of channelization has led to stream incision and streambank erosion, as well as to diminished value for aquatic habitat. Channelization alters hydrologic function, for example reducing groundwater storage, shortening the period of stream flow, and altering floodplain functions.

The Scotts, Kelsey, and Middle Creek Watershed Assessments identified sections of these major creeks that have been significantly altered leading to degraded streambeds and reduced groundwater recharge, increased streambank erosion, reduced floodplain function, and/or degraded aquatic and riparian habitats. These areas are Kelsey Creek below the Main Street Bridge in Kelseyville, Middle Creek in the area of the confluence of the East and West forks and continuing downstream to the town of Upper Lake, and Scotts Creek in the area of the confluence between the main channel and south fork. Eight Mile Valley, in the upper Scotts Creek Watershed was also identified due to extensive gully erosion. A survey of the east fork of Middle Creek is needed to investigate the source of greater sediment loads in this fork compared to the west fork.

Most of the stream channels in the Clear Lake Watershed have not been surveyed to document channel or riparian habitat conditions. The most extensive survey was carried out in 1985 for the Aggregate Resource Management Plan (LCPD 1992). This survey covered 69 miles of stream channels within the Clear Lake Watershed. It generally included larger channels in relatively level locations where gravel accumulates, and it included the channels where significant gravel mining had occurred. DFG has also surveyed numerous streams for aquatic habitat conditions, however, most of these surveys were carried out from the 1950s to 1970s.

Project Description: Significantly altered stream sections have been identified through the watershed assessments, stream channel surveys such as the 1985 ARMP survey, and personal knowledge of residents and county or state natural resource management personnel. GIS analysis using hydrologic, elevation, aerial photo, and other layers could be used to identify additional degraded stream sections, followed by ground verification of stream channel conditions. Restoration sites would be prioritized based on erosion hazard, potential for significant habitat improvement, and other factors. Funding would be sought for project design, implementation, and monitoring.

Key Participants: East Lake Resource Conservation District (ELRCD), West Lake Resource Conservation District (WLRCD), LCWRD, Tribes, CVRWQCB, DWR, USACE, BLM, and USFS.

Timeframe: On-going.

Technical Resources Required: RCDs, DFG, USACE, NRCS, staff of participating agencies, and consultants.

Cost Estimate: To be determined.

Milestones: Identify and prioritize restoration sites. For each project conduct environmental review, project design review, implementation, monitoring and on-going assessment of restoration improvement, and maintain and repair project as needed.

Effectiveness Criteria: Improvement in natural stream hydrologic function and/or streambank stability, reduced sediment loads in streams and to Clear Lake, and improved fish and wildlife habitat conditions.

3.10.4.2 Complete Eight Mile Valley Restoration Project

Background: Eight Mile Valley is an area where stream modifications have caused significant gully erosion on BLM land in the upper Scott's Creek watershed. Channels that once flowed through the center of the valley were routed around the perimeter of the valley, creating gullies averaging 12 feet deep. An artificial channel dug across the western edge of the valley also created a 10 foot deep gully. The deep gullies have lowered the water table reducing riparian and wetland vegetation and fish habitat in the valley (Arriaza 2005).

A major restoration project was attempted in the summer of 2005 to stop the gully erosion and restore hydrologic function to the valley. However, major storms in December 2005 and January 2006 (which resulted in state and federal disaster declarations in Lake and Mendocino Counties) led to a failure of the restoration efforts. Consequently "the restoration area is experiencing significant erosion, channel incision, and bank instability. Left alone, this erosion process will continue to propagate through the meadow as the system adjusts to a new equilibrium" (Winzler and Kelly 2008).

Project Description: With extensive and active gully erosion, Eight Mile Valley is a high priority for restoration. Not only would stabilization of the valley channel system restore the valley's hydrologic function and improve aquatic, wetland, and riparian habitats, it would also eliminate a large source of sediment to Clear Lake. The BLM is currently pursuing grant funds to re-design and implement a long-term solution to stabilize the valley channel system (Frank Arriaza, personal communication).

Key Participants: BLM, WLRCD, and LCWRD.

Timeframe: 0-2 years.

Technical Resources Required: Engineering consultants, and construction contractors.

Cost Estimate: \$800,000.

Milestones: Complete design by 2010, construction by 2011, and continue education and outreach.

Effectiveness Criteria: Reduced erosion and sediment loads to Scotts Creek and Clear Lake and restored natural hydrologic function in Eight Mile valley with consequent improvements in aquatic and wildlife habitat.

3.10.5 Fully Implement the Lake County Clean Water Program

Background: The LCCWP is the name of the Storm Water Management Plan (SWMP) required of the County of Lake, City of Clearlake, and City of Lakeport (co-permittees) under the NPDES California general permit for waste discharge requirements for stormwater discharges from small MS4s. In other words, the LCCWP is the main program for controlling stormwater pollution in the Clear Lake Watershed.

The LCCWP laid out a five year program to meet requirements in the areas of public education and outreach on stormwater impacts, public involvement/participation, illicit discharge detection and elimination, construction site stormwater run off control, post-construction stormwater management in new development and redevelopment, and pollution prevention/good housekeeping for municipal operations. High workloads and inadequate staffing levels in the departments assigned to implement the LCCWP have made it difficult to complete the planned work for this unfunded federal mandate.

Project Description: Lake County, the City of Clearlake, and the City of Lakeport will continue to work toward full compliance with and implementation of the LCCWP. To achieve this, additional staffing, for example a full time County LCCWP Coordinator, will be necessary.

Key Participants: LCCDD, LCWRD, City of Clearlake, and City of Lakeport.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies, NRCS.

Cost Estimate: \$80,000 annually.

Milestones: Complete plan goals.

Effectiveness Criteria: Measurable reduction in stormwater pollution, community based clean-up and prevention projects, and public participation.

3.10.6 Complete the Full Circle Wastewater Reuse System

Background: Due to the need for wastewater system upgrades and increased capacity, LACOSAN developed a wastewater reuse system that currently transports treated effluent from the Southeast Regional, Northwest Regional, Middletown, and Clearlake Oaks treatment plants to the Geysers for injection and geothermal power generation.

Project Description: The initial design for the Full Circle (phase three) of the wastewater reuse system would collect treated effluent from Lakeport and Kelseyville in a pipeline that would connect to the existing reuse system at Lower

Lake. LACOSAN has completed a preliminary design report for the Full Circle phase (CH2MHILL 2004). A draft EIR/EIS for the Full Circle effluent pipeline has been completed, but it has not been circulated due to funding limitations. LACOSAN is currently pursuing funds to upgrade the Kelseyville Wastewater Treatment Plant which will be necessary prior to connecting the plant to the Full Circle system. Other possible alignments, such as a direct pipeline to the North Geysers are being considered. As communities currently served by the wastewater reuse system grow, and when phase three of “Full Circle” is completed, the increased effluent flows will displace Clear Lake water currently being used to maintain pipeline capacity.

Key Participants: LACOSAN, Kelseyville County Water Works District No. 3, City of Lakeport, and Geysers geothermal energy companies.

Timeframe: 0-5 years.

Technical Resources Required: Staff of participating agencies and consultants.

Cost Estimate: \$35,000,000.

Milestones: Refine project, environmental review, project design, and construction.

Effectiveness Criteria: Reduction in wastewater spills, reduction in Clear Lake water used in system, and additional treated wastewater injected into Geysers steam fields.

3.10.7 Expand Wastewater Treatment System Capital Improvement Programs

Background: Wastewater treatment plants located in the Clear Lake Watershed include the Southeast Regional and Northwest Regional Plants, both operated by LACOSAN, and plants operated by the City of Lakeport, Clearlake Oaks County Water District, Konocti Harbor Resort, and LaBrea Park. Unauthorized wastewater releases due to insufficient capacity and aging infrastructure continue to occur. Capital improvements have the potential to reduce surface water contamination and reduce the risk of large fines for unauthorized releases.

The City of Lakeport has a Capital Improvement Plan that identifies five, 10, and 15 year goals. It estimates available funding sources and additional funding that will be needed over the planning period (City of Lakeport 2009). The Clearlake Oaks County Water District currently does not have funding for capital projects. They plan to apply for a loan to complete a preliminary engineering report and obtain a USDA Grant to fund capital projects. In addition, they may have to increase sewer user rates to fund improvements (Darin McCosker, personal communication). The Lake County Special Districts Department (LCSDD) developed a five year capital improvement program as part of a recently completed cost of service rate study for all the wastewater and water systems managed by that agency. This capital improvement program identified approximately \$31 million in capital improvements for the wastewater systems in the Clear Lake Watershed. Funding sources to implement the program will include a combination of rate increases, system capacity fees from new

development, and grants. LCPD has applied for approximately \$20 million in Economic Recovery Funds from the federal government to cover capital improvements at the Northwest Regional Wastewater System, Southeast Regional Wastewater System, and Kelseyville Wastewater Collection System (Mark Dellinger, personal communication).

Project Description: Wastewater treatment plan operators should continue to plan for and implement capital improvement projects to maintain and improve systems.

Key Participants: LACOSAN, City of Clearlake, City of Lakeport, Clear Lake Oaks County Water District, Konocti Harbor Resort, and LaBrea Park.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies and consultants.

Cost Estimate: To be determined.

Milestones: Completion of capital improvement projects.

Effectiveness Criteria: Improved operation, capacity and efficiency of wastewater treatment systems.

3.10.8 Improve Wastewater Treatment Options for Un-Sewered Areas

Background: Significant areas of the Clear Lake shoreline, including parts of Lower and Oaks Arms of Clear Lake, and to a lesser extent, the Upper Arm are served by septic systems, termed on-site wastewater treatment systems (OWTS). In addition, the communities surrounding Blue Lakes, which have a hydrologic connection to Clear Lake, are served by septic systems. These systems have the potential to contaminate surface waters through percolation of the wastewater through soil into groundwater that enters the lake or due to surfacing of septage wastewater during wet weather. Studies of septic systems at Jago Bay, Soda Bay, and Blue Lakes found failure rates of 10-23%, and evidence of surface and groundwater contamination at Blue Lakes (Questa Engineering Corp. 1990a, 1990b, 1990c). Frequently, the studies found a lack of suitable area to construct conventional septic systems.

The SWRQCB developed a first draft of new regulations for OWTS in November 2008. Due to high levels of public comment, these proposed regulations will be revised.

Project Description: In some cases alternative or supplemental systems to individual septic systems provide the most cost-effective solution for necessary improvements. Several communities with relatively high residential density around the lake would be well served by development of wastewater collection and treatment systems. Glenhaven, along the north shore of the Oaks Arm, is the highest priority for such a system, followed by the areas of concentrated residential development between Kelseyville and Lower Lake (Ray Ruminski, personal communication). If new state requirements for OWTS require major

upgrades or increases in maintenance, development of wastewater treatment and collection systems could become a less costly alternative.

Key Participants: LCEHD, LCSDD, and local communities.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies, and consultants.

Cost Estimate: To be determined.

Milestones: Improvements in OWTS and maintenance and development of new wastewater collection systems.

Effectiveness Criteria: Reduction in potential/actual ground and surface water pollution from wastewater.

3.10.9 Expand Programs to Prevent Illegal Waste Disposal

Background: Illegal dumping occurs in and adjacent to stream channels, on vacant or undeveloped public and private property, and along isolated roads throughout Lake County. This dumping causes potential water pollution, health hazards, unsightly conditions, and significant costs associated with prevention and clean-up.

Lake County and the Cities of Clearlake and Lakeport combat illegal dumping by providing low cost curbside trash pick-up, public education, and law enforcement. For those residents who choose to self-haul their refuse, the county has extremely low landfill disposal fees and many other low-cost/no-cost opportunities to dispose of a wide variety of recyclables and many non-recyclable materials. When there is evidence that could lead to prosecution, public safety officers become involved. DFG enforces state law which prohibits dumping within 150 feet of a water body (Section 3.6.3).

Project Description: Priorities for reducing illegal dumping are (1) increasing education about waste disposal options and the penalties for illegal dumping, and (2) greater enforcement of existing laws. Well-publicized cases, when violators are caught, can help to discourage other violations.

Changes in Lake County Code, for example greater fines for illegal waste hauling, or encouraging landlords to provide trash pick up for renters, could help to reduce illegal dumping.

State law is currently not clear on what documentation is required to prove responsibility for illegally dumped waste and the county cannot pre-empt state jurisdiction to establish criteria for enforcement. Therefore, law enforcement relies substantially on catching dumpers “in the act” or on the testimony of eyewitnesses. Frequently, waste includes documents with the name and address of the person(s) where the waste originated. State law could be changed to use this information to pursue violators of waste disposal laws.

Installing barriers to prevent illegal dumping should be continued, and installing cameras at high-traffic illegal dumpsites is an expensive, but potentially effective method to catch violators.

Key Participants: LCPSD, LCCED, LCEHD, City of Clearlake, City of Lakeport, LCPWD, Sheriff's Office, LCAQMD, DFG, CVRWQCB, and California Integrated Waste Management Board.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: To be determined.

Milestones: Improved prevention education program, increased enforcement program, barriers to dumpsites erected, and regulations strengthened.

Effectiveness Criteria: Reduction in the amount of waste disposed of illegally.

3.10.10 Prevent and Clean Up After Illegal Marijuana Growing

Background: In remote areas of the watershed, illegal marijuana growing operations are having an increasing impact on water resources and wildlife habitat. Many of these occur on public lands such as MNF and the Cow Mountain Recreation Area. These operations divert water from streams, contaminate streams with fertilizer, pesticides, fuel and other contaminants, poison wildlife, and leave behind large amounts of waste. In addition, the growing operations may be protected by armed guards, who are a danger to those participating in back country recreation. The Lake County Fish and Wildlife Advisory Committee held a meeting in November 2009 to discuss the impacts of illegal marijuana production on fish and wildlife. Representatives from LCSD, USFS, BLM, and DFG participated.

Project Description: Continuing meetings among law enforcement personnel, natural resource managers, and the public are needed to develop an improved program to prevent illegal marijuana growing and clean up locations where it has occurred. A significant portion of public safety resources is used in removal of mature marijuana plants. A review of options to prevent establishment of marijuana operations and increased clean-up following discovery of these operations, could have significant ecological benefits. Interception of people attempting to establish marijuana growing operations would also have public safety benefits.

Key Participants: LCSD, MNF, BLM, UCCE, Tribes, DFG, RCDs, CRMP groups, and environmental organizations.

Timeframe: Two years to develop program, then on-going.

Technical Resources Required: Staff of participating agencies and organizations.

Cost Estimate: To be determined.

Milestones: Review and improvement of current illegal marijuana prevention programs and clean-ups of marijuana growing sites.

Effectiveness Criteria: Reduced natural areas under illegal marijuana cultivation and reduced watershed pollution from marijuana growing.

3.10.11 Survey and Improve Road and Trail Conditions

Background: Roads can be a major source of erosion and sedimentation due to surface erosion from unpaved roads, direct drainage to waterways, and road failures from poor design, lack of maintenance, or severe storm events. There are an estimated 1,500 miles of unpaved roads, trails, and firebreaks in the mountainous portions of the Clear Lake Watershed, and the condition of most of these is unknown.

Public agencies such as the USFS, BLM, and CAL FIRE are responsible for roads, trails and firebreaks on the lands that they manage, many of which are unpaved. Lake County and Cities of Clearlake and Lakeport are responsible for approximately 125 miles of unpaved roads, and there are many unpaved roads and trails on private property.

Project Description: Government agencies will continue programs to survey road and trail conditions and maintain, upgrade, decommission, or re-route them as needed. In many cases, current funding for these activities is insufficient, and outside sources of funding should be sought. The construction of new roads on private property is regulated by the Lake County Grading Ordinance. A survey of the road system in the mountainous regions is needed in order to prioritize improvements. Education for private landowners on road construction and maintenance should be offered by agencies such as the NRCS and UCCE.

Key Participants: LCDPW, LCCDD, CAL FIRE, USFS, BLM, Caltrans, NRCS, UCCE, and private landowners..

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: To be determined.

Milestones: Road and trail surveys and projects to improve, decommission, and re-route trails and roads to reduce erosion and sedimentation.

Effectiveness Criteria: Reduced sedimentation of Clear Lake and its tributaries and improved road conditions.

3.10.12 Implement the Lake County Community Wildfire Protection Plan

Background: A Community Wildfire Protection Plan for the entire county was approved by the Lake County Board of Supervisors in August 2009. Ten community meetings held around the county identified community resources requiring protection, escape routes during wild fire, and potential fire hazards.

The plan was developed by a consultant who facilitated collaboration among local, state, and federal entities, and non-governmental stakeholders. Among the actions recommended in the CWPP are actions to increase defensible space, prioritize fuel reduction projects, reduce ignitability of structures, enhance fire prevention and response capacities, plan for emergencies and evacuation, and promote fire safety education.

In January 2009, Lake County authorized short term funding for a Fire Safe Coordinator whose duties will be to implement the Community Wildfire Protection Plan and to assist local communities in becoming Firewise Communities.

Project Description: Implementation of the CWPP will help protect public safety and community and cultural assets. The most significant CWPP actions to protect water quality are those that reduce the potential for catastrophic wildfires and subsequent erosion and water quality impacts. These include projects that reduce ignitions, e.g. roadside fuel breaks, and large-scale fuel reduction efforts.

Key Participants: Fire Safe Coordinator, Building Department of LCCDD, Lake County Fire Safe Council, CAL FIRE, BLM, USFS, local Fire Protection Districts, South Lake Fire Safe Council, homeowners associations, ELRCD, WLRCD.

Timeframe: On-going.

Technical Resources Required: Fire prevention specialists.

Cost Estimate: To be determined.

Milestones: Implementation of projects on CWPP priority project list.

Effectiveness Criteria: Practices and projects implemented to reduce potential for wildfire to occur, including reduction in watershed fuel loads, fuelbreaks and other projects to reduce ignitions, and increase in defensible space and homeowner prevention practices.

3.10.13 Other Actions

2.8.2 Complete the Middle Creek Flood Damage Reduction and Ecosystems Restoration Project

2.8.7 Support and Increase Watershed Education and Outreach

2.8.9 Complete the Integrated Regional Water Management Plan

2.8.10 Increase Reuse of Treated Wastewater

2.8.11 Increase Water Conservation

2.8.12 Complete the Adobe Creek Conjunctive Use Project

4.6.5 Develop a Tree Management Plan

5.5.7 Protect Open Space

7.5.3 Promote Compatible Uses of Floodplains

7.5.4 Reduce Flood Damage in Developed Areas

8.12.2 Update the Shoreline Ordinance (Chapter 23 Lake County Code)

**Clear Lake Integrated Watershed Management Plan****Chapter 4****WILDLIFE AND WILDLIFE
HABITAT RESOURCES****4.1 INTRODUCTION**

The Clear Lake Watershed supports a wide variety of wildlife habitats. The following sections describe the watershed's major wildlife habitats including current conditions, what is known of pre-European conditions, major wildlife and fish species, and sensitive species. The emphasis of this chapter is on aquatic habitats, and habitats are divided into lacustrine (lake), wetland, riparian, and upland categories. Most fish and wildlife rely on one or more of these habitats; consequently the discussions of these habitats will reflect the significant overlap in wildlife use. Each habitat section concludes with a discussion of management of the habitat and economic and environmental impacts.

The animals found in different habitats overlap considerably. Appendix C gives a list of vertebrates potentially found in the Clear Lake Watershed. The California Natural Diversity Database catalogues threatened, endangered and sensitive species that have been observed in a given area. The list for Lake County is given in Appendix D.

4.2 CLEAR LAKE LACUSTRINE HABITAT**Background**

Lacustrine habitats are aquatic habitats containing standing water, and they include ponds, lakes, and reservoirs. Clear Lake is the focus of this section. Other lakes in the Clear Lake Watershed include upper and lower Blue Lakes and Thurston Lake. Reservoirs include Adobe and Highland Springs Reservoirs (Plate 4).

Clear Lake is an ancient lake that has remained shallow and eutrophic for the past 450,000 years (Sims *et al.* 1988). Richerson describes the reasons for Clear Lake's eutrophic, or highly productive condition: "Clear Lake is a naturally productive lake. It has a fairly large drainage basin to contribute mineral nutrients to its waters. Its waters are shallow and well-mixed by the wind, and there is no summertime cold layer (hypolimnion) to trap nutrients" (Richerson *et al.* 1994). The pre-European condition of the lake is captured by the description of a fish biologist, Livingston Stone, based on field work in 1872-73:

“It is a singular fact, illustrating the inaptness with which names are often given to natural objects, that the water of Clear Lake is never clear. It is so cloudy, to use a mild word, that you cannot see three feet below the surface. The color of the water is yellowish brown, varying indefinitely with the varying light. The water has an earthy taste, like swamp-water, and is suggestive of moss and water-plants” (Stone 1875).

Stone also notes that “These conditions would seem to be unfavorable to fish-life in the lake; but by another of those numerous contradictions for which California is noted, this lake seems to be particularly adapted to fish, and the water teems with them.” Stone did not realize what biologists now understand, that plant life, both as microscopic, floating algae, and rooted aquatic plants, is the base of the food chain, and a large base contributes to large populations at higher levels in the food chain.



Figure 4-1 Tule wetlands and riparian vegetation on the shores of Clear Lake along Big Valley. *Photo by Lake County.*

Stone’s description of three foot water transparency and plant life as “moss” growing up to the surface and obstructing boat passage, appears to be similar to lake conditions since 1992, when improved water clarity and consequent rooted aquatic plant growth has increased significantly.

For a long period, however, starting in about 1930 with the advent of heavy earth moving equipment, nuisance blue-green algal blooms were extensive, and heavy algal biomass shaded out rooted aquatic plants. Fish die-

offs due to algal blooms and subsequent low dissolved oxygen levels occur in areas with poor water circulation. However, the California Department of Fish and Game (DFG) finds that these die-offs have little lakewide impact (CDFG 2000).

Another major change from the lake’s pre-European condition has been the removal of wetlands around the lake. An estimated 79% of the wetlands around Clear Lake have been removed or reclaimed for agriculture, development, and shoreline clearing. Wetlands provide an important function, filtering nutrients and sediment before they enter the lake. Wetland habitat intergrades with lacustrine habitat and provides valuable spawning and nursery habitat for fish, substrate for smaller algae, and cover for the minute aquatic animals that are an important food source for fish. Young of most fish species, including the Clear Lake hitch and juvenile bass, rely on shoreline vegetation during early life stages.

Mercury mining, primarily the open pit mining at the Sulphur Bank Mercury Mine on the shore of Clear Lake, has led to elevated sediment and dissolved mercury levels in the lake ([Section 2.2.3](#)). Mercury is potentially toxic to living

organisms and is primarily taken up in the form of methylmercury. Methylmercury biomagnifies in the aquatic food chain, meaning that its concentration increases with each step in the food chain. Therefore, fish at higher levels in the food chain contain levels of methylmercury potentially dangerous to humans and to birds, such as osprey and grebes, which consume the fish.

An increase in the use of aquatic herbicides to control the invasive aquatic plant, hydrilla, and other rooted aquatic vegetation has occurred in recent years. The DFG studied the effects of two herbicides, Sonar[®], and copper based Komeen[®], used to control hydrilla. While these herbicides were effective in controlling hydrilla, steep declines in zooplankton populations the first day of application as well as impacts on snails and aquatic invertebrates were seen after Komeen[®] application. The DFG perspective was that some harm to Clear Lake was acceptable rather than “permanently losing Clear Lake and the ultimate drainage into the Sacramento Delta due to the uncontrolled growth of hydrilla” (CDFG 2000). A discussion of invasive aquatic weeds such as hydrilla and water primrose is given in Chapter 6 ([Section 6.2.1](#)).

Along with physical and chemical changes to the Clear Lake ecosystem, introductions of non-native fish species have had a large effect on native species. Clear Lake and tributary streams have always supported abundant warm water fish populations. Today, an estimated 11 native and 19 introduced fish species are found in Clear lake, and three native species are now presumed extinct (Table 4-1). Table 4-1 indicates that threadfin shad are rare. In fact, threadfin shad populations in Clear Lake can reach very high levels in some years, and in other years population levels are very low, or threadfin shad are not observed at all.

Bass, carp, and catfish prey on native hitch and roach species (). Although most hitch spawn in tributary streams, in the past some spawned over clean gravel along the shores of Clear Lake. The success of shoreline spawning has likely declined due to heavy predation on eggs and larvae by carp and other introduced species (Moyle *et al.* 1995). As early as 1894, Sacramento perch in Clear Lake were described as “formerly very common but now becoming scarcer as its spawning-grounds are devastated by carp” (Jordan and Gilbert 1894). Some introduced fish species, such as the inland silverside and threadfin shad, compete with hitch for food, and this competition may have contributed to the extinction of the Clear Lake splittail (Moyle 2002). Clear Lake hitch, once very numerous in the lake, have declined in recent decades. This is due in part to loss of shoreline vegetation discussed above, in part to predation by and competition with introduced fish, and in part to changes in stream conditions, discussed in the riparian section below.

Table 4- 1 Past and present fish species known to have occurred in Clear Lake, California.

Common and Scientific Names	Native (N) or Introduced (I)	Status (A,C,R,E)*
Rainbow trout, <i>Oncorhynchus mykiss</i>	N	R
Brown trout, <i>Salmo trutta</i>	I	R
Pacific lamprey, <i>Lampetra tridentata</i>	N	E
Goldfish, <i>Carassius auratus</i>	I	A
Carp, <i>Cyprinus carpio</i>	I	A
Clear Lake hitch, <i>Lavinia exilicauda chi</i>	N	R-C
Golden shiner, <i>Notemigonus crysoleucas</i>	I	R
Sacramento blackfish, <i>Orthodon microlepidotus</i>	N	C
Clear Lake splittail, <i>Pogonichthys ciscoides</i>	N	E
Sacramento Pikeminnow, <i>Ptychocheilus grandis</i>	N	R
California roach, <i>Hesperoleucas symmetricus</i>	N	R
Hardhead, <i>Mylopharodon conocephalus</i>	N	E
Fathead minnow, <i>Pimephales promelas</i>	I	C
Thicktail chub, <i>Gila crassicauda</i>	N	E
Sacramento sucker, <i>Catostornus occidentalis</i>	N	C
White catfish, <i>Ictalurus catus</i>	I	C
Brown bullhead, <i>Ictalurus nebulosus</i>	I	C
Channel catfish, <i>Ictalurus punctatus</i>	I	C
Mosquitofish, <i>Gambusia affinis</i>	I	C
Threadfin shad, <i>Dorosoma petenense</i>	I	R
Inland silverside, <i>Menidia beryllina</i>	I	A
Threespine stickleback, <i>Gasterosteus aculeatus</i>	N	R
Sacramento perch, <i>Archoplites interruptus</i>	N	R
Green sunfish, <i>Lepomis cyanellus</i>	I	R
Bluegill, <i>Lepomis macrochirus</i>	I	A
Redear sunfish, <i>Lepomis microlophus</i>	I	R-C
Pumpkinseed, <i>Lepomis gibbosus</i>	I	R
Largemouth bass, <i>Micropterus salmoides</i>	I	A
Smallmouth bass, <i>Micropterus dolomieu</i>	I	R
Black crappie, <i>Pomoxis nigromaculatus</i>	I	R-C
White crappie, <i>Pomoxis annularis</i>	I	R-C
Tule Perch, <i>Hysterocarpus traski</i>	N	C
Prickly sculpin, <i>Cottus asper</i>	N	A

* Status designations are subjective, based on electrofishing observations, and do not represent a definitive survey of the abundance of each fish species. These status designations have not attempted to place the species population in context relative to historical abundance. Electrofishing stations are typically associated with a variety of littoral, or shoreline habitats are usually observed at night, and most of the stations have been revisited regularly over the past eight years in the spring and fall. A= Abundant, or present in large numbers at all or nearly all stations that correspond to the species preferred habitat; C=Common or present at most stations; R=Rare, or present at a few stations; E=Extinct, or have not observed the species at any stations.

Source: CDFG 2000. This table was updated in 1995

To most anglers, the introduction of non-native game fish to Clear Lake has improved fishing opportunities. Clear Lake supports an excellent bass fishery, and has averaged about 200 bass fishing tournaments per year for the past five years. Surveys of fish caught by Clear Lake anglers found that largemouth bass made up 67% of the total catch in 1991 and 85% in 1994 (DFG 2000). Fluctuations in bass populations are expected, however, due to numerous factors. These include competition among juvenile bass and similar-sized forage fish (for example threadfin shad), reduced spawning habitat when low lake levels occur (during droughts), loss of juvenile fish habitat from development, predation on juvenile bass, short term impacts of aquatic plant herbicides that affect the bottom of the food chain, and biomagnification of toxins. The increased water clarity and aquatic plant growth in recent years may be providing valuable spawning and rearing habitat for bass (DFG 2000).

Clear Lake has supported commercial food and bait fisheries in the past. The commercial catch of Sacramento blackfish, common carp and goldfish produced an average 295,000 pounds per year from 1932-1962. From 1964 to 1994, the blackfish catch averaged 175,000 pounds per year, and the DFG found that “a review of Sacramento blackfish commercial harvest suggests that the fishery has undergone considerable decline in recent years” (DFG 2000). There have been no live bait fish harvesters in Clear Lake since 1991. A commercial license for collecting dead bait is not required; however, DFG has monitored seining for dead bait, and the yield appears to be almost exclusively silversides (DFG 2000).

Fish die-offs occur periodically in Clear Lake. One cause has been high nutrient loading and warm temperatures promoting blue-green algal blooms. When these algae die, their decomposition reduces dissolved oxygen to levels where fish die-offs occur. The DFG finds that “These are primarily problems of aesthetics and not problems detrimental to fish populations...These problems in small lagoons and channels in Clear Lake, relative to the entire lake ecosystem, appear to be minimal from a biological perspective. However, from a sociological perspective these issues are important” (CDFG 2000). While blue-green algal blooms in Clear Lake have declined since 1992, possibly due to reduced soil erosion and sedimentation, stagnant water conditions in lagoons and channels still produce algal blooms and fish die-offs.

Cold water temperatures and disease have also caused fish die-offs. In the winter, rapid declines in temperature have caused die-offs of non-native fish species that are not adapted to cold water temperatures. For example, threadfin shad populations were significantly reduced by cold winter conditions in 1990-91, 2007-08 and 2008-09. Fish die-offs are often most visible in channels and lagoons adjacent to the lake, because the smaller water volume in these areas allows for more rapid and greater cooling. An example of a fish die-off due to disease occurred during September and October of 2008. Because only carp were affected, a disease was suspected, and the DFG confirmed that the cause of the die-offs was “Koi Herpes Virus,” probably caused by release of Koi fish into the lake (LCRB 2008).

Countless birds live around Clear Lake, forage for fish, invertebrates, and plants in the lake, nest in emergent vegetation such as tules, or use the lake as a stop-over during migration. Some of the impressive birds to observe around Clear Lake include American white pelicans, osprey, western and Clark's grebes, and great blue herons. American pelicans use Clear Lake as a stop over on their way to nesting grounds in the Klamath Basin, and sometimes over-winter on the lake. Great blue herons are large wading birds that feed primarily on small fish, and large great blue Heron rookeries (communal nesting sites in trees) are found around Clear Lake.

Studies have been carried out on the effects of mercury biomagnification in osprey and grebes near Clear Lake. Osprey are a fish-eating bird of prey. They build large, bulky nests, often at the top of dead trees. Grebes are long-necked water birds with elegant black and white coloring. They are also fish eaters and nest almost exclusively on stable emergent aquatic vegetation such as tules. There are several nesting colonies of grebes in wetlands around Clear Lake. Mercury levels tested from feathers of ospreys and grebes were elevated relative to levels for these birds in non-contaminated locations and at times approached toxic levels.

Researchers found a surprising effect of fish populations on mercury bioaccumulation in osprey and grebes. Threadfin shad, a small, non-native fish that lives on plankton, sometimes increases to very large populations in Clear Lake. In years when threadfin shad populations were high, they out-competed inland silversides and juvenile largemouth bass for zooplankton (tiny animals suspended in lake water) shifting the silversides and bass to consumption of zoobenthos (tiny animals from the lake bottom). Because mercury levels are higher in zoobenthos than zooplankton, mercury levels increased in the silversides and juvenile bass and also spiked in osprey and grebe feathers (Anderson *et al.* 2008, Eagles-Smith *et al.* 2008).

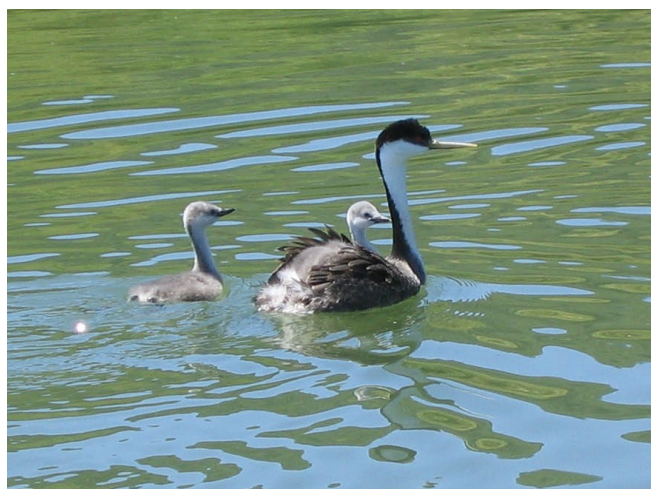


Figure 4-2 Western grebe with young on Clear Lake. Photo by Jacqueline Smythe.

After several studies on the effects of mercury on osprey and grebes, researchers concluded that other factors than mercury levels were more important in determining breeding success. For osprey, these factors were availability of adequate, stable nest sites and abundant food, and for grebes they were protection from disturbance and stable water levels during nesting. Specific disturbances to grebe nesting at Clear Lake are disturbance by motorized water craft, and cattle grazing at low water levels (Anderson *et al.* 2008, Anderson *et al.* 2007, Ivey 2004). A report on grebe conservation in Clear Lake found that “reckless personal watercraft operation, waterskiing, wakeboarding, and tubing; and finally airboat and aircraft activity were presumed to play a contributory role in

this (breeding) failure” (Robison *et al.* 2008). Motor boat disturbance is thought to disrupt and discourage grebes from nesting, swamp their nests, and harm their young due to separation from the parents.

Clear Lake’s grebe populations were severely affected in the 1950s when DDD was applied to control the Clear Lake gnat. Applications were increased over the years as the gnat populations became more resistant to the pest, and biomagnification led to high levels of DDD in fish, grebes, and other birds. By 1960, the grebe population declined to 30 nesting pairs compared to 1,000 in pre-insecticide years, and apparently no young were reared successfully (Carson 1962). These events were one of the examples used by Rachel Carson in her book “Silent Spring” that helped lead to today’s environmental movement, to a better understanding of potential threats posed by chemical use, and to greater regulation of pesticide use in order to reduce threats to human health and the environment.

An outbreak of avian cholera killed more than 7,000 ruddy ducks on Clear Lake in January 2004. Outbreaks of avian cholera occur during cold weather, and when birds are present in high concentrations. It does not affect humans, and volunteers helped collect and dispose of the birds to limit the spread of the disease at Clear Lake. Avian cholera is one of the leading causes of death of migratory birds to disease in California (CDFG 2004, CDFG 2007).

Management

Activities impacting lakes and other aquatic habitats are regulated at state and federal levels. Placement of structures or dredged or fill materials in waters of the United States⁶ requires a Section 404 permit from the United States Army Corps of Engineers (USACE) and Section 401 Water Quality Certification from the Central Valley Regional Water Quality Control Board (CVRWQCB). The types of projects regulated by Section 404 include fill for development, water resources programs such as dams and levees, and infrastructure such as roads and highways. For most discharges that would have only minimal adverse effects, general permits are issued that eliminate individual review and allow certain activities to proceed with little or no delay as long as conditions for the general permit are met (USEPA 2009b). Examples of activities for which general permits are available are repair and maintenance of previously authorized fill or structures, and placement of aids to navigation (USACE 2009).

In addition, activities with the following impacts may require DFG approval. Activities that:

- Substantially divert or obstruct the natural flow of any river, stream or lake.
- Substantially change or use any material from the bed, channel, or bank of, any river, stream, or lake.

⁶ Waters of the United States include all waters used in interstate or foreign commerce, including their tributaries and adjacent wetlands. This definition encompasses most of the surface water in the United States as well as territorial ocean waters.

- Deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake.

The notification requirement applies to any work undertaken in or near a river, stream, or lake that flows at least intermittently through a bed or channel. This includes ephemeral streams, desert washes, and watercourses with a subsurface flow. It may also apply to work undertaken within the flood plain of a body of water (DFG 2008). If DFG finds that “the activity may substantially adversely affect fish and wildlife resources” then a Lake or Streambed Alteration Agreement is necessary as required in Section 1602 of the Fish and Game Code.

The United States Fish and Wildlife Service (USFWS) administers the Endangered Species Act to protect species and the ecosystems on which they depend. They carry out the scientific studies and list species as “threatened” or “endangered.” Once species are listed as endangered, trafficking in the species is prohibited, and critical habitat for the species is protected. The USFWS also has a Division of Migratory Bird Management to conserve migratory birds and their habitats.

The California Fish and Game Commission adopts fishing and hunting regulations and guidelines for determining whether species have California endangered or threatened status. The California DFG is the lead agency for fisheries and wildlife management in the state. A description of the agency’s role from their website reads:

“The Department of Fish and Game maintains native fish, wildlife, plant species, and natural communities for their intrinsic and ecological value and their benefits to people. This includes habitat protection and maintenance in a sufficient amount and quality to ensure the survival of all species and natural communities. The department is also responsible for the diversified use of fish and wildlife including recreational, commercial, scientific, and educational uses.”

With respect to non-game species, the DFG manages species of special concern to achieve conservation and recovery before they require California Endangered Species Act listing.

Currently, DFG maintains a boat year-round on Clear Lake and has a game warden assigned to spend a minimum of 60% of his/her work time on the lake.

The DFG and USFWS work together to respond to bird die-offs in California. This involves prompt removal and disposal of dead birds, and diagnostic testing to determine the cause of the deaths (CDFG 2007).

The DFG has an Invasive Species Program to prevent the introduction of invasive species, detect and respond to introductions that occur, and prevent the spread of invasive species. As part of this program, they have developed the California Aquatic Invasive Species Management Program (CDFG 2008c), and their K9 Program uses dogs to detect invasive aquatic mussels on boats and other vessels.

University of California researchers have carried out extensive research into mercury bioaccumulation and biomagnification in the aquatic food chain, and in birds consuming Clear Lake fish (Suchanek *et al.*, 2000, Anderson *et al.* 1997, Anderson *et al.* 2007, Suchanek *et al.*, 2008c). The University of California (UC) Davis has a statewide on-going research and conservation program for western and Clark's Grebes. Clear Lake is considered to be the third most important breeding site for grebes in California (Ivey 2004).

The DFG 2000 Clear Lake Fishery Management Plan has the objectives "to maintain and enhance 1) fishery resources and the habitats upon which they depend, and 2) provide and where possible, improve fishing opportunities." The DFG issues permits for bass fishing tournaments and commercial fishing on Clear Lake and enforces compliance with these permits, and it regulates sport fishing through the issuance of licenses and enforcement of fishing regulations (CDFG 2008b). DFG also investigates the causes of fish die-offs in Clear Lake.

The 2000 DFG Clear Lake Fishery Management Plan includes the following list of action items:

- Work with Yolo County Flood Control and Water Conservation District (YCFCWCD) to maintain lake elevations for fish habitat and cooler water temperatures.
- Monitor effects of aquatic herbicides and agricultural runoff.
- Protect and encourage planting of tules and other riparian vegetation.
- Acquire land for habitat preservation and improvement.
- Eliminate stream blockages that hinder Clear Lake hitch migration.
- Encourage control of erosion and sedimentation.
- Follow Fish and Game Commission policy for warmwater fish stocking.
- Acquire shoreline property for public fishing access.
- Provide public education on responsible angling and aquatic and watershed awareness.
- Continue to publish warnings on fish consumption and to encourage mercury clean-up.
- Reduce conflicts between vascular aquatic plants and angling use.
- Conduct fishery investigations on panfish and catfish, and a wide variety of potential studies on crappie, bluegill, Sacramento perch, catfish and bass are suggested.
- Study future algae abatement activities.
- Monitor water quality and level effects on fish populations.
- Monitor levels of toxins in aquatic organisms.

- Conduct creel surveys every five years for up-to-date information on the fishery.
- Establish total fish biomass for forage and game fish every five years.
- Study tournament effects on the fishery.
- Monitor aquatic plant growth.
- Initiate a study on the Clear Lake hitch.
- Determine whether commercial bait fishery monitoring is necessary.

As part of the efforts to monitor fish populations, the most recent electrofishing survey at Clear Lake was carried out in 2006 (CDFG 2006).

Fish stocking in Clear Lake with warm water fish such as largemouth bass, channel catfish, and black crappie has been carried out in recent decades by the DFG, Lakebed Management (now part of the Lake County Public Works Department Water Resource Division, LCWRD) and various bass clubs and chambers of commerce (CDFG 2000). There are currently no stocking programs for warm water fish.

Lake County designates eight fish areas around Clear Lake where the speed limit is 5 mph for a distance extending 400 feet from the shore, and one which extends 200 feet from shore (Section 15-11 Lake County Code). The fish areas are along sections of the lake with significant wetland and riparian vegetation that provides important fish and wildlife habitat.

The Lake County Vector Control District has sampled a wide variety of organisms in Clear Lake dating back to the 1950s in order to investigate population dynamics of pests and other organisms. They sample lake surface sediments for benthic invertebrates, take plankton samples, and carry out surface trawls and beach seining for fish species. They have a long record of fish composition taken in beach seines. These data are not highly accurate as species present in large numbers are enumerated by a visual estimate.

4.3 WETLANDS HABITAT

Background

There are two major types of wetlands in the Clear Lake Watershed; freshwater marshes, including wet meadows that are at least seasonally flooded or saturated; and vernal pools. Freshwater marshes have erect, emergent wetland vegetation. This includes plants such as sedges, rushes, cattails, and tules (CDFG 1988). These plants differ from rooted, submerged aquatic plants that grow in shallow areas of Clear Lake. Although many submerged aquatic plants grow up to the lake's surface, they are not self-supporting and erect when lake levels drop. Most freshwater marshes in the Clear Lake Watershed are located surrounding and adjacent to Clear Lake (Plate 9), although they also occur along seasonally flooded sections of streams and as hillside seeps. Vernal pools are seasonally

flooded depressions found on soils with an impermeable layer such as a hardpan, claypan, or volcanic basalt. Vernal pools contain a distinct set of species adapted to both flooded and dry conditions, and they are found in upland locations.

According to the USACE wetlands definition in Section 404 of the Clean Water Act, wetlands are “areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions” (33 CFR 328.3[b] and 40 CFR 230.3). The County of Lake definition also includes the definition that three wetland identification parameters be present. These are: wetland hydrology, hydric soils, and hydrophytic vegetation.

The total area of freshwater wetlands surrounding and adjacent to Clear Lake prior to European settlement was estimated to be “not less than 9,000 acres” (Week 1982). The most recent estimate, using 2002 satellite imagery, found about 1,920 acres, or 21%, of this area remaining (LCWRD 2003). The four areas with the largest and most viable remaining wetlands are Anderson Marsh State Park, the Rodman Slough area, the Big Valley shoreline, and the area between Clearlake Oaks and the Sulphur Bank Mercury Mine. These wetlands make up 1,800 acres, or 94% of the remaining wetlands. Of the remaining wetlands, the mean size is three quarters of an acre. Although these remaining wetlands are small and widely scattered, they provide important fish and wildlife habitat.

Anderson Marsh demonstrates the biological richness and recreational value of the wetland habitats around Clear Lake. A 1973 survey found 91 bird species, 57 of which are known to nest in the area. In the adjacent riparian uplands, deer, gray squirrels, fox, mink, black-tailed jackrabbit, and muskrats were observed (CDFG 1975). California Species of Special Concern that may be observed in wetlands include tricolored and yellow headed blackbirds, which nest in tules and cattails, and western pond turtles. As discussed in the lacustrine section above, western and Clark’s grebes build their nests in tules. Wetlands are important to fish for food, cover and spawning habitat. Week (1982) found that 10 out of 13 fish species sampled preferred tule habitat over artificial habitats such as bulkheads or rip-rap, or un-vegetated areas. Fish that preferred tule habitat included largemouth bass, bluegill, black crappie, green sunfish, brown bullhead, white catfish, Sacramento blackfish, tule perch, and prickly sculpin. Hitch preferred both gravel/tule and tule habitat.

Wetland loss around Clear Lake has occurred as a result of reclamation for agriculture, for housing developments, such as the Clearlake Keys, and to extend shoreline areas, such as the waterfront along Lakeport ([Section 4.2](#)). Also important were small wetland losses around the lake where bulkheads, marinas, and docks were built, or where lakefront property owners cleared vegetation along the beaches (Week 1982).

In the Clear Lake Watershed a total of 1,640 acres of vernal pools in 28 areas have been mapped as part of a DFG project (Holland 1998). These mapped areas occur almost entirely in private lands. Because of the unique hydrology of vernal pools, which cycle between flooded and extremely dry conditions, they contain a

large number of specially adapted plants found only in vernal pools. Springtime vernal pool wildflower displays can be spectacularly beautiful with brightly colored concentric rings of flowers. Animals found in vernal pools include freshwater crustaceans, insects, and amphibians. Vernal pools are most commonly located in the middle of surrounding grasslands, which typically contain a majority of non-native species. Vernal pools, however, with their unique hydrology, contain over 91% native plant species. Because of the previously limited extent and continuing losses of vernal pool habitat, about one-third of vernal pool plant species are listed in the California Native Plant Society's Inventory of Rare and Endangered Vascular Plants of California. Potential losses of vernal pool habitat occur due to development, heavy livestock grazing, and conversion to agriculture. In the latter case, deep tillage of soil destroys the impermeable soil layers that create vernal pools (Smithsonian Institution, Undated).

Management

Management and regulatory activities described in the Lacustrine Section (Section 4.2) (with the exception of Clear Lake management) apply to wetlands as well. Vernal pools and isolated wetlands do not fit the definition of “Waters of the United States” and therefore do not fall under USACE jurisdiction. However, the State of California requires a permit for discharge into isolated waterbodies (SWRCB 2008b).

Specific regulations with regard to wetland habitat around Clear Lake include Section 23-15 of the Clear Lake Shoreline Ordinance (adopted in 2003). To prevent further destruction of shoreline vegetation, the ordinance states that “On residential properties, within the nearshore and foreshore of littoral parcels, management activities that result in the death of woody species (i.e. willow, cottonwood, buttonbush) and tules (scirpus sp., bulrushes) is prohibited. The above types of vegetation may be mowed, pruned, or trimmed so long as it does not result in the death of the plant.” For commercial, resort, or public properties, a lakewide, no-net-loss program is in place that requires replacement planting for any new areas of beach cleared.

The Lake County Zoning Ordinance (Article 29) has a wetlands or “W” combining district with the purpose of preserving and protecting environmentally sensitive wetlands.

Lake County has been pursuing the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project (Middle Creek Project) since 1995, which would nearly double the current area of wetlands around Clear Lake (USACE 2002). This project is described in Section 2.8.2.

4.4 RIPARIAN AND RIVERINE HABITAT

Background

Riparian habitats are relatively narrow strips of land bordering streams, rivers, lakes, and other water bodies. The vegetation in riparian habitats differs from the

surrounding landscape because it requires or tolerates wet and sometimes flooded conditions. Although riparian habitats make up a small proportion of the total land area, they provide important habitat for a wide variety of animals. Of all California animal species, an estimated 25% of land mammals, 40% of reptiles, and 83% of amphibians depend on riparian systems for some or all of their life



Figure 4-3 Great blue herons and snowy egrets on Rodman Slough. *Photo by Tom Smythe.*

cycle (Brode and Bury 1984, Williams and Kilburn 1984). Riparian habitat is considered the most critical habitat for conservation of resident and neo-tropical migrant birds in the western United States. Riparian vegetation provides shade, food, and nutrients that are the basis of the aquatic food chain within the streams and water bodies that they surround. Despite the importance of riparian habitat, it is estimated that only 2-15% of historic riparian habitat remains in California (RHJV 2004).

Riparian habitats in this section will be discussed in

terms of changes with elevation and gradient (steepness of the stream). Riverine habitats, the aquatic habitat characterized by intermittent or continually running water in streams and rivers, also vary based on elevation and gradient, so these habitat types will be discussed concurrently.

Streams found in the headwaters, or highest portions of the watershed are typically small, with steeper gradients. The headwaters area is dominated by erosion of sediments, so streams flow through valleys that are V-shaped with no floodplains. In many cases, riparian vegetation is simply an extension of the surrounding forest, or shrub canopy; however, this canopy is important for maintaining stable stream temperatures. While the smallest streams may be ephemeral, larger streams flow year round, and cool water temperatures are maintained from groundwater recharge. Cold, permanent streams such as those found in the upper Kelsey and Middle Creek Watersheds are excellent trout habitat, supporting native rainbow trout and introduced brown trout.

Downstream from the headwaters is the transitional zone. Stream gradients decrease, and some of the material eroded from above is deposited to create a limited floodplain area, typically with a meandering stream channel. Plant communities adapted to periodic flooding occur in the floodplain. Tree species may include willow, ash, alder and maple. As the channel widens, the stream is exposed to more sunlight which causes larger daily water temperature fluctuations, and an increase in the average water temperature.

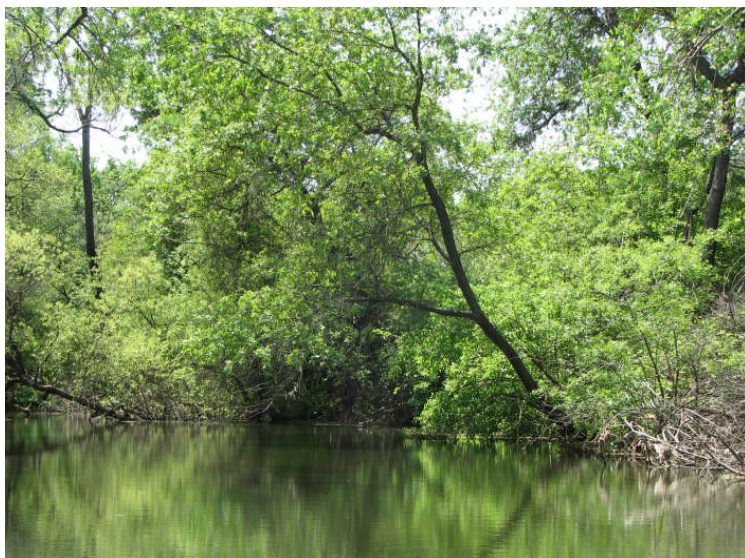


Figure 4-4 Riparian vegetation along Rodman Slough. Photo by Tom Smythe.

Finally, in lower portions of the watershed, broad level valleys are created by stream deposition of sediments (alluvial material). In their natural condition, stream channels meander, creating a mosaic of riparian vegetation stages. The deep alluvial soils support complex, multi-layered tree and shrub canopies that are important to a wide array of wildlife. Dominant tree species include cottonwood and Valley Oak, while other trees such as box elder and ash may be present in a sub-canopy. Shrubs and vines include wild grape, wild rose, blackberry, and poison oak. This type of vegetation is also found

surrounding Clear Lake. Wetlands may be present in this nearly level terrain. Within the wide channels, water temperatures are generally warmer, suitable for warm water fish species including many of those found in Clear Lake. The lowest sections of all the tributaries to Clear Lake typically dry up, or are limited to a series of pools by early to mid-summer.



Figure 4-5 Clear Lake hitch. Photo by Tom Taylor.

Several fish species once used and some continue to use, the lower reaches of tributaries to Clear Lake for spawning. Enormous spring migrations of the Clear Lake hitch, splittail, and Sacramento pikeminnow once occurred when these fish moved up the low gradient, gravelly reaches of Clear Lake tributaries to spawn. In the past, a large lake

population of Sacramento Suckers used Clear Lake tributaries for spawning;

however, this population has declined significantly. Sacramento Suckers are found resident in Clear Lake tributaries (Cook *et al.* 1966). Steelhead, the anadromous form of rainbow trout, passed through Clear Lake to spawn in tributary streams prior to the construction of the Cache Creek Dam in 1914.

Currently, only the hitch continues spring migrations in significant numbers, and these numbers have declined from past levels.

Land use activities are discussed in detail in Chapter 3. In this section, land use impacts on riparian and riverine systems are discussed briefly. Information on stream channel conditions in the Kelsey, Middle, and Scotts Creek Watersheds is compiled in the respective watershed assessments (ELRCD and WLRCD 2009, WLRCD 2009a, 2009b).

Livestock grazing, timber harvesting, road building and operation, and Off-highway vehicle (OHV) travel in stream channels and on stream banks are potential major impacts in headwaters and transitional stream habitats. All of these activities can lead to soil compaction, stream bank erosion, increased erosion and sedimentation, and reduction of riparian vegetation. Improper livestock management may contribute fecal contamination and nutrients to streams.

Soil compaction reduces water infiltration, contributing to higher peak flows and lower sustained flows. Excessive inputs of sediment impact riverine habitats throughout the stream system. Deposited sediments fill pools that were used for fish habitat, as well as the interstices within gravel beds. When gravel beds are filled with sediment, they are no longer suitable for fish spawning, and benthic macroinvertebrates, an important source of food in the aquatic food chain, are smothered. Sediments and fecal contamination are sources of nutrients that contribute to eutrophication, and subsequent increased demand for oxygen that can cause fish die-offs. Removal of riparian vegetation reduces a vital habitat area for many terrestrial species. It eliminates the large woody debris that helps create pools and shelter for fish in streams. As stream cover is reduced, water temperatures rise, and dissolved oxygen levels decline (Harrington and Born, 2000).

Transitional and valley riparian areas have been subject to gravel mining, reservoir development, groundwater pumping, channel straightening to improve land use efficiency or reduce flooding, and levee building for flood control. A variety of in-stream structures such as bridge abutments, culverts, and water retention structures are partial or complete barriers to fish migration. Because human land use, both urban and agricultural, has been concentrated in level valleys, there has been a greater reduction in riparian habitats in these areas compared to higher elevations. Pesticides, fertilizer, and animal or human waste have the potential to contaminate streams and harm aquatic life.

Gravel mining, stream straightening and flood control levees all contribute to higher stream flows, increased stream bank erosion, and stream down-cutting. Lower stream channels drain out groundwater and lower the surrounding groundwater table. Riparian vegetation, especially vegetation immediately adjacent to the stream channel, is removed for gravel mining and flood control. This process of channelization, creating a deep, straight channel, has several effects on stream processes and riparian and riverine habitats. It interrupts the natural process by which the stream's curves migrate over the floodplain and create varied stages of riparian growth. In addition, alteration of flood regimes

and depth to groundwater may affect the composition of riparian trees and shrubs. In naturally meandering streams, pools occur at the curves and riffles (shallower gravelly sections) occur at the crossover between curves. Straightening stream courses therefore reduces the presence of pool and riffle sequences that provide varied aquatic habitat.

Several activities in the lower watershed have contributed to reductions in (or elimination of) spring migrations of the Clear Lake hitch, Clear Lake splittail, and the pikeminnow. The Clear Lake splittail was found only in Clear Lake and its tributaries. Its population underwent drastic reductions in the early 1940s, and it has not been observed since the 1970s. Channelization may have reduced flooded areas needed for splittail spawning and larval rearing. Earlier drying of Clear Lake tributaries due to water diversions and groundwater pumping may have contributed to the demise of the splittail and loss of pikeminnow populations that were once abundant in Clear Lake. Both of these fish spawned later than the Clear Lake hitch (Cook, S.F. *et al.* 1966, Macedo, R. 1994, Moyle 2002).

The hitch have been designated a species of special concern in California because of decreasing populations and limited geographic distribution (Moyle *et al.* 1995). Early stream drying may be reducing the success of hitch spawning, and numerous man-made barriers have reduced the area of streams available for spawning. Barriers of 1-2 feet in height block the passage of hitch, which are not strong jumpers. Crowded spawning conditions occur below the barriers that may suffocate eggs due to lack of oxygen or high concentrations of nitrogenous wastes. (Macedo, R. 1994). Some of the major barriers include the Kelsey Creek Detention Structure, which blocks a portion of the hitch migration, and the footing of the Main Street Bridge in Kelseyville, which completely blocks hitch passage. On Middle Creek, the footing of the Rancheria Bridge was a complete barrier to hitch passage. Following the construction of a series of rock weirs below the footing, however, a hitch was observed upstream of the bridge in 2008. On Scotts Creek, the footing of the “Decker Bridge” in Scotts Valley blocks hitch passage. While many of these major barriers are documented, there has not been a systematic effort to document all potential barriers.

Areas of riparian vegetation in the level valleys surrounding Clear Lake were undoubtedly reduced when early settlers cleared land for agriculture and town building. Remnants of multi-story riparian forests can still be seen in areas such as Clear Lake State Park and the county Lakeside Park in Big Valley. Riparian vegetation along stream courses still provides important wildlife habitat, including nesting, feeding, cover, water, shade, and travel corridors. Since the adoption of a Creek Management Plan (1981) and Aggregate Resource Management Plan (1994), gravel mining in Lake County streams has been nearly eliminated, and riparian vegetation has increased in several former gravel mined areas since that time (ELRCD and WLRCD 2009, WLRCD 2009a, 2009b).

Potential water pollutants such as pesticides, fertilizers, and animal or human wastes are discussed in greater detail in the Land Use Chapter ([Sections 3.4.4](#) and [3.4.5](#)). Some pesticides are toxic to aquatic life, and pesticide regulations take this factor into account when defining how, when, and where pesticides can be

used. Recent monitoring for pesticides in Clear Lake tributaries has shown very little evidence of pesticide contamination ([Section 3.4.4](#)). Fertilizers and wastes that enter streams contribute to eutrophication, which can reduce the diversity of aquatic life and contribute to low oxygen levels.

Management

The roles of the USACE, USFWS, CVRWQCB, and DFG in wildlife, fisheries and habitat preservation are discussed above in [Section 4.2](#) above. Additional management activities of riparian and riverine zones in the Clear Lake Watershed are discussed here.

Lake County operates Adobe and Highland Springs Reservoirs on Adobe Creek. During the spring, stream flows pass directly through the reservoirs. The presence of the reservoirs appears to have little effect on spring fish migrations, as Adobe Creek currently supports the largest run of hitch in the county (Chi Council 2008). At the Kelsey Creek Detention Structure, operated by Lake County to increase groundwater recharge on Kelsey Creek, operating criteria require maintenance of spring flows and opening the structure when hitch runs are detected. The Detention Structure has two fish ladders on either side of it to assist hitch migration. However, due to its height and design, the Detention Structure remains a partial barrier to hitch passage.

Local Tribes are developing an Adaptive Management Plan for the Clear Lake Hitch that will address the following issues:

- Migration barriers.
- High nutrient loads.
- Water use for agriculture and development.
- Stream flows.
- Mitigation measures for all of the above issues.
- GIS mapping of hydrologic lines and historic and current streams used for hitch spawning (Irenia Quitiquit, personal communication).

Federal agencies charged with land management recognize the importance of riparian and riverine habitat for wildlife and fish, as well as the importance of riparian vegetation for filtering sediments. On Mendocino National Forest (MNF) in the Middle Creek Watershed, lands are managed to meet Aquatic Conservation Strategy objectives which include:

- Maintaining and restoring watershed and landscape-scale features to ensure the protection of aquatic systems.
- Maintaining and restoring the water quality necessary to support healthy riparian, aquatic, and wetland ecosystems.
- Maintaining and restoring plant communities in riparian areas and wetlands to provide thermal regulation and nutrient filtering.

- Preventing or regulating activities in riparian reserves (setbacks along stream corridors, ponds, reservoirs, lakes, and wetlands) (USDA FS 1995).

The Upper Lake Watershed Analysis Report prepared by the United States Forest Service (USFS) designated riparian reserves based on the widths recommended in the MNF Land and Resource Management Plan and also included all inactive landslides as part of the riparian reserve (USDA FS 1999).

In the Middle Creek area of MNF, OHV recreation is a major activity, and management is directed at designing trails to direct OHV use away from wet meadows and streambeds (USDA FS 1995). A portion of an OHV riding area adjacent to the West Fork of Middle Creek near the Middle Creek Campground is being converted to riparian vegetation. In addition, USFS has inventoried roads in the Middle Creek Watershed to prioritize drainage improvements. Its goals are to reconstruct poorly designed roads and decommission unnecessary roads (CLTSC 2008, USDA FS 1999). There is limited timber harvesting on USFS lands. Logging and log hauling are not allowed during the rainy season, and Best Management Practices (BMPs) to reduce sedimentation include construction of waterbars on skid trails prior to the rainy season (USDA FS 1999).

On Cow Mountain Recreation Area Bureau of Land Management (BLM) lands in the Scotts Creek Watershed, riparian habitats are recognized as important fish and wildlife habitat, and management objectives include restoring and enhancing riparian habitats for migratory birds and enhancement of game fisheries in streams with the greatest potential (USDI BLM 2006).

Article 37 of the Lake County Zoning ordinance limits development in riparian corridors and describes conditions under which exceptions can be granted. The waterway, or WW, combining district defines riparian corridors as an area extending 30 feet from the top streambank of a perennial stream, 20 feet from the top streambank of an intermittent stream, and 20 feet from the high water mark of a wetland or small water body. In addition, the riparian corridor extends to the limits of the occurrence of riparian vegetation where this exceeds the distances listed above (Lake County 2009b).

The Lake County Grading Ordinance defines watercourse corridor widths based on the stream classification (Classes I-IV) and erosion hazard rating (slight, moderate, severe). The setbacks range from 20 to 100 feet and are greater in streams that support fish (Class I) as compared with those that support non-fish invertebrates, or macroinvertebrates (Class II), or other natural stream courses (Class III). Lakes, wetlands, and vernal pools are also classified Class I, II, or III based on the aquatic habitat that they provide. Watercourse corridor widths also increase as the erosion hazard rating goes from slight to moderate to severe (Chapter 30, Lake County Code). Man-made (Class IV) watercourses do not have watercourse corridors defined. Specific standards for grading in watercourse corridors are described in the ordinance, and grading that occurs within Class I, II, or III watercourse corridors is considered complex grading, requiring completion of an Initial Study pursuant to the California Environmental Quality Act.

4.5 UPLAND HABITAT

Background

Upland habitats⁷ in the watershed consist primarily of blue oak and interior live oak woodlands and grasslands in low elevation, chaparral and oak-foothill pine woodlands on slopes and middle elevations, and mixed conifer and conifer-hardwood forests and woodlands at higher elevations in the watersheds (Plate 10). Land use practices, such as clearing natural vegetation for agriculture and development, fire prevention and suppression activities, logging, and livestock grazing, have adversely affected the diversity and structure of upland habitats (USDA FS 1999). However, the dominant species composition of oak woodlands, conifer forests, and chaparral communities is still largely intact (Richerson *et al.* 2008).

The wide, lower elevation valleys in the Clear Lake Watershed were once dominated by valley oak woodlands. Valley oaks grow in deep soils, and they provide nesting sites for cavity nesting birds and supply abundant acorns that are a food source for many animals. Valley oak woodlands are still found in scattered lots and along some roads and riparian corridors; however, this habitat has been more heavily modified from pre-European conditions compared to other upland habitats. Early settlers rapidly cleared these level valleys with their deep soils that were well-suited to agriculture (Simoons 1952).

Moving up in elevation, blue oak woodlands, and blue oak-foothill pine forests dominate lower elevation slopes. Blue oaks thrive in hot foothill areas with shallow soils, and like all oaks, their acorns are an important food source for many animals. Their under-story is typical of California grasslands with an array of introduced grasses and forbs which have replaced native perennial bunch grasses (CPIF 2000, CDFG 1988). Beginning with the first Spanish colonists in California, livestock grazing led to replacement of native perennial bunch grasses with non-native annual grasses over a period of about 100 years. Most of California's original grasslands have been converted to agriculture, and today the majority of California grasslands occur in areas that were cleared by ranchers from shrub and oak woodlands (CPIF 2000, CDFG 1988). In most of California grasslands (and in other habitats with a grass understory), common annual grasses include wild oats, soft chess, ripgut brome, red brome, wild barley, and foxtail fescue. Common forbs include filarees, turkey mullein, clovers, and popcorn flower.

⁷ For this document, upland habitats are all habitats located above lacustrine, wetland, and riparian habitats.



Figure 4-6 Grasslands and blue oak woodlands. *Photo courtesy of Lake County.*

Statewide, both valley and blue oaks show poor regeneration. Young, first year seedlings and old trees are present, but a combination of competition from introduced grasses, fire suppression, and herbivory appears to prevent seedling survival (CPIF 2002). In Lake County, there have been no systematic studies of oak tree regeneration. Anecdotal evidence indicates that regeneration is uneven, occurring in some areas, but not others (ELRCD and WLRCD 2009, WLRCD 2009a, WLRCD 2009b).

Large areas of the Clear Lake Watershed are covered by chaparral,

shrubby vegetation that occurs on dry, shallow soils of hills and mountainsides. Chaparral plants are adapted to fire; some have seeds that germinate following fire and roots that re-sprout following fire. Many chaparral plants have evergreen leaves covered with a heavy waxy cuticle to prevent water loss. Dominant plants in chaparral include scrub oak, chaparral oak, chamise, and several species of manzanita and ceanothus. In mature stands of chaparral, vegetative cover is often greater than 80%. On very rocky soils, or soils formed on ultramafic minerals, cover may reach only 30% (CDFG 1988). On north and east facing slopes, plant species change due to reduced sunlight and water stress. Dominant species can be shrubby live and canyon oaks, mountain mahogany, ceanothus, madrone, bay, and sometimes black oak (CDFG 1988, Nielson and McQuaid 1981).

On north and east facing slopes at higher elevations hardwood or douglas fir forests occur, and dominant species include canyon live oak, California bay laurel, madrone, black oak, and Douglas fir. These forests support abundant wildlife. Mature forests provide nesting sites for cavity nesting birds, and acorns are a food source for many birds and mammals. In cooler locations, many amphibians are found in the leaf litter layer (CDFG 1988).



Figure 4-7 Ponderosa pine & Douglas fir forest in the Kelsey Creek sub-watershed south of Clear Lake. Photo courtesy of

The oaks found in the upper watershed do not have problems with regeneration, but they are susceptible to sudden oak death (SOD), caused by a fungus-like agent, *Phytophthora ramorum*. This pathogen infects a wide range of plant species (including bay laurel, manzanita, Douglas fir, rhododendrons, and buckeye), but causes mortality in only a few (including tanoak, black oak, and coast live oak). SOD has not been found in the Clear Lake Watershed, and the risk of

SOD spread may be low because the watershed is inland from the coastal fog belt where SOD has spread. Nevertheless, watershed residents and visitors should avoid introducing potentially contaminated plant material or soil attached to vehicle tires and shoes from infected areas (COMTF 2004).

Douglas fir is the most commonly found conifer in the highest elevations of the Clear Lake Watershed. In addition ponderosa pine, incense cedar, and sugar pine are found in drier areas on south and west facing slopes. In areas of chaparral, islands of knobcone pine and cypress are found. These trees rely on fire for their seeds to germinate (CDFG 1988).

Before European settlement and active fire suppression, wildfires were more frequent but had lower intensity. Compared to present conditions, chaparral communities were characterized by a mosaic of uneven age classes, and forests and woodlands contained fewer but larger trees with reduced understory vegetation. The young, tender stages of chaparral growth are important deer browse. The cessation of regular controlled burning was cited as the cause of a decline in deer populations in the Cow Mountain area following decades of fire suppression (Hendricks 1968). The DFG record of deer kills in Lake County shows a peak in the numbers of bucks killed (and likely the deer population as a whole) in the 1940s and 1950s and a decline in the 1960s. Numbers have remained low since that time (CDFG 2007). Wildfires also benefit wildlife by increasing the flow of streams and springs for several years following a fire due to reduced plant water use.

The current accumulation of fuels in many upland communities in the upper portions of the watershed puts vegetation and wildlife habitats more at risk of catastrophic losses from wildfires. Catastrophic fires tend to have large,

continuous areas of high intensity burns that remove all or most of the native vegetation. For example, in 1996, the Fork Fire burned 16,605 acres, comprising 33% of the Middle Creek Watershed. (The total size of the Fork Fire both in and outside the Clear Lake Watershed was 83,323 acres.) Deer populations are expected to increase in the area burned by the Fork Fire as early plant successional stages provide increased forage; however, as brush fields mature, deer populations are expected to decline. The limited area of late successional forests in the Middle Creek Watershed that are suitable habitat for the endangered northern spotted owl were reduced by up to 20% during the Fork Fire (USDA FS 1999).

Other activities affecting upland wildlife habitats include residential and urban development, timber harvesting, OHV use, livestock grazing, and introduction of invasive species. Areas with residential and limited urban development in the upland areas of the Clear Lake Watershed are primarily in the Cobb Mountain area and in the Clearlake Rivas on and near Mt. Konocti. The primary effect of such development is reduction of wildlife habitat. In addition, stream pollution from stormwater runoff may occur, and residential and urban water use may lead to declines in local water tables, reducing stream flows and the water available to aquatic and terrestrial animals.

Logging has changed forest age and structure, and therefore, wildlife habitat. Extensive logging occurred from the late 1850s to the early 1930s in both the Middle Creek Watershed and the Kelsey Creek Watershed (USDA FS 1999, Dillon 1995). In BMDSF, virtually all of the timber was gone by 1949, which is why the state was able to purchase the land for a reasonable price. The forest is now a young, even-aged forest, and forest management objectives are to “create an all-aged forest structure, with stands containing a variety of age and size classes” that “will provide for a more biologically diverse habitat than is found in the current predominantly young forest” (CDFFP 2008). In USFS lands in the Middle Creek Watershed, selective removal of conifers has converted many conifer plant communities to conifer-hardwood communities (USDA FS 1999).

A major impact of livestock grazing has been conversion of California grasslands from predominantly native perennial grasses and forbs to predominantly annual, introduced grasses. Heavy livestock grazing reduces plant cover and causes soil erosion, and the most serious effects occur in riparian areas. The introduction and spread of invasive plant and animal species is a threat to wildlife habitat and species. It is covered in Chapter 6 ([Section 6.3.1](#)).

Management

As discussed in the lacustrine section ([Section 4.2](#)), the USFWS is charged with endangered species designation and protection, and management and conservation of migratory bird populations. The DFG also works on conservation of sensitive fish, wildlife, plants and natural communities.

Along with enforcement of hunting and fishing regulations, DFG has programs to deal with animal depredations such as bears or mountain lions that threaten humans or livestock, care for orphaned and injured animals, and enforce

environmental laws with regard to streambed alterations or pollution leading to stream degradation. With other agencies, DFG works to arrest people who have been found growing marijuana illegally, and clean-up the sites where illegal marijuana cultivation threatens wildlife habitat and water quality (Linnette Shimek, personal communication).

Fire management has had, and will continue to have a major impact on upland wildlife habitats. On MNF lands in the Middle Creek Watershed, the goal is to carry out prescribed burns on approximately 5% of the chaparral area on an annual basis. This management practice is intended to improve wildlife habitat and reduce the potential for fires to reach stands of timber. On the BLM Cow Mountain Recreation Area, the Fire Management Plan calls for prescribed burning to reduce fuel loads, improve wildlife habitat, and manage invasive weeds. While the target for annual prescribed fire and mechanical fuel treatments is up to 1,000 acres in the Cow Mountain unit, in most years, less than 400 acres are burned and/or treated (USDI 2006, Jeffrey Tunnell personal communication).

Some private landowners carry out prescribed burning, primarily in chaparral areas. Private landowners must contact the Lake County Air Quality Management District (LCAQMD) and California Department of Forestry and Fire Protection (CAL FIRE) for permits to carry out prescribed burns. CAL FIRE can provide technical advice, and in some instances, when a large area of brushland is involved, CAL FIRE can cost share and provide expertise for prescribed burning.

4.6 WILDLIFE AND HABITAT ACTIONS

4.6.1 Overall Strategy

The Lake County General Plan goal for Clear Lake management is “to manage and preserve fish and wildlife habitat areas and areas of natural scenic beauty, while enhancing the water quality of Clear Lake” (LCCDD 2008). Policies include preserving diverse fish and wildlife and aquatic habitats, supporting efforts for public acquisition of environmentally significant lands, limiting new urbanization along the shoreline to preserve the natural environment, restoring wetlands in the reclamation area south of Upper Lake, and coordinating among public agencies and private property owners to enhance fish and wildlife habitats, improve water quality, and control environmental problems such as the spread of invasive species.

The Lake County goal for biological resources is “to preserve and protect environmentally sensitive significant habitats, enhance biodiversity, and promote healthy ecosystems throughout the County” (LCCDD 2008). A wide range of specific policies promote this goal. The county ensures protection of sensitive species. County development policies include clustering development, limiting development in areas with sensitive habitat, and requiring buffers between development and significant watercourses, riparian vegetation and wetlands. The county supports management of wetland and riparian plant communities for passive recreation, groundwater recharge, and wildlife habitat. The importance of

oak woodland conservation and management is specifically mentioned. The county works with other government land agencies to preserve biological resources while maintaining opportunities to enjoy the county's natural resources. This includes supporting the public's right to appropriate access to resource-managed land, and providing opportunities for hunting and fishing pursuant to regulations of the California Fish and Game Code.

4.6.2 Research and Develop a Management Plan for Native Clear Lake Fish

Background

Despite apparently significant declines in native fish populations, there have been relatively limited studies of native fish species in Clear Lake. One exception is a program by local Native American Tribes to tag spawning Clear Lake hitch, which began in 2009. Along with the Clear Lake hitch, native species that may have declining populations in Clear Lake include the Sacramento pikeminnow, Sacramento sucker, and the Sacramento blackfish. Sacramento perch populations have declined in Clear Lake, as they have all over the state. Both the Clear Lake hitch and Sacramento perch are DFG Species of Special Concern.

There have been relatively few studies of Clear Lake fish, their trophic interactions, and factors such as temperature, lake level, or aquatic vegetation, that may affect the success of fish populations. Environmental and biological factors that may control spring spawning migrations, e.g. flow regime, water temperature, chemical "signature" of a stream, or chemical signals among spawning fish, are not well understood. Improved access to streams for spring spawning migrations is important for species such as the Clear Lake hitch, Sacramento sucker, and Sacramento pikeminnow. Additional factors in Clear Lake, such as availability of shoreline vegetation as habitat, competition for food, and predation by non-native fish are likely to influence their populations. Trophic interactions among native and non-native fish species have been shown to affect mercury bioaccumulation (Anderson *et al.* 2008, Eagles-Smith *et al.* 2008). The impact of high threadfin shad populations on zooplankton may have an impact on plankton-feeding fish and algal blooms; however, this impact, if any, has not been analyzed.

Project Description: Research on native fish populations in Clear Lake could be conducted by fisheries biologists from DFG or from a research institution such as UC Davis. Development of a research and management program for native Clear Lake fish would require the following steps:

1. Identify gaps in information and understanding of factors influencing Clear Lake fish populations.
2. Design studies to fill in these knowledge gaps.
3. Use study results as a guide to developing a fish management plan.
4. Monitor and adaptively manage Clear Lake fish populations.

Key Participants: DFG, LCWRD, Clear Lake Advisory Subcommittee (CLAS), Tribes, research scientists.

Timeframe: 0-5 years.

Technical Resources Required: Fisheries biologists.

Cost Estimate: \$100,000.

Milestones: Steps 1 through 4 above.

Effectiveness Criteria: Increasing native fish populations.

4.6.3 Protect and Restore Lake and Shoreline Habitats

4.6.3.1 Protect Critical Lake Habitat

Background

Some critical wildlife habitat areas around Clear Lake are protected. For example, Anderson Marsh State Historic Park, Clear Lake State Park, DFG and Lake County Land Trust (LCLT) properties at Rodman Slough, and County of Lake Rodman Slough and Lakeside Parks, all protect vital wetland and adjacent upland habitats. Other important wildlife habitat is not currently protected. Important habitat areas include:

- The Clear Lake shoreline from Clear Lake State Park west to Lakeport, which LCLT has identified as “the largest remaining areas of unprotected wetland/riparian habitats adjacent to Clear Lake. The shoreline currently maintains high value habitats with pristine lakeshore vegetation and mature oaks used by a variety of species” (LCLT 2008). The significance of this area is recognized in the Lake County General Plan (LCCDD 2008). It is also an area that supports important nesting habitat for western and Clark’s grebes. The emergent vegetation such as tules in this area also provides habitat for juvenile fish.
- The area around Rodman Slough has been proposed as a DFG Conceptual Area Protection Plan (CAPP) (Section 4.6.3.3). This area includes the Middle Creek Project, additional land surrounding Rodman Slough, and Tule Lake. It would total an area of about 3,225 acres of wetland, riparian, and mixed upland habitats. It is recognized as an important area for wetlands protection in the Lake County General Plan (LCCDD 2008).
- Several islands in Clear Lake provide important wildlife habitat. Rattlesnake Island, in the Oaks Arm of Clear Lake is not only the largest island in the lake, but is important for its undisturbed condition. Indian Island in the Lower Arm, and Anderson Island south of the Narrows, are also significant islands.

Project Description: Protection of critical wildlife habitat will require a combination of public and private actions. These could include conservation

easements, land acquisition, zoning changes, and county or state management plans.

Expansion of fish areas, areas designated by County Ordinance with a 5 mph speed limit extending 400 feet from the shoreline, could protect both fish and water fowl habitats. For example, Quercus Point has a fish area along its west side; however, the east side is an important grebe nesting area, and is not currently protected by boating speed limits.

Key Participants: LCLT, LCCDD, LCWRD, CLAS, Tribes, DFG, and USACE .

Timeframe: On-going.

Technical Resources Required: Wildlife and Fisheries Biologists and staff of participating agencies.

Cost Estimate: To be determined.

Milestones: Each additional habitat area protected.

Effectiveness Criteria: Increase in area of critical wildlife habitat that is protected.

4.6.3.2 Protect and Expand Small-Scale Habitat Areas on the Clear Lake Shoreline

Background

There are many small areas of wetland and riparian habitat along the Clear Lake shoreline that provide dispersed fish and wildlife habitat and environmental benefits such as sediment and nutrient filtration. Areas with small and scattered habitat include lightly and undeveloped shoreline, such as those between Nice and Lucerne, and developed areas with remnant riparian and wetland habitats. Although it is difficult to determine the importance of these habitats, they may be critical to fish and wildlife because they span many miles of Clear Lake shoreline where no large areas of habitat are present.

Project Description: Education of private property owners is an essential part of preserving and expanding small-scale shoreline habitat areas. Education and outreach should include topics such as the importance of riparian and wetland vegetation as wildlife and fish habitat and as buffers to limit nutrient inputs to the lake, avoiding the use of fertilizers and pesticides adjacent to the lake, and the use of native plants in landscaping.

The County Wetland Policy encourages the preservation of shoreline habitat. The Zoning Ordinance implements shoreline protection through the Waterway Combining District (WW) and the Shoreline Ordinance limits the removal of wetland and riparian vegetation. The General Plan includes goals and policies intended to protect these areas. As part of reviewing and revising county wetland policies and ordinances ([Section](#)

3.10.2), the county should ensure the protection of small-scale shoreline habitat areas.

Key Participants: LCCDD, LCWRD, CLAS, DFG, volunteers, and educators.

Timeframe: On-going.

Technical Resources Required: Wildlife and fisheries biologists and staff of participating agencies.

Cost Estimate: Regular staff time.

Milestones: Education and outreach events and revision of county wetland policies and ordinances.

Effectiveness Criteria: Increase in area of small-scale shoreline wetlands and riparian habitat.

4.6.3.3 Pursue the Clear Lake Wildlife Area Conceptual Area Protection Plan

Background: The DFG has completed a Clear Lake Wildlife Area CAPP for an area of approximately 3,225 acres surrounding Rodman Slough. A CAPP is a planning document used to support land acquisition or purchase of easements by the California Wildlife Conservation Board (WCB). The WCB may also facilitate acquisition by another group when it meets the CAPP goals for the area and is in the public's best interest. The CAPP provides the required documentation so that the WCB can immediately consider properties as they become available. The WCB has a system for prioritizing properties available for acquisition throughout the state and considers acquisition as funds are available.

The Clear Lake Wildlife Area CAPP states that "The purpose of this acquisition is the conservation, protection and restoration of significant wetland and upland habitats and their associated species in one of the few remaining natural areas on Clear Lake" (CDFG 2008d). The CAPP is divided into three units. The Middle Creek unit has an area of approximately 1,690 acres and consists largely of the land proposed for the Middle Creek Project. The Rodman Slough unit has an area of about 425 acres. It extends along the south side of Rodman Slough and Middle and Scotts Creeks up to the intersection of Scotts Creek and Highway 29. This unit includes land owned by DFG, LCLT and private landowners. The Scotts Creek unit, at approximately 990 acres, is located primarily in the Tule Lake Basin and is under private ownership.

Project Description: The CAPP streamlines the WCB land acquisition process, but it does not require the WCB to pursue land acquisition. Availability of the Clear Lake Wildlife Area CAPP will facilitate WCB participation in land acquisition for the Middle Creek Project. For the WCB to consider properties in other portions of the CAPP, landowners,

non-governmental organizations such as LCLT, or Lake County would need to contact the WCB about property availability.

Key Participants: DFG, WCB, LCWRD, LCLT, and USACE.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: To be determined.

Milestones: Acquisition of lands in CAPP area.

Effectiveness Criteria: Area of land protected in Clear Lake Wildlife Area CAPP.

4.6.4 Improve Fish Passage in Clear Lake Tributaries

Background: Clear Lake hitch, Sacramento pikeminnow, and Sacramento suckers spawn in tributary streams during spring (March-June). The most important spawning streams are Adobe, Kelsey, Middle, Scotts, Cole, Seigler Canyon, and Manning Creeks. Several other streams or unnamed drainage channels are also utilized for spawning on an infrequent basis (Moyle *et al.* 1995). In-stream structures such as bridge abutments, culverts, and water retention structures, and alterations of natural hydrology due to water diversions and groundwater pumping, all have adversely affected the migration, reproduction, and populations of native fish species. In addition to directly impeding fish passage, altered stream flow due to structures and diversions can also adversely affect native fish by facilitating predation.

Barriers to fish passage have been identified on the main stems of Kelsey, Scotts, Middle and Clover Creeks; however, a systematic survey of tributaries to these creeks and of other creeks is lacking.

Project Description: Projects to eliminate some of the major barriers to fish passage are in the design stages. (See Sections 4.6.4a. and 4.6.4b below.) On other streams, the first step to eliminating barriers to fish passage is an inventory of all potential barriers to fish passage such as culverts and in-stream structures. This would be followed by prioritization of locations where barriers could be eliminated based on the potential to improve stream access, current spawning activity levels, and other factors.

Improving access for fish in streams tributary to Clear Lake will involve the removal of barriers and/or installation, improvement, and maintenance of fish passage structures where fish migration is impeded. Fish migration can also be improved by restoring the natural hydrologic connection between Clear Lake and spawning streams during the spawning season (March-June). This could be accomplished by altering water management practices (e.g., timing of diversions, reoperation of the Highland Springs Dam as part of the proposed Adobe Creek Conjunctive Use Project, and reduced groundwater pumping).

Key Participants: Local Coordinated Resource Management and Planning (CRMP) groups, East Lake Resource Conservation District (ELRCD), West Lake

Resource Conservation District (WLRCD), LCWRD, Tribes, LCWRD, DFG, USACE.

Timeframe: On-going.

Technical Resources Required: Fisheries Biologists, staff, and consulting engineers.

Cost Estimate: To be determined.

Milestones: Completion of projects to promote fish passage.

Effectiveness Criteria: Increased number of fish migrating past area where barrier(s) was/were present.

4.6.4.1 Construct a Fish Ladder at the Main Street Bridge on Kelsey Creek

Background: Due to significant down-cutting of Kelsey Creek, a footing was built to protect the Main Street Bridge in Kelseyville in about 1965. This footing created a barrier about four feet high that prevents Clear Lake hitch from migrating above this point on the creek. In 1999-2000 a fish ladder was built on the east side of the channel; however, the ladder is not used by hitch. They appear to follow the main streamflow up the center of the creek.

Project Description: LCWRD staff is working on the design for an alternative fish ladder. This ladder would be a ramp built with rocks and boulders across the entire creek. Project completion will involve additional design work, environmental review, and project construction.

Key Participants: LCWRD, Tribes, DFG, USACE, ELRCD, and WLRCD.

Timeframe: 0-10 years.

Technical Resources Required: Fisheries biologists, staff of participating agencies, and consulting engineers.

Cost Estimate: \$600,000.

Milestones: Project design, environmental review, and construction.

Effectiveness Criteria: Number of Clear Lake hitch migrating past the Kelseyville Main Street Bridge.

4.6.5 Develop a Tree Management Plan

Background: Numerous cities and counties in California have tree ordinances and/or management plans enacted to protect or conserve native, cultivated, and ornamental tree species. The ordinances and plans vary by the tree species that are covered, permitting and mitigation requirements, and by the types of projects covered by the ordinance. In general, these ordinances fall into two categories. Ordinances to protect specimen trees are more common to urban jurisdictions. Ordinances that protect intact woodland and forest communities to benefit

wildlife, preserve ecosystems, and protect watershed functions usually work on a larger geographic scale. A management plan or ordinance provides cities and counties an opportunity to review new construction, improvements, renovations, or other land clearance activities, and provides an instrument to ensure that the values of mature trees are conserved on the landscape and/or within communities.

The quantitative and qualitative value of trees can be assessed in several ways. In urban and suburban settings, trees ameliorate climates, reduce heating and cooling costs, reduce noise, and improving air quality. Ornamental and cultivated trees planted by early European settlers are important symbols of cultural heritage and local history. The aesthetic value of trees can be substantial, as properties with mature trees typically command significantly higher prices than similar properties without trees.

Trees in woodlands or forests provide valuable wildlife habitat and conserve soil and water quality. In Lake County, oak and mixed hardwood-conifer woodlands are a defining element of the appearance of the landscape, and as such, provide important social and cultural values and identifying characteristics to the region.

Native oak trees in California have been substantially reduced in numbers and extent over the last 150 years as a result of land conversion and development. Oak habitats in Lake County include valley oak woodlands located in level valleys with deep soils, blue oak or mixed blue oak-foothill pine woodlands in foothill areas with shallow soils, and mixed hardwood forests at higher elevations. Oaks found in the mixed hardwood forests include California black oak, interior live oak, Shreve oak, canyon live oak, coast live oak, and tanoak. Statewide, both valley and blue oaks have been identified as showing poor to moderate regeneration resulting in concern for their future viability as a forest type. Because valley oaks occur in level areas with deep soils, most valley oak woodlands have been converted to agriculture and other uses.

The City of Clearlake has an ordinance protecting oak trees and “heritage” trees. Native tree removal permits are required for six species of oak trees, and these permits specify replacement requirements for trees that are removed. A process is outlined by which a tree or group of trees can be designated as heritage trees. Trees with this designation may not be removed unless they are declassified as described in the ordinance (City of Clearlake Ordinance No. 2008-138).

Project Description: The development of a management plan for Lake County’s tree resources would start by determining the concerns of county residents and gathering the input of experts in natural resource management. For example, the plan might include certain non-native trees considered important to the county’s cultural inheritance or aesthetics, or it might be limited to native trees, or to specific native trees or habitats such as oaks and oak woodlands. The plan would include available information on the county’s tree resources and issues related to their conservation and might require additional surveys to adequately define the resource. A review of current management plans and ordinances from other cities and counties would help define options for a Lake County Tree Management Plan, but this review should be guided by local concerns and conditions.

Key Participants: LCCDD, UCCE, RCDs, NRCS, CRMPs, and DFG.

Timeframe: 0-10 years.

Technical Resources Required: Staff of participating agencies, biologists, and foresters.

Cost Estimate: \$10,000.

Milestones: Definition of management goals; and writing, review, and adoption of plan and/or ordinance.

Effectiveness Criteria: Area of woodland/forest and/or number of trees protected and restored.

4.6.6 Other Actions

- 2.8.2 Complete the Middle Creek Flood Damage Reduction and Ecosystems Restoration Project
- 2.8.4 Implement Site Remediation at Sulphur Bank Mercury Mine
- 2.8.7 Support and Increase Watershed Education and Outreach
- 2.8.9 Complete the Integrated Regional Water Management Plan
- 2.8.12 Complete the Adobe Creek Conjunctive Use Project
- 3.10.2 Review and Revise County Wetland Policies and Ordinances
- 3.10.3 Encourage Wetland Mitigation Bank Development
- 3.10.4 Restore Stream Channel Hydrology and Associated Habitats
- 3.10.10 Implement the Lake County Community Wildfire Protection Plan
- 5.4.7 Protect Open Space
- 6.5.3 Adaptively Manage Invasive Mussel Prevention
- 6.5.5 Develop an Aquatic Invasive Species Management Plan
- 6.5.6 Complete, Adopt and Implement a Countywide Weed Management Plan
- 7.5.3 Promote Compatible Uses of Floodplains
- 8.12.2 Update the Shoreline Ordinance (Chapter 23 Lake County Code)
- 8.12.3 Fully Implement the Integrated Aquatic Plant Management Plan



Clear Lake Integrated Watershed Management Plan

Chapter 5

RECREATION AND AESTHETICS

5.1 INTRODUCTION

The natural resources of the Clear Lake Watershed provide the attraction for a wide range of recreational activities. With Clear Lake as the focus, lakes provide opportunities for fishing, boating, swimming, and wildlife viewing. In the surrounding watershed, additional activities include hiking, biking, horseback riding, hunting, and off-highway vehicle (OHV) use. Ensuring public access to lake recreational opportunities is part of Lake County's responsibility to manage the lake in the public trust ([Section 8.9](#)). Numerous county, city, and state parks are located around the lake. In the surrounding watershed large publicly owned areas are available for public access at Highland Springs Recreation Area, Boggs Mountain Demonstration State Forest (BMDSF), Cow Mountain Recreation Area, and Mendocino National Forest (MNF). Land purchased by Lake County in November 2009, will create a county park on much of Mt. Konocti.

The natural and rural landscapes of the Clear Lake Watershed are a tremendous visual and quality-of-life resource for county residents and visitors. The wide expanse of Clear Lake is set off by hills and mountains, largely in their native condition, while surrounding agricultural areas and small towns provide an attractive rural landscape.

This chapter begins with a section on recreational activities available on lakes, followed by a section on those available in the surrounding watershed. The scope of this chapter encompasses recreational activities that are carried out on water bodies or in natural areas. For each type of recreational activity, a description of current availability and management, and a discussion of issues such as insufficient access, user group conflicts, and environmental and economic impacts is provided to the extent that the information is available. A section on a popular new category of recreation, ecotourism, is included at the end.

5.2 LAKE RECREATION

As the largest lake in the North Coast region, Clear Lake attracts visitors for a wide range of recreational uses including motorized and non-motorized boating, sailing, fishing, swimming, and wildlife viewing. Tourism is a large component of the local economy, and lake-based recreation is one of the highlights of Lake County's quality of life. Two smaller areas, Blue Lakes and the Highland Springs

Reservoir, offer additional lake-based recreation in the Clear Lake Watershed. Plate 11 shows public lakeside recreational facilities around these lakes, including those areas recommended for wildlife viewing.

Recreational uses of Clear Lake and other lakes in the watershed are discussed below, as well as issues related to, and benefits from, the uses. Limited public access is a constraint to all of the activities; therefore, it is discussed in a separate section at the end. All forms of lake recreational use have the potential to introduce invasive species, and this threat is also discussed separately at the end of the section.

5.2.1 Swimming

Swimming is a popular summer activity for residents and tourists, and swimming conditions in Clear Lake have improved since the frequency and severity of algal blooms has declined beginning in 1992. Upper Blue Lake and Highland Springs Reservoir also provide attractive locations for swimming with excellent water quality. Constraints to swimming include hazards from motorized boat use, limited public access, nuisance algal blooms, and aquatic plants.

Most parks around Clear Lake have areas for swimming; however, none have showers or lifeguards present. In addition to public areas on Clear Lake, many of the private resorts around the lake have beaches, piers, and other facilities to enhance swimming and boating opportunities. On Blue Lakes, most public access is along the Highway 20 corridor, and resorts offer beach use for a fee. Highland Springs Reservoir is surrounded by county owned and managed property. Its southern end has swimming access. In most years Clear Lake, Blue Lakes, and Highland Springs Reservoirs warm to a comfortable swimming temperature by the end of April.

Swimming in areas where motorized watercraft operate can be hazardous. In general, where parks offer both motorized boating and swimming around Clear Lake, there are designated swim areas that have been roped off to prohibit boat access. California boating law prohibits speeds in excess of 5 mph within 100 feet of a swimmer, or within 200 feet of a beach, swimming float, diving platform, or lifeline (CDBW 2008). At Blue Lakes, the speed limit for motorized boat operation is 5 mph, which reduces the boating hazard to swimmers. Motorized watercrafts are not allowed at Highland Springs Reservoir.

Clear Lake is naturally eutrophic, supporting abundant algae and aquatic plants. Nuisance algal blooms were common during summer and fall months in Clear Lake from about 1930 to 1992. Algal blooms have been largely limited to late summer/fall since 1992 until 2009 when an algal bloom began in May ([Section 2.2.1](#)). These blooms sometimes formed dense algal mats, and they rendered the water green, opaque, and sometimes malodorous. Algal blooms have generally been more severe in the south east end of the lake (Oaks and Lower Arms), due to the prevailing wind direction, and they are significantly worse in areas of still water, such as the Clear Lake Keys and other man-made lagoons and harbors.

Upper Blue Lake usually remains quite clear. In contrast, lower Blue Lake is shallower, subject to greater mixing by wind, and therefore has lower water clarity. Therefore, Upper Blue Lake is more popular for swimming. Highland Springs Reservoir remains clear and pleasant for swimming during most summer and fall seasons.

Since 1992, when water clarity improved in Clear Lake, aquatic plant growth has become much more extensive. In general, swimmers do not prefer to swim in areas where they contact aquatic plants. Swimming in areas of aquatic plant growth can also be hazardous because swimmers can become entangled in areas with dense aquatic plant growth or disoriented in areas with emergent vegetation such as tules. The occurrence of “swimmer’s itch” is also more common in the presence of aquatic plants. Swimmer’s itch is caused by a parasite that alternates between snails (found on aquatic plants) and aquatic animals. The parasites released from the snails can burrow into a person’s skin, causing an allergic reaction from minutes to days after being in the contaminated water. The parasites do not infect humans; however, in their normal life cycle they would infect gulls, ducks, or muskrats to complete their life cycle (CDPH 2009).

The Clear Lake Integrated Aquatic Plant Management Plan (IAPMP) addresses control of aquatic plants in Clear Lake ([Section 8.10](#)). It includes a permitting process for the control of aquatic plants (Chapter 26 of Lake County Code, Clear Lake Aquatic Plant Management). Public swimming areas are treated to control aquatic plants in most years.

5.2.2 Fishing

Recreational angling is a major visitor attraction to Clear Lake. It is considered the “Bass Capital of the West” and is also popular for fish such as crappie, catfish, and bluegill. Upper Blue Lake is a popular location for trout fishing, and both Blue Lakes are popular angling spots for warm water fish. Highland Springs is popular for trout, bass, and other warm water fish. Due to mercury contamination of Clear Lake, the state has issued fish consumption guidelines for fish caught in Clear Lake (CalEPA 2005). Other issues related to recreational angling are limited public access to the lake, and potential conflicts with other lake uses, such as speed boats.

Clear Lake has significantly more bass angling contests than other lakes in Northern California (CDFG 2009). The number of bass fishing tournaments has been growing consistently. There were seven permitted bass tournaments in 1985, 74 in 1988, 96 in 2001 and 206 in 2008 (Bairrington 2000, 2001-2008 data provided by Jay Rowan, California Department of Fish and Game, DFG). Clear Lake’s popularity stems from the large size of bass caught in the lake. Average fish weight is generally over three pounds, while most other lakes yield average weights below two pounds (Terry Knight, personal communication). Bass angling contests are catch and release, with strict regulations to ensure fish survival. Most recreational bass anglers also release bass immediately after catching them. Bass anglers often use specially designed fishing boats with

powerful engines, and bass boats make up a significant proportion of the motor boats that are active on Clear Lake.

Other fish popular with anglers in Clear Lake include crappie, bluegill, and catfish. Many residents and visitors enjoy fishing from their docks, or from the piers at public parks. Rainbow trout are native to Clear Lake, but they are only rarely caught by anglers. Upper Blue Lake, which is cold and clear, is regularly stocked with rainbow trout by DFG and is a popular location for trout fishing.

There is one catfish tournament held each year on Clear Lake, the Clearlake Oaks/Glenhaven Catfish Derby. This three day tournament is held in May and attracts 500 to 600 anglers from all over California and neighboring states. There is one annual carp tournament on Clear Lake, which attracts about 200 participants. It is usually held in May or June, and the carp are caught by bow and arrow in shallow water.

Sport fishing is regulated by DFG, which issues fishing licenses for a fee and enforces fishing regulations. Those who hold fishing contests apply to DFG for a permit and must receive DFG approval to hold the contest.

A health advisory recommending limited consumption of Clear Lake fish has been issued by the California Office of Environmental Health Hazard Assessment (CalEPA



Figure 5-1 Fishing on Clear Lake. *Photo courtesy of Lake County.*

2005). Most of the mercury contamination in Clear Lake comes from the Sulphur Bank Mercury Mine (SBMM) on the Oaks Arm. This mine is currently a United States Environmental Protection Agency (USEPA) Superfund site, and clean-up of the site is on-going. The Clear Lake Mercury Total Maximum Daily Load (TMDL) requires reductions in fish tissue mercury levels and sets the amount of mercury contamination permissible from different sources around the lake (load

allocations). By far, the majority of reductions in mercury loads will come from clean-up of the

SBMM site ([Section 2.2.3](#)).

To reduce conflicts between speed boats and anglers, there are nine designated fish areas around Clear Lake (Section 15-11 Lake County Code). The fish areas are along sections of the lake with significant wetland and riparian vegetation that

provides important fish and wildlife habitat. In eight of these areas, the boat speed limit is 5 mph for a distance extending 400 feet from the shore. In one area, this speed limit extends 200 feet from the shore. In addition, the speed limit is 5 mph in areas surrounding city, county and state parks, and it is 10 mph in Rodman Slough. The boating speed limit is 5 mph on Blue Lakes, and motor boats are not allowed on Highland Springs Reservoir.

5.2.3 Wildlife and Scenery Viewing

The diversity and abundance of life supported by Clear Lake offer tremendous opportunities for wildlife viewing. The lake provides a convenient stop-over for migratory water fowl on the Pacific Flyway, and numerous resident and migratory birds are found in the watershed. Lake County's crystal clear air sets off the views of hills and mountains surrounding Clear Lake that are covered by oak woodlands, chaparral, forests, orchards, and vineyards. The most extensive natural areas around the lake available to nature enthusiasts and photographers are at the State Parks, Rodman Slough, and Lakeside Park (Plate 11). Trails at these parks are described in the watershed recreation section below. An excellent way to view wildlife and the lake's scenic vistas is from a kayak, canoe, or other non-motorized boat ([Section 5.2.5](#) below). Motor boats on the lake and transportation corridors around the lake, are also excellent ways to view the lake and its surroundings.

Nature and watershed education is offered through a variety of different organizations and agencies. Clear Lake State Park, located on the shores of Clear Lake in Big Valley, has a visitor center offering interpretive displays on the natural, cultural, and recreational resources of Clear Lake. Construction of an Outdoor Education Pavilion to support the park's education mission began in 2009. Anderson Marsh State Historical Park offers monthly nature walks. Reduced funding limits tours of the historic ranch house at the park. The Rodman Slough Preserve is managed by the Lake County Land Trust, which provides guided weekly nature walks and quarterly lectures on nature topics. The Land Trust is developing a nature center at a small house on the property. More details of environmental education and outreach programs offered in the watershed are given in ([Section 2.7](#)).



Figure 5-2 American white pelicans on Clear Lake. Photo courtesy of Lake County.

5.2.4 Hunting

Duck and goose hunting is limited around and on Clear Lake. The most popular location for duck hunting is the Rodman Slough, Tule Island area (Terry Knight, personal communication).

5.2.5 Non-Motorized Boating

Clear Lake's scenic beauty and relatively limited presence of motorized boats make it an excellent

location for non-motorized boating. Constraints to non-motorized boat use include limited public access points, hazards from motorized boat use and lack of safety precautions, and difficult passage in areas of heavy aquatic plant growth. Benefits of non-motorized boat use include better compatibility with wildlife habitat, promotion of a healthy lifestyle, and a potential for increased tourism opportunities.

In their report on “Non-Motorized Boating in California,” the California Department of Boating and Waterways (CDBW) defined non-motorized boats as:

any boat not currently registered with a vessel registration (CF) number from the California Department of Motor Vehicles. This non-motorized boat definition includes: (1) boats propelled by paddles or oars (and usually without a motor), such as canoes, kayaks, inflatable boats and rafts, rowing boats including row boats, shells, sculls, dories, and driftboats), and other types of manually propelled boats; (2) small sailboats, 8 feet in length or shorter (and usually without a motor); and (3) sailboards and kiteboards. Non-motorized boats do not include “toy like” blow-up rafts and other non-durable water toys, nor do non-motorized boats include inner tubes or fisherman float tubes (without oars). Finally, non-motorized boats do not include normal surfboards, beach boogie boards, or riverboards (CDBW 2008b).

In 2008, urgency and permanent ordinances were passed that require screening of all vessels launched in Clear Lake. As part of the screening process, boat owners fill out an application form for an inspection sticker, and this form includes a description of the type of boat or other vessel. This information has been compiled in a database. Therefore, there is a thorough record of the numbers and kinds of vessels used in Clear Lake (Table 5.1). The application did not document usage levels of individual boats, however. The CDBW survey on non-motorized boating use found that kayaks are more regularly used than canoes and inflatable rafts. Table 5-1 shows the types and numbers of boats on Clear Lake, both motorized and non-motorized.

Table 5-1 Boat types on Clear Lake.

2008 Boat Type statistics		
	Number	Percentage
Motorized Boats		
Fishing	2,047	18.2%
House boats	3	0.0%
Jet Ski	1,113	9.9%
Patio/pontoon boat	297	2.6%
Pleasure boat	3,142	28.0%
Wakeboard	26	0.2%
TOTAL	6,628	59.0%
Sailboats	483	4.3%
Non-Motorized		
Canoe/Row Boat	831	7.4%
Kayak	1,498	13.3%
Peddle boat	341	3.0%
Float tube/kick boat	411	3.7%
Windsurfer	133	1.2%
Inflatables/other	905	8.1%
TOTAL	4,602	41.0%
TOTAL	11,230	

Source: Lake County Quagga Mussel Inspection Sticker Application forms, 2008

In addition to privately owned non-motorized boats, rentals are available at several locations around the lake. The Clear Lake Scullers, located in Lakeport, is a non-profit organization providing training and the use of a wide variety of non-motorized boats to members.

A series of water trails and a map describing access points for non-motorized boaters around Clear Lake is being developed by the Lake County Public Services Department (LCPSD). The Clear Lake Paddling Map describes public parks and their amenities and lists 44 other public access points around the lake including the availability of parking, road access and “soft launches”⁸. Brochures have been developed describing seven water trails around the lake. Each brochure contains a map, description of the launch point, scenic attractions along the route, and information on the wildlife, natural, and cultural history specific to the area. The

⁸ A soft launch is a beach or other area where a small non-motorized vessel can readily be launched.

brochures also discuss paddling safety, respecting private landowner rights and privacy, and invasive species prevention. The draft brochures are currently available on the Konocti Trails website, www.konoctitrails.com.

The State of California publishes “ABCs of the California Boating Law,” a guide that is available online or at Department of Motor Vehicles offices. This guide describes regulations and important safety information for all boaters.

Motor boats are perceived as a safety issue by non-motorized boat users. It is likely that the presence of motorized vessels causes non-motorized boat users to avoid certain areas or times of day for boat use. The presence of motorized vessels also reduces the enjoyment of a quiet, scenic experience and the opportunities for wildlife viewing. A statewide survey of non-motorized boat users found that the leading safety concern was interactions with motorized vessels (CDBW 2008b). An analysis of boating accident data, however, found that the leading cause of reported injuries and deaths⁹ was capsizing (CDBW 2008b). Safety issues for kayaks and canoes were found to be their small size, and in the case of canoes, their inherent stability, making them prone to capsizing, frequent failure to wear a personal flotation device, and failure to understand and prepare for changing water and weather conditions.

These safety issues are an important consideration on a large lake such as Clear Lake, where weather conditions can change rapidly. Compared to motorized vessels, non-motorized watercraft are more prone to capsizing. When weather changes, it is more difficult for non-motorized vessels to return because they move more slowly and are hand-powered. Therefore, it is especially important for non-motorized boaters to check weather and water conditions before boating, and to wear personal flotation devices and appropriate clothing.

Excessive aquatic plant growth can inhibit the passage of non-motorized boats by fowling paddles and oars. In many cases non-motorized boat users can avoid this issue by going out into deeper waters; however, this may increase the time needed to return to the shore or the initial launching point, and so it highlights the need to be aware of weather and water conditions and their potential to change.

Non-motorized boating is growing in popularity in California. There were nearly twice as many non-motorized as motorized boats in California in 2006 (CDBW 2008b). With Clear Lake’s scenic and wildlife viewing opportunities there is potential to increase non-motorized boating opportunities on the lake, possibly leading to increased recreational opportunities and tourism in the county. Non-motorized boating is also more compatible with wildlife habitat areas around Clear Lake than is motorized boating. For Lake County residents, non-motorized boating provides the opportunity for an active, healthy lifestyle.

5.2.6 Sailboats and Motorized Boating

A wide variety of motorized vessels are enjoyed on Clear Lake. These include pleasure boats, ski boats, fishing boats, pontoon or “patio” boats, and personal

⁹ This report indicated that the data gathered likely include the majority of fatal accidents, but only a small portion of injury-causing accidents.

watercraft. Sailboats¹⁰ are included in this section because many have at least a small outboard motor, and because they often require the same kind of boat launch facilities as do motor boats. The numbers and types of motorized boats launched on Clear Lake in 2008 is given in Table 5-1; however, the numbers do not indicate how frequently the boats were used.

Public boat launch facilities are available in 10 locations around Clear Lake (Plate 11). Several of these locations have multiple ramps for a total of 16 public boat ramps. With the exception of Clear Lake State Park, fees are not charged at any of these public facilities. In addition, 66 resorts around the lake have boat ramps. Availability of these ramps to the public, and fees charged at the resorts, vary on a case by case basis. Rentals of motor boats and personal watercraft are also available at several locations around the lake.

Boat pumpout facilities on Clear Lake are severely limited, with only one currently available at Braito's Marina on the Buckingham Peninsula. There is also a gravity fed wastewater disposal site that requires that boats first be removed from the water at Fifth Street in Lakeport.



Figure 5-3 Sailboat on Clear Lake. Photo by Tom Smythe.

State of California boating and navigation laws are enforced by the Boat Patrol Officers of the Lake County Sheriff's Marine Patrol (Section 15-12 Lake County Code). The Marine Patrol has two boats on the lake during winter months that spend 8-9 hours per day on the lake and are on call 24 hours a day. During the summer season from just before Memorial Day to just after Labor Day there are up to 7 Marine Patrol boats available. Patrol boats are present on the lake for 15 hours per day and are on call 24 hours a day. Approximately 80% of the funding for the Sheriff's Marine Patrol comes from boat registration fees (Ralph Simkins, personal communication).

Navigation aids on the lake use the uniform state waterway marking system. Placement of navigation aids by private property owners around the lake requires a permit through the Lakebed Management (LCLM) function of the Lake County Water Resources Division of the Public Works

Department. Public navigation aids are placed and maintained by LCLM.

¹⁰ Sailboats greater in length than eight feet are included in this section. Those shorter than eight feet in length do not have to be registered with the Department of Motor Vehicles, and are considered non-motorized boats.

The state guide “ABCs of the California Boating Law” describes a variety of safety information for boaters, including “rules of the road,” navigation aids, and requirements for navigation lights, personal flotation devices, and other equipment (CDBW 2007). Boaters need to be aware that Clear Lake weather can change rapidly from calm to windy and choppy conditions.

Motorized boating on Clear Lake is restricted by areas of significant aquatic plant growth, which reach up to the water’s surface around much of the shoreline. Operation of boats in these areas leads to fouling of engines and/or propellers and potentially significant damage. Owners of boat launch facilities, both public and private, generally apply herbicides or use mechanical methods to maintain clear passage for boats. Property owners around the lake who want motor boat access to their property also frequently must control aquatic plants. All aquatic plant control is regulated by the IAPMP, and permits are required through the county’s one-stop permit process. ([Section 8.10](#))

The use of motorized boats on Clear Lake has several potential negative environmental impacts. Boats can leak gasoline and oil into the water, and this is most severe with older two stroke engines more commonly found in personal watercraft. The concern with gasoline pollution was greater when the additive MTBE (Methyl tertiary butyl ether) was being used. MTBE is very persistent in water, imparts an unpleasant taste at very low concentrations, and may be a health risk. The use of MTBE has been banned in California since January 1, 2004. It has not been detected by water utilities using Clear Lake water since 2003 (Forsgren Associates Inc. 2007).

Sanitary waste and trash dumping by boaters are potential sources of pollution to Clear Lake and Blue Lakes. Availability of public restrooms and trash receptacles that are readily accessible to boaters is insufficient. ([Section 5.2.7](#))

As discussed in [Section 5.2.1](#) on swimming above, motorized boating in areas frequented by swimmers is hazardous. However, state law limits speeds to 5 mph within 100 feet of swimmers and within 200 feet of swimming areas and piers or landing areas where boats are present (CDBW 2008).

Many types of motorized boats are quite noisy, potentially disturbing residents and visitors around the lake. The noise of boat engines can disturb wildlife as well, interrupting feeding, nesting, and other activities. The operation of motorized watercraft in and near grebe nesting areas has been cited as a source of breeding failure. A report on grebe conservation in Clear Lake found that “reckless personal watercraft operation, waterskiing, wakeboarding, and tubing; and finally airboat and aircraft activity were presumed to play a contributory role in this (breeding) failure” (Robison *et al.* 2008). Motor boat disturbance is thought to disrupt and discourage grebes from nesting. In addition, boat wakes can swamp their floating nests. Young grebes ride on their parents backs and cannot dive for their first 2-4 weeks of life. Therefore ,boats that cause the parents to dive can harm the young, or cause them to starve after being separated from their parents.

Sailboats are less likely to disturb people or wildlife around the lake because they generally have small engines that are used primarily to maneuver in and out of mooring locations.

Expanding fish areas, which limit speeds to 5 mph for a distance of 400 feet from the shoreline, could reduce impacts to wildlife on Clear Lake. For example, Quercus Point has a fish area along its west side, but an important grebe nesting area on the east side, and is not currently protected by boating speed limits.

Although there are no current studies available, it is clear that motorized boat use on Clear Lake brings a substantial economic benefit to Lake County and is a significant source of enjoyment for many residents. A large portion of Lake County tourism is attracted to the county for boating activities on the lake. This includes personal water craft, wakeboard, and tubing and water-ski boats, pleasure boats, bass boats, and other boats for fishing on the lake.

5.2.7 Public Access



Figure 5-4 Motor boat activities such as tubing are popular on Clear Lake. Photo courtesy of Lake County.

Public access to Clear Lake is limited. Most of the shoreline is occupied by residences, resorts, and businesses, or is undeveloped private land. The area around the lake between the high and low watermarks is managed for the public trust, and therefore, is accessible to the public. In practice, however, private property limits the ability of the public to reach this area. Significant development or redevelopment along the Clear Lake shoreline is reviewed by LCLM to ensure that public access to the lake is maintained.

There are currently 63 public access points around Clear Lake. Nineteen of them have some kind of amenities such as boat ramps, piers, parking, swimming, picnic areas, restrooms, or playgrounds (Plate 11). The rest are unimproved parcels owned by the county, cities, or state (including five islands), or they are accessed from a street adjacent to or ending at the lake. Some of these street access points are owned by the subdivision in which they are located.

The lack of access for boaters, both motorized and non-motorized, to public restrooms and trash receptacles has the potential to contribute to pollution of Clear Lake. The public accesses Blue Lakes along Highway 20, and there are no amenities available. The lack of public restrooms or trash receptacles leads to accumulation of trash and waste, such as baby diapers in this area. Parking and safe highway entry/exit can also be problems in this area. At Highland Springs Reservoir, rest rooms and trash receptacles are available in the area where most access to the lake occurs.

Along the north shore of Clear Lake, significant plans and work have been initiated by the Lake County Redevelopment Agency (LCRDA) that will improve lake public access and amenities. The Northshore Redevelopment Project Area Plan covers four communities, and three of these communities, Nice, Lucerne, and Clearlake Oaks, are on the shore of Clear Lake. As part of the plan, the Redevelopment Agency and county are acquiring additional lands with lake access and improving public amenities in existing public access areas.

In Nice, a Parks Master Plan has been developed (LCRDA 2006). Lake access will be enhanced by improvements to the facilities at Keeling Park, and to county-owned lakefront property in front of Holiday Harbor marina. Holiday Harbor is intended to provide a community center for Nice, and LCRDA is working to attract private investment in this area. LCRDA removed the boat fueling station and RV sanitary dumping facility at Holiday Harbor, and until future development occurs, there are no plans to replace them. Other county-owned lake access points in Nice will have lighting and a small viewing platform constructed at each site. Many of these small access points currently have been over-run by neighboring land owners (Eric Seely, personal communication).

Lucerne redevelopment is guided by the Lucerne Promenade Master Plan (LCRDA 2005). Currently the county is improving four public areas along the Lucerne waterfront between First and Seventeenth Avenues. Alpine Park, from First to Third Avenues, will be expanded by additional lake front properties purchased at the end of Third Avenue. State Parks bond funds have been approved to develop the Third Avenue Plaza project, which includes a new, larger pier at the site. In the area from Seventh to Ninth Avenues, Lucerne Harbor Park has been expanded with properties acquired to the east and west. It now includes an artists' village to the west and dog park to the east. The area across from Thirteenth Avenue is intended as the focal point for the promenade. LCRDA has acquired four out of eight properties needed to create a central area for the community center with hotel, restaurant, and retail uses. There are plans for a park and pier as well in this area. To the east, at Fifteenth Avenue, the county owns the Lucerne Club House which includes a swimming beach. This area will be improved, potentially adding a kayak and small boat launch.

Public access improvements in Clearlake Oaks include the addition of boat launch facilities at Island Drive and improvements to Clarks Island. Clarks Island was an RV park that was purchased by Lake County. Current plans for the site are to develop it for passive recreation with picnic tables and benches (Kim Clymire, personal communication).

5.2.8 Invasive Species

Recreational use of surface water bodies is a potential vector for invasive species when people and their equipment move from one body of water to another. Invasive species, such as quagga and zebra mussels, can survive for up to a week attached to hard surfaces such as a boat hull. Their larvae, which are too small to be seen without a microscope, can be transported in boat bilges, ballast water, live wells, or other areas holding water. New Zealand mud snails can travel on almost

any wet gear used by anglers and other recreationists. Aquatic plants, such as hydrilla, are spread as plant fragments or seeds attached to boats and gear, or in water transported in boats or other watercraft.

The DFG website has instructions for cleaning and drying gear to prevent the spread of invasive species, such as New Zealand mud snails and Quagga and Zebra mussels. They recommend cleaning, draining, and drying boats to prevent the spread of mussels (DFG 2008e), and these actions are also effective for preventing the spread of many other aquatic invasive species (AIS). Public education to ensure that recreational users understand and practice invasive species prevention is essential to protecting lakes and rivers. Prevention and control of AIS is covered in [Section 6.4](#).

5.3 WATERSHED RECREATION

This section focuses on the outdoor recreational uses of the Clear Lake Watershed on lands surrounding the lakes. Most of the watershed is relatively undeveloped with natural habitats largely intact. Large areas of public lands in the northwest portion of the watershed, as well as smaller parks around the lake, offer opportunities for walking, hiking, horseback riding, bicycling, fishing, hunting, OHV use, and nature and wildlife viewing (Plate 12). In agricultural areas, farms and rural communities provide an attractive backdrop for scenic drives and bicycling. Opportunities for the different types of outdoor recreation as well as planning for a Master Trails Plan to connect many kinds of outdoor and lake-based recreation, are discussed in this section. The potential environmental and economic impacts from, and constraints to, outdoor recreation are also covered.

5.3.1 Hiking, Mountain Biking, and Horseback Riding

Public trails for pedestrian use, mountain biking and horseback riding can be found in a variety of locations in the Clear Lake Watershed (Plate 12). In some cases, these trails are restricted to only one or two of these uses, while in other cases, all three uses are permitted. Unpaved, and some low use paved roads around the county are also used for these activities; however, this section focuses on trails available for these uses. Bicycle riding on paved roads is covered in [Section 5.3.2](#), and OHV roads and trails are covered in [Section 5.3.5](#).

Clear Lake State Park offers several miles of hiking trails. Most of the terrain is hilly, with elevations of 1,320 to 1,600 feet. The two mile Dorn Nature Trail winds through oak woodland and chaparral and provides an overlook of Clear Lake, vineyards, and the Mayacmas Range beyond. The half mile Indian Nature Trail passes through the site of a former Pomo Indian village. Clear Lake State Park also provides horse trails for equestrian use.

Anderson Marsh Historic State Park includes 400 acres of tule marsh 470 acres of meadow, oak, and manzanita; and 13,000 feet of lake and stream shoreline. The park also includes the 540 acre McVicar Wildlife Sanctuary and provides visitors with bird watching, hiking, and picnicking opportunities. There are

archaeological sites at the park, and the historic ranch house is available for tours by appointment. Anderson Marsh is the location for the annual Bluegrass Festival.

BMDSF is accessed from Highway 175 in the southern portion of the Clear Lake Watershed. Approximately 28% of BMDSF lies within the Clear Lake Watershed. It provides 21 miles of non-motorized use trails, 25 miles of unimproved roads, and two no-fee campgrounds with 19 campsites. The non-motorized trails are all multiple use, open for hiking, bicycling, and horseback riding. The unimproved roads are open to street legal vehicles only. OHVs are not allowed on BMDSF. The Friends of Boggs Mountain is a non-profit group that works closely with BMDSF to enhance opportunities for visitors to the forest. They sponsor volunteer trail maintenance days, hikes, and bike rides. Several mountain bike races are held each year at BMDSF, as well as other events such as orienteering (FBM 2009).

The Boggs Lake Preserve includes a one mile loop along the Boggs Lake shore and over rolling hills. The area, protected by the Nature Conservancy since 1972, provides habitat for rare bird and plant species.

The county Highland Springs Recreation Area, an area of about 3,200 acres managed by the Lake County Watershed Protection District (LCWPD), offers about 21 miles of trails for non-motorized use. In general, trails immediately around Highland Springs Reservoir are used by hikers, and trails higher in the recreation area are used primarily by horseback riders.

The Bureau of Land Management (BLM) Cow Mountain Recreation Area straddles the Mayacmas Range between Ukiah and Lakeport, and the majority of the Recreation Area lies within the Scotts Creek Watershed, a sub-watershed of Clear Lake. The northern section of BLM land, North Cow Mountain, is managed for non-motorized activities including hiking, hunting, camping, horseback riding, and mountain biking. It has one developed campground, a designated rifle range, and 17 miles of foot trails. A large area of this section is managed under the BLM classification of “backcountry”, which is an essentially roadless area, providing wildland recreation while protecting watersheds and wildlife (USDI BLM 2006). The southern portion of BLM land, South Cow Mountain, is managed primarily for OHV use.

MNF Service land within the Clear Lake Watershed is managed primarily for OHV use. There are 25 miles of OHV trails and no trails designated for pedestrian and horseback use within the Clear Lake Watershed portion of MNF.

With assistance from a National Park Service advisory grant, LCPSD formed a volunteer advisory committee, the Konocti Regional Trails Group, to create a strategy and plans for a countywide system of water and terrestrial trails. Meeting since 2008, this group helped to formulate the scope of work for a consultant recently hired by the county. This scope of work includes the following major goals:

- Assure that public policies are in place to plan, fund develop, and manage the trails system.

- Establish a planning and implementation framework.
- Build a trails inventory that includes GIS layers and maps of existing and potential trails.
- Assure comprehensive stakeholder engagement in development of the plan.
- Establish a conceptual framework for signage.
- Recommend a short term implementation strategy (Lake County 2009).

LCPSD has begun to develop a non-motorized, ridgeline trail along the north shore of Clear Lake. The trail system would provide scenic views of Clear Lake, low-lying valleys, and distant wilderness areas. Appropriate parcels along the north shore ridgeline have been identified and discussions with property owners along the trail have been initiated. Landowners have concerns about issues such as liability, vandalism, and unauthorized OHV use, and therefore, progress on gaining easements for the trail has been slow. It is hoped that development of a first portion of the trail in the Clearlake Oaks, Glenhaven area will provide a successful example to encourage further development of the trail (Chuck Lamb, personal communication).

Lake County completed acquisition of large land holdings on the top of Mt. Konocti, the dramatic volcano along the southern shore of Clear Lake in November 2009. The total land area being acquired is 1,520 acres, and this land is adjacent to 821 acres of BLM lands that include the Black Forest on the north side of Mt. Konocti. The owners from whom the county is purchasing the land, the Fowler Family Trust, have specified that the land shall be for non-motorized use. LCPSD is holding meetings around the county to develop a management plan for the property. Uses on the mountain are likely to include trails for hiking, mountain biking, and horseback riding. The county is also putting a priority on acquiring lands between Clear Lake State Park and the Mt. Konocti property, and trails may eventually be developed from the State Park on the shores of Clear Lake to the top of Mt. Konocti.

Despite the natural condition of much of the Clear Lake Watershed, current opportunities for non-motorized trail-based recreation are relatively limited. Creation of the north shore Ridgeline Trail and future Mt. Konocti trails will provide significant new opportunities for county residents and visitors.

Both current and future trails require management of conflicts among non-motorized trail users. In particular, mountain bikes can frighten horses when the cyclists travel at high speeds. Dogs, even when leashed as required by state law, can also frighten horses. Possibilities to reduce these conflicts include restricting some uses, creating parallel trail systems, and providing signage and education.

Erosion caused by poorly designed, poorly constructed, or poorly maintained non-motorized trails causes sedimentation and damages water quality. Where bridges are not present at stream crossings, stream bank erosion is more likely. Trails located in sensitive areas such as meadows damage soils, vegetation, and

hydrology. In general, erosion and sedimentation due to non-motorized trail use is less than that due to OHV use because trails are generally smaller, and soil disturbance is less.

There are currently no facilities offering horseback riding and horse rentals that are open on a daily basis in the Clear Lake Watershed. Several businesses offer horseback riding on a reservation basis. Businesses offering mountain bike or other bicycle rentals are also very limited in the watershed.

Although Clear Lake Watershed residents and visitors are surrounded by lands in a mostly open and natural condition, much of the land is in private ownership, and access to hiking, biking, or horseback riding trails often requires significant travel. Plans to increase the availability of trails will improve opportunities for tourism, enjoyment of nature, and healthy, active lifestyles.

The economic benefits of non-motorized, trail-based recreation have not been determined for Lake County. However, non-motorized trails offer opportunities for wildlife viewing, and a range of outdoor activities that are attractive to tourists and visitors to the area.

5.3.2 Bicycling

With vistas of lakes, forests, and farm land, and the cleanest air in the state, Lake County's roads are inviting to cyclists. Constraints to cycling include conflicts with agricultural land use and potential hazards where roads are narrow, lack a shoulder, and/or have heavy vehicle traffic.

There are currently four constructed bikeways around Clear Lake: Lakeshore Boulevard Bikeway, which extends from Main Street in Lakeport to Park Way north of Lakeport; Lake Street Bikeway, which extends from Morgan Valley Road in Lower Lake to Cache Creek in Clearlake; Konocti Road Bikeway, which extends from the Konocti Road junction at Main Street in Kelseyville to a point 0.7 miles east; and Old Highway 53 bikeway from Lakeshore Drive to Lakeview Way in Clearlake. Lake County has applied for funding to extend the Lakeshore Blvd. Bikeway to the north, and the City of Clearlake has plans to expand the Old Highway 53 Bikeway. Lake County is developing a bicycle/pedestrian path from Upper Lake along levees to Bridge Arbor Road, which connects to Lakeshore Blvd. and North Lakeport. This project will require a bicycle/pedestrian bridge over Middle Creek or Scotts Creek.

The Lake County Public Works Department (LCPWD) adds shoulders and other safety improvements to roads during road improvement projects when the opportunity exists. These improvements improve safety in the short term and will facilitate construction of future bike lanes.

The most recent version of the Lake County Regional Bikeway Plan was adopted by the Lake County/City Area Planning Council in August 2006 (LCCAPC 2006). This plan incorporates all proposals for bikeway improvements in county jurisdictions, is consistent with the 2005 Regional Transportation Plan, and is intended to meet the provisions of the California Bicycle Transportation Act. Proposed bikeways throughout the county are prioritized in the plan. Policies

from the non-motorized transportation element of the Regional Transportation Plan that are included in the LCRBP include the following:

- Consider the needs of non-motorized users when constructing, upgrading, or maintaining street, roadway, and highway facilities.
- Reserve two percent of Transportation Development Act funds annually for allocation to pedestrian and bicycle projects.
- Develop projects consistent with the Lake County Regional Bikeway Plan in order to be considered for Transportation Development Act funding.
- Continue the development of inter-community bikeways from Lower Lake to Clearlake, Lakeport to Nice, and Lakeport to Kelseyville (LCCAPC 2006).

5.3.3 Fishing

Fishing in Lake County streams and creeks is a popular activity. Rainbow and brown trout are found in many of the permanent streams in the upper watershed. Warm water fish are found in the lower sections of Clear Lake tributaries when they are flowing. MNF in the Middle Creek Watershed and Cow Mountain Recreation Area in the Scotts Creek Watershed provide the two largest areas for public access to fishing in the upper watershed.

5.3.4 Hunting and Target Shooting

Both residents and visitors to Lake County enjoy hunting a variety of big game, water fowl, and upland game. DFG information on the number of animals taken is available at the county level; however, there is no information specific to the Clear Lake Watershed. The DFG annual Game Take Hunter Survey reports on the range of animals hunted in the county (CDFG 2006b). Big game hunted in the county include deer, elk, bear, and wild pigs. Other animals taken in Lake county are jackrabbits, tree squirrels and coyotes. Waterfowl and game birds taken in Lake County include ducks, geese, pheasant, chukar, quail, crows, doves, pigeons, and wild turkeys.

Deer are one of the most popular animals to hunt, and DFG has records of the deer kill (based on tags turned in by hunters) in each county going back to 1927 (CDFG 2007b). Since 2000, the number of reported buck kills in Lake County has been around 300 per year. This is down from previous reported levels. These levels ranged from 400-1,000 from 1927-1936, 1,500-2,500 from the mid 1930s to the mid 1960s, and about 400-1,000 from the late 1960s until 2000. These trends are roughly parallel to state trends as well. There are several possible reasons for these trends including changes in reporting and the number of hunters. However, a large part of the change is probably due to a decline in deer populations (Paul Hofmann, personal communication). The population reduction may be due to changes in land use such as winter grazing of cattle on upland habitats, increased road kills, and a reduction in browse due to fire suppression (Paul Hofmann, personal communication; Hendricks 1968).

An annual Junior Apprentice Pheasant Hunt is offered through the DFG Gamebird Heritage Program at the Highland Springs Recreation Area.

There are two shooting ranges at the county Highland Springs Recreation Area, a rifle and handgun range leased by the Lake County Sheriff's Department (LCSD) and sublet to the Konocti Rod and Gun Club, and a skeet shooting range, operated by the Lake County Rod and Gun Club. These ranges are available only to the LCSD and members of the clubs. In the BLM Cow Mountain Recreation Area, shooting is allowed in designated areas only (USDI BLM 2006), and there is only one designated area, a rifle range located outside the Clear Lake Watershed, on the Ukiah side of North Cow Mountain.

5.3.6 Golfing

Golfing is a popular form of recreation for tourists and residents. There are three 9 hole golf courses located in the Clear Lake Watershed: Rob Roy Golf Club, located in Cobb; Riviera Hills Golf Club, located on Fairway Drive in the Clear Lake Riviera; and Buckingham Country Club, located at the beginning of the Buckingham Peninsula.

Although golf courses represent a very small percentage of the Clear Lake Watershed area, they potentially have greater impacts on water resources on an area basis, than do many other land uses. Water use to maintain golf course greens is relatively high. A proposed new golf course in the Lakeport area would use approximately three acre-feet of water per acre of golf course turf per year (LCCDD 2008b). Along with relatively high water use, maintenance of turf grass requires nitrogen fertilizer and herbicide use, both of which have the potential to pollute surface and ground water. Golf courses, along with landscaped and agricultural areas, are good sites for re-use of treated wastewater. As the population, and therefore amount of wastewater grows, re-use of treated wastewater can reduce demands on freshwater supplies.

5.3.5 Off-Highway Vehicle (OHV) Use

OHV use is a popular form of recreation in the Clear Lake Watershed. An OHV is a registered, non-street legal vehicle, which may include motorcycles, all terrain vehicles (ATVs), and four-wheel drive vehicles. On public lands, OHVs are used on designated routes that range from improved dirt roads to trails that are only open to ATVs and motorcycles. On private lands, OHV use is at the discretion of the landowner. A constraint to OHV use is the need to transport OHVs to public lands where designated OHV trails are available. Impacts from OHV use include incompatibility with non-motorized trail use, creation of noise and dust, and increased soil erosion and sedimentation. OHV use attracts visitors from outside the county, contributing to the county's tourism economy.

The Cow Mountain Recreation Area, west of Lakeport, and MNF, north of Upper Lake, provide the two main areas for public OHV use in the Clear Lake Watershed. The southern portion of BLM land, South Cow Mountain, is managed primarily for OHV use. It has 93 miles of vehicle trails, two developed campgrounds and two OHV staging areas on 23,000 acres.

The recreation emphasis for the Middle Creek Management Area of MNF is on OHV use. There are seven miles of OHV trails and roads in the Middle Creek Watershed. The Middle Creek Campground, located at the confluence of the East and West Forks, is the main OHV staging area for OHV users in the southern portion of MNF, and the OHV trails on National Forest land extend well north of the Clear Lake Watershed.

By definition, OHVs are not street legal, although street legal four wheel drive or other vehicles share some of the roads that are open to OHV use. This means that OHVs must be transported to OHV use areas. This limitation probably contributes to unauthorized OHV use on private lands. Because of significant unauthorized OHV use on the north shore of Clear Lake, the Nice Watershed Group led an effort that resulted in a revision to the Lake County Transportation Ordinance in 2006 (Lake County Code Section 19-52). The ordinance now requires OHV users on private lands to carry written permission from the landowner; however, it has been difficult to enforce this ordinance.

Non-motorized trail users often do not like to share trails with OHVs because of noise and dust. Horseback riding is particularly incompatible with OHVs due to limited trail size and the potential for OHVs to frighten horses. On the BLM Cow Mountain Recreation Area, motorized and non-motorized uses are separated to avoid these incompatible uses. Trails are for non-motorized use only in BMDSF. There are currently no trails designated non-motorized use only on MNF land in the Clear Lake Watershed.

There are several ways in which OHV use contributes to soil erosion and sedimentation of surface waters. The presence of any trails is likely to increase erosion above background levels; however, poorly designed and/or poorly maintained trails will greatly increase this potential. OHV users sometimes ride off trails, in stream beds, or on fire lines, which can cause significant erosion. At times, unauthorized use creates new trails with a high potential to cause soil erosion.

Public lands managers rely on grant funding from state OHV fees, volunteers, and in house personnel to improve and maintain trails and to close unauthorized trails. On OHV trails in South Cow Mountain, trail maintenance, including erosion prevention and brushing, is carried out once every three years on average. OHV trails are closed during wet weather, and the BLM is currently developing a soil monitoring plan to comply with state OHV funding requirements. Monitoring of trail conditions and OHV activity on BLM lands has declined in recent years because the position for recreation planner for South Cow Mountain has not been filled for the last three years. Due to a recent closure of the BLM Clear Creek Management Area south of San Francisco, there has been an estimated tripling of OHV use in South Cow Mountain (Gary Sharpe, personal communication). MNF OHV trails are closed on United States Forest Service (USFS) lands during periods of wet weather. USFS personnel attempt to restrict use of unauthorized areas using natural brush barriers, hay bales and fences (USDA FS 1999).

OHV use on private lands, both authorized and unauthorized, is likely to be more damaging than on public lands. This is because off-trail riding is more frequent,

and trail maintenance and design measures to control erosion are less common than on public lands.

5.3.6 Agritourism

Tourism activities connected to agriculture have become increasingly popular in Lake County. The county has developed a “farm trails discovery” brochure with a map and descriptions of farm-based activities (LCMP 2008a). These include farm visits, produce stands, and activities such as horseback riding and wagon tours. The brochure also describes events around the county that celebrate Lake County agriculture, such as the Kelseyville Pear Festival, Lake County Fair, and Lake County Wine Adventure. Lake County’s vineyard and wine industries have grown dramatically in recent decades, and there are now 24 wineries and tasting rooms in the county, most located in the Clear Lake Watershed (LCMP 2008b). Agritourism has the double advantage of supporting farmers and the tourist industry in the county. Continuation of agriculture also helps to maintain open space and Lake County’s rural way of life.

5.4 ECOTOURISM

Ecotourism is defined in this document as nature based tourism that has a low impact on the environment. As such, many of the activities discussed above qualify as ecotourism. These include visiting parks, wildlife viewing ([Section 5.2.3](#)), hiking, bicycling, horseback riding ([Section 5.3.1](#)), and non-motorized boating ([Section 5.2.5](#)).

The advantages of ecotourism for the Clear Lake Watershed are that it usually requires little infrastructure, has less impact on the environment, and is more compatible with preserving natural ecosystems than other forms of tourism. With Clear Lake’s spectacular scenery and abundant wildlife, ecotourism has the potential to be a significant attraction for out-of-county visitors. A group comprised of Lake County government and business representatives came up with the following vision statement for recreation in the Clear Lake Watershed that focuses on the advantages of ecotourism. Their vision is:

“A healthy lake offering a variety of recreational opportunities that embrace its ecological diversity and richness of natural beauty.” (Pamela Francis, personal communication).

5.5 RECREATION AND AESTHETICS ACTIONS

5.5.1 Overall Strategy

Recreation on Clear Lake is important both as a quality of life and an economic resource for Lake County residents. Because Clear Lake is the largest naturally occurring freshwater lake entirely within in California, it is a significant resource for the entire state. The Lake County General Plan describes the following goals for Clear Lake recreation management: “to maximize the opportunity for human enjoyment of Clear Lake, ensure frequent and easy public access to the lake, and enhance the recreation based economy of the County” (LCCDD 2008).

The importance of recreation in the watershed is also recognized in the General Plan goal “to provide a parks, recreation, and open space system that serves the recreational needs of county residents and visitors, including a regional non-motorized recreational trail system” (LCCDD 2008). The General Plan states that “An integrated multi-purpose trail system should be developed that provides access to recreational facilities, as well as offering a recreational experience apart from that available at the neighborhood and community parks.” This trail system should include scenic and educational trails, ridgeline trails, and water trails, and it should interconnect with other public facilities, communities, and points of interest. The General Plan also covers the importance of working with federal, state, and local land management agencies to ensure access to open space and recreation, and encourages land use policies to preserve natural open space resources.

5.5.2 Improve Lake Access and Public Amenities

Background: Most of the Clear Lake shoreline is developed or is privately owned. Therefore improving currently owned public access points and acquiring additional public lands for access to Clear Lake are important to ensure public enjoyment of the lake. There are currently 63 public access points around Clear Lake, however only 19 of them have some kind of amenities such as boat ramps, piers, parking, swimming, picnic areas, restrooms or playgrounds. The rest are unimproved parcels owned by the county, cities, or state (including five islands), or they are accessed from a street adjacent to or ending at the lake. Some of the access points in the latter category are owned by the subdivision in which they are located.

Project Description: The Clear Lake Advisory Subcommittee (CLAS) will review currently available public services and access points and make recommendations for improvements and land acquisition. Past evaluations have identified a lack of public boat launches from Clear Lake Oaks Park to Redbud Park/Thompson Harbor and from Redbud Park to Clear Lake State Park (Ralph Simkins, personal communication). Currently, the one county boat launch location without a permanent restroom is Rodman Slough. Other projects are planned by LCRDA (Section 5.2.7). Funding for improvements and/or land acquisition will come from grant funding as it becomes available.

Key Participants: CLAS, LCPSD, Water Resources Division (LCWRD) of the Lake County Public Works Department, and LCRDA.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies and consultants.

Cost Estimate: To be determined.

Milestones: Each project improving public access points and new land acquisitions for public access on Clear Lake.

Effectiveness Criteria: Increased public use of lakeside facilities and lake recreation.

5.5.3 Promote a Private Boat Tow Service on Clear Lake

Background: There is currently no privately operated boat tow service on Clear Lake. The Lake County Sheriff's Department Marine Service tows boats that are in need of assistance to the nearest public launch, or to the boat owner's home if it is nearby, but they will not tow boats for a long distance due to the expense, time, and wear and tear on their boats.

Project Description: Creation of a privately operated boat tow service on Clear Lake would enable the Sheriff's Office to focus resources on more important tasks and would provide a necessary long distance service. The tow service would probably be part of a lakeside business, because it is needed only sporadically.

Key Participants: LCSD, CLAS, LCLM, and private businesses.

Timeframe: 0-5 years.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: Regular staff time.

Milestones: Initiation of private boat tow service.

Effectiveness Criteria: Safe recovery of boats needing towing and reduction in Sheriff's Office time and funds dedicated to boat rescue.

5.5.4 Develop Boat Pumpout Stations Around Clear Lake

Background: Without access to pumpout stations, contamination of the lake with sewage is more likely. Currently, there is only one pumpout station available to the public at Braito's Marina on the Buckingham Peninsula. There is also a gravity fed wastewater disposal site that requires that boats first be removed from the water at the Fifth Street launch ramp in Lakeport. Pumpout stations are best located at commercial marinas where personnel are available to assist with operation, maintenance, and security. Gravity fed wastewater disposal sites are a viable option at public access points where disposal to a sanitary sewer system is possible.

Project Description: LCLM now requires installation of pumpout stations as a condition for development of new commercial marinas on Clear Lake. Gravity fed waste disposal systems should be considered at public access points where sewer systems are available. Major county boat launch facilities that do not currently have boat wastewater disposal facilities are Lakeside Park, Clearlake Oaks Beach, and Lucerne Harbor.

Key Participants: LCCDD, LCPSD, CLAS, LCLM, LCRDA, and commercial marinas.

Timeframe: 0-10 years.

Technical Resources Required: Staff of participating agencies

Cost Estimate: To be determined.

Milestones: Each additional pumpout station or gravity fed system.

Effectiveness Criteria: Reduced discharge of wastewater to Clear Lake.

5.5.5 Improve Public Access at Blue Lakes

Background: Currently public access at Blue Lakes is limited to the Highway 20 corridor where there are issues with traffic safety and trash disposal.

Project Description: Should the opportunity arise, purchase of land adjacent to Blue Lakes by Lake County or another public entity would provide opportunities for safe and sanitary public access to excellent swimming and fishing opportunities.

Key Participants: Lake County or other public entity.

Timeframe: 5-20 years.

Technical Resources Required: Staff of participating agencies and consultants.

Cost Estimate: To be determined.

Milestones: Public entity purchase of land adjacent to Blue Lakes, design, environmental review, and construction of lake access facilities.

Effectiveness Criteria: Improved public access to Blue Lakes and reduced pollution to Blue Lakes.

5.5.6 Create and Implement an Integrated Countywide Multiple Use Trails Plan

5.5.6.1 Complete a Countywide Multiple Use Trails Plan

Background: Lake County recently (May 2009) hired a consultant, Alta Planning, to complete the Konocti Regional Trails Plan (KRTP), a countywide multiple use trails plan ([Section 5.3.1](#)).

Project Description: The consultant has been hired to establish a planning and implementation framework that includes building a GIS inventory of trail resources and recommending a short term implementation strategy. Some of the trails projects in the Clear Lake Watershed to be included in the KRTP are water trails, the Ridgeline Trail, Mt. Konocti trails, and the Bridge Arbor Trail. In addition, improvement of linkages between trail and park systems and other public lands such as MNF, Cow Mountain Recreation Area and BMDSF are being considered.

Key Participants: LCPD, Local volunteers, Lake County Marketing and Economic Development Department (LCMEDD), LCRDA, LCPWD, LCCDD, USFS, and BLM.

Timeframe: Completion of plan 1 year, implementation on-going.

Technical Resources Required: Staff of participating agencies and recreation specialists.

Cost Estimate: \$50,000.

Milestones: Complete Plan by 2010.

Effectiveness Criteria: Comprehensive trails plan that identifies current trails, recommends additions or improvements, and identifies funding sources and management requirements.

5.5.6.2 Support Water Trails Development

Background: A series of seven water trails and a map describing access points for non-motorized boaters around Clear Lake is currently being developed by LCPD. The brochures for these trails are under review, and final versions will soon be available.

Project Description: Completion of the water trails maps will provide a valuable resource to Lake County residents and visitors. In addition to these maps, further water trails projects include integrating water trails with terrestrial trails such as the Ridgeline trail, and mapping shoreline amenities such as food, lodging, and shopping.

Key Participants: LCPD, Local volunteers, LCMEDD, LCRDA, CLAS, LCLM, and LCCDD.

Timeframe: 1 year.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: Regular staff time.

Milestones: Release of final maps and/or brochures on shoreline amenities and public facilities, and publication on County and City websites.

Effectiveness Criteria: Increased non-motorized boat activity in Clear Lake.

5.5.6.3 Improve Mountain Bike and Cycling Opportunities

Background: The K RTP will take a comprehensive look at the availability of trails for mountain biking and at the potential for improving paved bicycle routes between recreation areas and communities in the county. Proposed improvements to bikeway routes are also covered in the Lake County Regional Bikeway Plan.

Project Description: Recommendations of the KRTP for mountain bike trails and bicycle route additions and improvements should be implemented as funding becomes available.

Key Participants: LCPD, Local volunteers, LCMEDD, LCDPW, California State Parks Department, USFS, BLM, and BMSDF.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: To be determined.

Milestones: Trail and bike route projects.

Effectiveness Criteria: Additional and/or improved bike trails and routes, increased user hours on bike trails and routes.

5.5.6.4 Improve and Increase Non-Motorized Trail Systems

Background: The KRTP will recommend additional trails and trail improvements throughout Lake County. Trail systems already in the works include a non-motorized, ridgeline trail along the North Shore of Clear Lake, and the Bridge Arbor Trail. Trail additions on publicly owned Mt. Konocti lands are also likely.

Project Description: Additional non-motorized trails and trail improvements as recommended by the KRTP should be constructed as funding becomes available.

Key Participants: LCPD, Local volunteers, LCMEDD, LCDPW, California State Parks Department, USFS, BLM and BMSDF.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies and consultants.

Cost Estimate: To be determined.

Milestones: New or improved trail systems.

Effectiveness Criteria: Additional and/or improved trails and increased user hours for trail systems.

5.5.6.5 Support Creation of Equestrian Centers and Horseback Riding Trails

Background: Horseback riding is a popular tourist activity compatible with Lake County's open space and scenic beauty. There are currently several local businesses that offer horseback riding and horseback tours to the public on an appointment basis. Horse trails are located on private property, at Highland Springs Recreation Area, and on the BLM North Cow Mountain Recreation Area. The KRTP will include recommendations for horseback riding trail additions/improvements.

Project Description: Recommendations from the KRTP for additional horse trails should be implemented when funding becomes available. Opportunities for public horse rentals should be encouraged by the county.

Key Participants: LCPSD, Local volunteers, LCMEDD, LCDPW, LCWPD, BMDSF, BLM, USFS, and horse rental businesses.

Timeframe: On-going .

Technical Resources Required: Staff of participating agencies and consultants.

Cost Estimate: To be determined.

Milestones: New or improved horse trails and more businesses that offer horse rentals and horse back riding.

Effectiveness Criteria: Increased availability of horse trails, horse rentals, and horseback riding.

5.5.7 Create a Lake County Recreation Program

Background: A county recreation program would provide greater opportunities to enjoy parks, sports facilities and recreation areas, and it would increase opportunities for youth and adults to participate in organized sports and outdoor activities. The recreation program could provide increased ecotourism opportunities such as guided walks, hikes, or kayak and canoe tours, and nature interpretive programs. Organized recreation could include summer youth camps, sports such as baseball, football and soccer, and water sports such as swimming, rowing and kayaking.

Project Description: LCPSD, currently charged with managing most county parks, would develop and run the Lake County recreation program. Public meetings would be held to identify the scope of the recreation program. Funding could be sought through a voter-approved annual tax assessment.

Key Participants: LCPSD, Local volunteers, youth sports organizations, and State Parks.

Timeframe: 5-20 years, two years to develop program, then on-going.

Technical Resources Required: Staff of participating agencies and organizations.

Cost Estimate: To be determined.

Milestones: Develop plan for organized recreation program, pass voter-approved funding, and run program.

Effectiveness Criteria: Increased availability of, and participation in, outdoor recreation activities and ecotourism.

5.5.8 Protect Open Space

Background: Lake County and the Clear Lake Watershed's tremendous visual resources; Clear Lake, surrounding hills and mountains, vineyards and orchards, and rural communities, are valued by county residents and attractive to visitors. Open space protection not only preserves these visual resources, it also preserves wildlife habitat and watershed functions such as groundwater recharge, flood attenuation, and water quality improvement.

Project Description: Important wildlife habitat areas, agricultural areas, floodplains, and visual resources can be protected through a combination of direct purchase, conservation easements and county policies/ordinances.

The Lake County General Plan places a strong emphasis on open space protection. Policy OSC-6.12 states that "The County shall preserve natural open space resources through the concentration of development in existing communities, use of cluster development techniques, maintaining large lot sizes in agricultural areas, avoiding conversion of lands currently used for agricultural production, and limiting development in areas constrained by natural hazards" (LCCDD 2008). Additional policies restrict development in floodplains and encourage protection of wetlands, riparian areas and other wildlife habitat, protection of cultural and archeological resources and protection of critical water resource areas. It is important that county agencies continue to support these policies in order to preserve Lake County's valuable open space.

Other recommended actions that contribute to open space protection are included in Sections 2.8.2, 3.10.2, 3.10.3, 3.10.4, 4.6.3, 4.6.5, 7.5.3, and 8.12.2.

Key Participants: LCCDD, LCPSD, LCWRD and local NGOs.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: To be determined.

Milestones: Areas purchased and protected and county policies strengthened and implemented to protect open space.

Effectiveness Criteria: Area of protected open space.

5.5.9 Support and Expand Ecotourism Opportunities

Background: Many ecotourism opportunities are currently available or in development in the Clear Lake Watershed. These include swimming, non-motorized boating, nature and wildlife, viewing, hiking, bicycling, and horseback riding.

Project Description: Several of the actions described in this plan will improve opportunities for ecotourism in the Clear Lake Watershed. Development and implementation of the Countywide Multiple Use Trails Plan will expand opportunities for non-motorized water and trail-based activities (Section 5.4). Expanding watershed and nature-based education, including development of a watershed discovery center, will enhance ecotourism options (Section 2.8.7). Open space protection helps preserve the scenery and wildlife that attract nature-based tourism (Section 5.4).

Key Participants: LCPSP, LCMEDD, local Coordinated Resource Management and Planning groups (CRMPs), local environmental organizations, ELRCD, WLRC, LCWRD, LCOE, Tribes, local businesses, DFG UCCE, State Parks, BLM, and USFS.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: To be determined.

Milestones: Development of projects such as trails and nature centers, and continued and improved nature and watershed education/outreach.

Effectiveness Criteria: Increase visitor hours in ecotourism activities.

5.5.10 Other Actions

- 2.8.2 Complete the Middle Creek Flood Damage Reduction and Ecosystems Restoration Project
- 2.8.7 Support and Increase Watershed Education and Outreach
- 2.8.9 Complete the Integrated Regional Water Management Plan
- 4.6.2 Research and Develop a Management Plan for Native Clear Lake Fish
- 4.6.3 Protect and Restore Lake and Shoreline Wildlife Habitat
- 4.6.5 Develop a Tree Management Plan
- 6.5.2 Develop Boat Cleaning Stations around Clear Lake
- 6.5.3 Adaptively Manage Invasive Mussel Protection
- 6.5.5 Develop an Aquatic Invasive Species Management Plan
- 7.5.3 Promote Compatible Uses of Floodplains
- 8.12.2 Update the Shoreline Ordinance (Chapter 23 Lake County Code)
- 8.12.3 Fully Implement the Integrated Aquatic Plant Management Plan



Clear Lake Integrated Watershed Management Plan

Chapter 6

INVASIVE SPECIES

6.1 INTRODUCTION

Invasive species are a form of “biological pollution,” capable of damaging ecosystems just like other forms of pollution. Invasive species are defined as any non-native species “whose introduction does or is likely to cause economic or environmental harm or harm to human, animal or plant health” (United States 1999). They include plants, animals and disease-causing microorganisms such as bacteria and fungi, and they occur in all ecosystems from lakes and streams to forests, grasslands, and agricultural areas. Some traits that are common to many invasive species include rapid growth and reproduction, and the abilities to spread, adapt to a wide range of conditions, and live off a range of food types. Once established, invasive species may be spread both by human activities and natural causes, such as animal movement, wind, or water movement. In most cases, however, the original introduction of a non-native species occurs as a result of human activities.

Identification of which species are invasive is complicated by differing human perspectives. While a non-native species may provide benefits to some people, if its negative effects outweigh the beneficial effects, it is considered invasive. An example is water hyacinth which has been popular in aquatic gardens, but when introduced to natural areas, it can completely cover lakes and rivers, devastating their ecology. As a practical matter, resource managers target the most damaging invasive species and ones for which control or eradication is realistic. “Because invasive species management is difficult and often very expensive, these worst offenders are the most obvious and best targets for policy attention and management” (NISC 2006). Invasive species are also considered to be those not under human control or domestication. Therefore, uncontrolled domestic plants and animals can be considered invasive if they meet the definition of invasive species (NISC 2006).

This chapter begins with sections on aquatic and terrestrial invasive species common to this area. Invasive species management is then covered in one section because many agencies have responsibilities in the control and prevention of both aquatic and terrestrial invasive species.

6.1 AQUATIC INVASIVE SPECIES

6.2.1 Plants

Many invasive aquatic plants arrived as aquarium flora (hydrilla and Eurasian watermilfoil) or landscaping plants (water hyacinth, water primrose) (Table 6-1). These plants have the ability to form dense mats, interfering with boating and swimming. In some cases, they out-compete native aquatic plants, such as tules, and provide habitat for mosquito larvae in small protected pools of water in their foliage.

Table 6-1 Invasive aquatic plants in Lake County, California.

Name	Description	Economic or Environmental Harm
Hydrilla <i>Hydrilla verticillata</i>	Rooted, submerged plant with branching stems, pointed leaves, reaches up to 36 ft.	Forms dense vegetation mats that interfere with recreation and destroy fish and wildlife habitat; Spreads by fragmentation, seeds, tubers.
Eurasian Watermilfoil <i>Myriophyllum spicatum</i>	Rooted, submerged plant with feathery leaves., 3-10 ft. tall or more.	Forms very dense mats; Spreads by fragments; Competitive due to early spring growth.
Water hyacinth <i>Eichornia crassipes</i>	Free-floating with rounded, leathery leaves, large purple to violet flowers, few inches to 3 ft. tall.	Rapid growth and reproduction cause rapid extension of free-floating mats; Seeds eaten and transported by water fowl.
Water primrose <i>Ludwigia peploides</i> and <i>L. hexapetala</i>	Bright yellow flowers and willow-like leaves, creeping on shoreline, floating, or upright.	Forms dense of mats of vegetation, primarily along margins of lakes and streams; Spread by seeds and plant fragments; Out-competes tules and other emergent aquatic vegetation.

Source: Lake County Agricultural Commissioner. 2002. *Invasive Weeds of Lake County*.

Of the plants listed in Table 6-1, hydrilla is considered the most serious invasive plant. It is an A-rated weed¹¹ and was found in Clear Lake in 1994. Hydrilla has the ability to spread rapidly and form dense mats throughout the water column, choking boat engines and water intakes, and potentially disrupting the Clear Lake ecosystem with unpredictable effects on fish and wildlife (Figure 6.1). Because Clear Lake is located upstream of the Sacramento- San Joaquin River Delta, it is important to prevent movement of hydrilla to this vital state water resource.

¹¹ California A-rated weeds are subject to quarantine and eradication by CDFA and County Agriculture Departments.

Hydrilla has been targeted for eradication by the California Department of Food and Agriculture (CDFA) since its discovery in Clear Lake in 1994 (Section 6.4).

Water primrose is a damaging invasive because it climbs on and smothers tules, which are important nesting habitat for western grebes, and important habitat for many fish. Water primrose leaves can hold small pools of water that become protected habitat for mosquito larvae (Figure 6.2). Eurasian watermilfoil is present in Clear Lake, but has not reached damaging populations.



Figure 6-1 Hydrilla along the Big Valley shoreline in 1994.



Figure 6-2 Water primrose at Lake County Lakeside Park. Photo by Carolyn Ruttan.

Introduction of non-native algae also has the potential to harm aquatic ecosystems. One example is golden algae, *Prymnesium parvum*, which have been found throughout the south and in western states including Arizona. This algae thrives in brackish water, but has been found in freshwater. Golden algae release a toxin that affects gill breathing organisms including fish, bivalves, crayfish and gill breathing amphibians. The toxin causes hemorrhaging in the gills and death.

6.2.2 Animals

Numerous fish species have been introduced to Clear Lake (Table 4-1), and these introductions have reduced native fish populations. Some of the introduced fish such as bass, bluegill, crappie, and catfish, prey on juveniles of native fish, and bass and catfish consume adult fish as well. Other introduced fish such as the silversides and shad are planktivores that compete for food with native fish such as the Clear Lake hitch. The

introduced fish species do not fit the definition of invasive species because many provide benefits such as improved sport fishing, and because elimination of the introduced species is not possible. Management, for example increasing wetlands important for the survival of juvenile fish, may help to ensure the success of native fish populations.

Bull frogs, *Rana catesbeiana*, are native to the eastern United States, and were introduced to California around 1900. Along with invertebrate prey, adult bull frogs prey on other amphibians and even mice, snakes, birds, and young turtles. They damage native amphibian populations both by preying on them and by

competing for space (CDFG 2005). They are found where year-round water is available.

Non-native freshwater mussels such as the quagga and zebra mussels and New Zealand mud snail pose a significant threat to Clear Lake. Both of the mussel species reproduce rapidly, covering hard surfaces, clogging water intake pipes, and covering beaches with their small, sharp shells. They are filter feeders capable of consuming a large proportion of the plankton present in a water body. Because plankton are the base of the food chain for aquatic ecosystems, the mussels can severely affect the entire ecosystem. Both species are found throughout the eastern United States, and both are now found in several water bodies in California (USGS 2008). Zebra and quagga mussels are spread when people move boats and other aquatic vessels from one water body to another. Preventing the spread of mussels requires thorough cleaning and drying. Mussels attached to hard surfaces can survive up to a week out of water. Their microscopic larvae survive in places that hold water such as bilges, ballast water, and live wells.

The New Zealand mud snail is found in scattered locations around California including Putah Creek and the Russian River. It prefers moving water and is found in streams, rivers, and lakes. It may have the potential to out-compete native invertebrates that are important food sources for fish, such as mayflies, caddisflies, and chironomids (CDFG 2008c). To prevent spread of the New Zealand mud snail, the California Department of Fish and Game (DFG) recommends freezing or completely drying out any gear that has been in potentially contaminated waters.

6.2.3 Diseases and Parasites

Some diseases and parasites are included in definitions of invasive species (NISC 2006). Viral hemorrhagic septicemia is an example of a recently introduced, potentially lethal fish disease. It was found first in the Great Lakes region in 2003. It has now spread throughout the Great Lakes and is found in inland waters of Wisconsin, Michigan, and New York States. To avoid spreading the disease, fish should not be transferred from one body of water to another, and thorough cleaning of fishing equipment, boats and trailers are recommended (USDA APHIS 2006).

6.3 TERRESTRIAL INVASIVE SPECIES

6.3.1 Plants

Invasive plant species cause significant impacts including reduction of native plant populations, loss of wildlife habitat and food sources, degraded range and timber lands, increased fuel loads, and reduced water resources. A brief summary of the plants considered to be most threatening in Lake County is given in Table 6-2 .

Table 6-2 Invasive terrestrial weeds in Lake County, California.

Name	Description	Economic or Environmental Harm
Arundo/Giant Reed <i>Arundo donax</i>	10-20 ft. tall cane-like stems, perennial.	Found in riparian areas; Excludes other vegetation creating monoculture unsuitable for bird and wildlife habitat.
Brooms, Scotch and French <i>Cytisus scoparius</i> and <i>C. monspessulanus</i>	5-10 ft. tall shrubs with yellow flowers in late spring.	Replaces native woody and annual species; Prevents tree seedling growth; Increases fuel load.
Medusa Head <i>Elymus caput-medusae</i>	Winter annual grass resembling foxtail, 10-12 in. tall.	Replaces desirable rangeland forage plants; High silica content makes it unpalatable to livestock and wildlife.
Milk thistle <i>Silybum marianum</i>	6 ft. tall thistle with 2 ft. long dark green leaves, pink flowers in late spring.	Forms dense, impenetrable thickets; Can be poisonous to livestock.
Perennial Pepperweed/White top <i>Lepidum latifolium</i>	2-4 ft. tall stalks, white flowers in early June.	Common in riparian areas, roadsides and fields; Displaces native species and habitat.
Puncture vine/Goats head <i>Tribulus terrestris</i>	Annual, forms circular, flat mat, seeds sharp, yellow flowers.	Found in disturbed areas; Seeds that form by late summer puncture bicycle tires, injure feet and hooves.
Tamarisk/ Salt cedar <i>Tamarisk sp.</i>	Large, up to 25 ft. tall shrub, pink blooms in late spring	Grows in stream channels, moist areas; Eliminates native plants through rapid growth and reproduction and accumulation of salt in soil; High water user.
Tree of heaven/Chinese sumac <i>Ailanthus altissima</i>	Deciduous tree with large, compound leaves, yellow green flowers become papery seeds	Extensive, vigorous root system damages roads, sidewalks, buildings; Spreads; Toxin from roots inhibits other plants.
Yellow Starthistle <i>Centaurea solstitialis</i>	Annual or biennial weed, up to 3 ft. tall, yellow flowered, spiny seed heads.	Poisonous to horses, mules and donkeys; Poor forage for cattle; Competitive, replaces desirable plants.

Source: Lake County Agricultural Commissioner. 2002. *Invasive Weeds of Lake County*.

Of the plants in Table 6-2, arundo, perennial pepperweed, and tamarisk are found in riparian zones. Arundo, which has been used for landscaping and erosion control, grows prolifically along streams and lakes and is a heavy water user. It spreads from portions of stem or root that break off. It is flammable even when green, and sprouts back readily following fire. Its flammability threatens adjacent riparian vegetation that is not fire adapted (SEC 2008). Tamarisk is also a heavy water user and is fire adapted. It concentrates salts at the soil surface, preventing

the establishment of other plants. Individual tamarisk plants can each produce 500,000 seeds per year (Cal-IPC 2008).

6.3.2 Animals

Often, the populations of threatened and endangered animal species are reduced by habitat loss and degradation. The addition of a non-native species that preys on them or competes for food and other resources poses a serious additional threat.

Examples of mammals that may be considered invasive include the roof rat, Norway rat and feral cats, all of which prey on ground nesting birds. Feral pigs cause environmental damage, digging up the soil and causing erosion and feeding on native wildlife and vegetation. At the same time, feral pigs provide popular hunting activities. DFG reported 5,438 were taken in the state in 2005/2006 (Kreith, M. 2007).

The European starling was introduced to the United States in 1890 and is a widespread species that competes with other birds for nest cavities. Brown-headed cowbirds were once found only in the Midwest where they followed bison herds. They have shifted to reliance on livestock and agricultural areas, and their range has expanded to most of North America. Cowbirds are brood parasites, laying their eggs in the nests of other birds, and they can seriously affect reproduction of numerous songbird species.

With a \$31 billion agriculture industry in California, introduced insect pests pose a significant economic threat. In addition, eradication or control of the pests may require increased pesticide use with the potential for environmental harm. Insect pests newly introduced to California with the potential to damage Lake County crops include two vineyard pests, the glassy-winged sharpshooter¹² and vine mealybug. Light brown apple moth threatens a variety of orchard crops, grapes, trees, and ornamental plants. Other insect pests that may affect agriculture, landscape, and forest plant species include several fruit fly species, the Japanese beetle, and the Gypsy moth. The Lake County Agriculture Department (LCAD) has trapping programs for these pests, and thus far the Clear Lake Watershed appears to be free of them¹³.

6.3.3 Diseases and Parasites

West Nile Virus (WNV), transmitted by mosquitoes and causing disease in humans, birds, and some other animals, is considered an invasive species. In 2008, there was one confirmed horse and two confirmed bird deaths from WNV in Lake County. In addition, the virus was found in two mosquito samples. In 2008, there were no infections in two flocks of chickens maintained by the Lake County Vector Control District (LCVCD) near areas with high mosquito populations; however, there were infections in these flocks in 2007. Statewide

¹² The glassy-winger sharpshooter is a threat because it vectors Pierce's disease, which can kill grapevines. Pierce's disease is caused by the bacteria *Xylella fastidiosa*.

¹³ Glassy-winged sharpshooter has not been found in Lake County. An infestation of vine mealybug has been found in the Middletown area.

fatal cases in humans, horses, and birds peaked in 2004 and 2005, and they declined approximately 50% from these levels in humans and birds, and over 90% in horses by 2007 (CDPH 2008).

Sudden Oak Death (SOD), a fungus-like disease affecting many oaks in coastal areas, is also considered an invasive species ([Section 4.6.5](#)).

6.4 MANAGEMENT

The US Fish and Wildlife Service has numerous mandates for prevention and control of invasive species. Under the Lacey Act, it regulates the “importation and transport of species, including offspring and eggs, determined to be injurious to the health and welfare of humans, the interests of agriculture, horticulture or forestry, and the welfare and survival of wildlife resources of the U.S. Wild mammals, wild birds, fish, mollusks, crustaceans, amphibians, and reptiles are the only organisms that can be added to the injurious wildlife list (USFWS 2008).” The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 regulates release and exchange of ballast waters from shipping vessels in the United States and its waters. The National Invasive Species Council is a council of 13 federal departments that deal with invasive species. It was created in 1999 by Executive Order 13112 “to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause” (USDA 2008).

In California, DFG focuses on aquatic invasive species (AIS), and they completed a California Aquatic Invasive Species Management Plan (CAISMP) in 2008 (CDFG 2008c). DFG maintains a website with educational and resource materials on quagga and zebra mussels and the New Zealand mud snail. They also track and provide maps of where these pests have been found. As part of their K9 program, the DFG has dogs trained to detect zebra and quagga mussels on boats.

CDFA is charged with preventing importation of pests and diseases and controlling pests within the state. CDFA works in cooperation with the state DFG and the USDA. CDFA’s exclusion branch includes inspection stations on major highways entering the state and enforcement of quarantines and inspection of packages at parcel carrier terminals within the state. CDFA also provides oversight of nurseries in California (CDFA 2008b). Once finalized, a new amendment to Section 3060.3, Title 3 of the California Code of Regulations will make it illegal for plants classified as noxious weeds to be sold as nursery stock.

CDFA enforces the SOD quarantine which prohibits interstate and intrastate movement of specified articles. These articles include bark chips, forest stock, firewood, lumber, greenery, and nursery stock of host plant species (7CFR 301.92). Because SOD has been found in southern Lake County near the border with Sonoma County, all of Lake County is a quarantine area.

CDFA began a hydrilla monitoring and eradication program in Clear Lake in 1994. The eradication program relies on chemical control because mechanical control spreads the plants. The herbicides used are Komeen[®], a copper-based

herbicide, and Sonar[®], an herbicide with the active ingredient fluridone. CDFA's protocol for hydrilla eradication involves three seasons of treatment and survey, followed by three seasons of survey without treatment. The pattern of hydrilla finds from 1994 to 2002 is shown in Figure 6.3. Following three seasons without hydrilla detection in Clear Lake, no herbicides were applied to control hydrilla in 2006 (CDFA, 2006). Beginning in 2007, however, additional hydrilla finds were made and treatment resumed in the areas of the finds (Figure 6.4). The CDFA Hydrilla Eradication Program is under a National Pollutant Discharge Elimination System (NPDES) permit, and as part of the permit, CDFA monitors for herbicides that it applies to Clear Lake. The CDFA Hydrilla Eradication Program cooperates with Lake County for the county's NPDES permit, providing CDFA fluridone and copper monitoring data, including monitoring water flowing into, and out of, Clear Lake. In addition, DFG monitored copper and sonar levels and toxicity to fish in 1996 and 1997 (Trumbo 1997; Trumbo 1998).

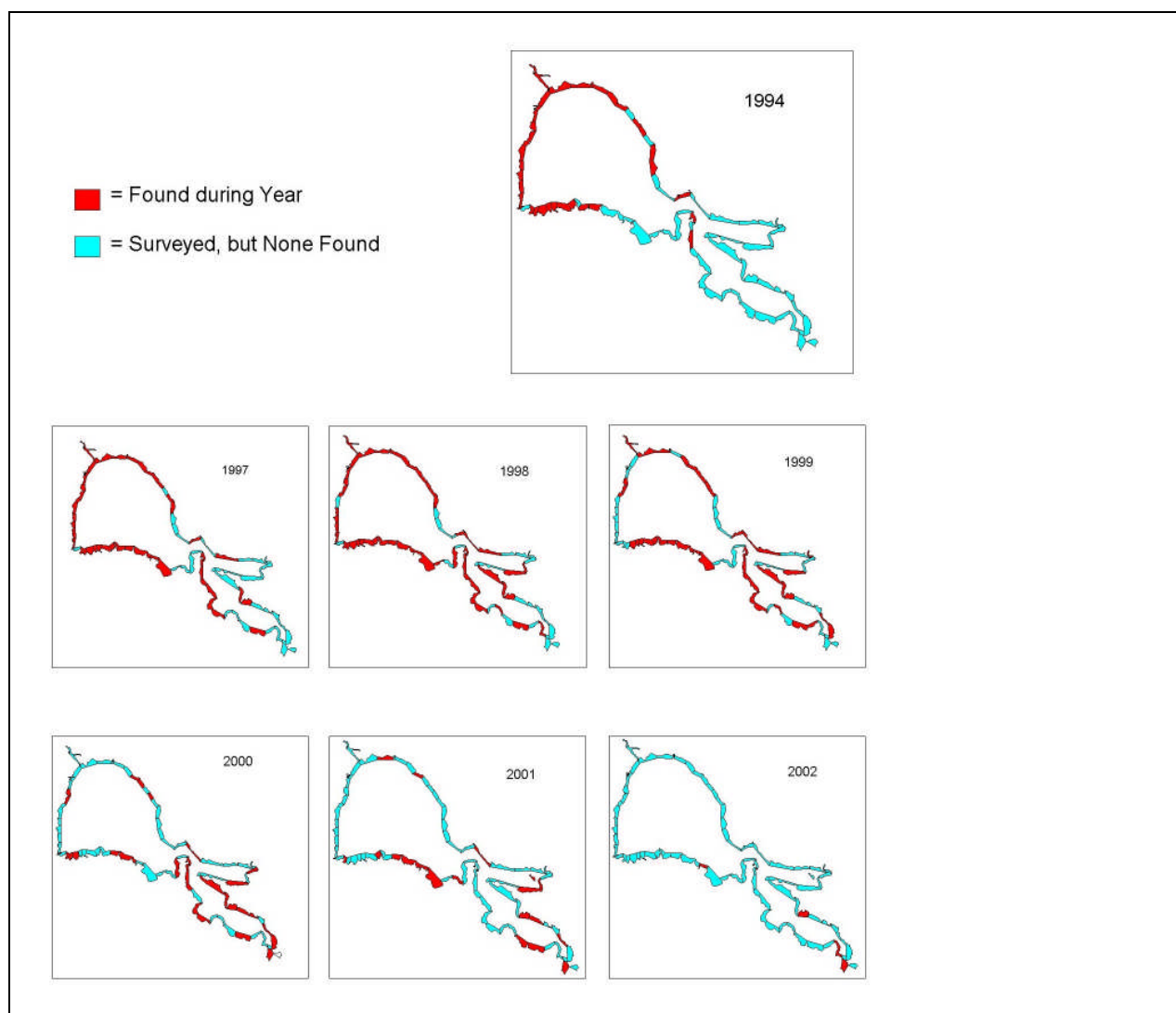


Figure 6-3 Yearly Clear Lake hydrilla survey results, 1994-2002. *Figure by CDFA Hydrilla Eradication Program.*

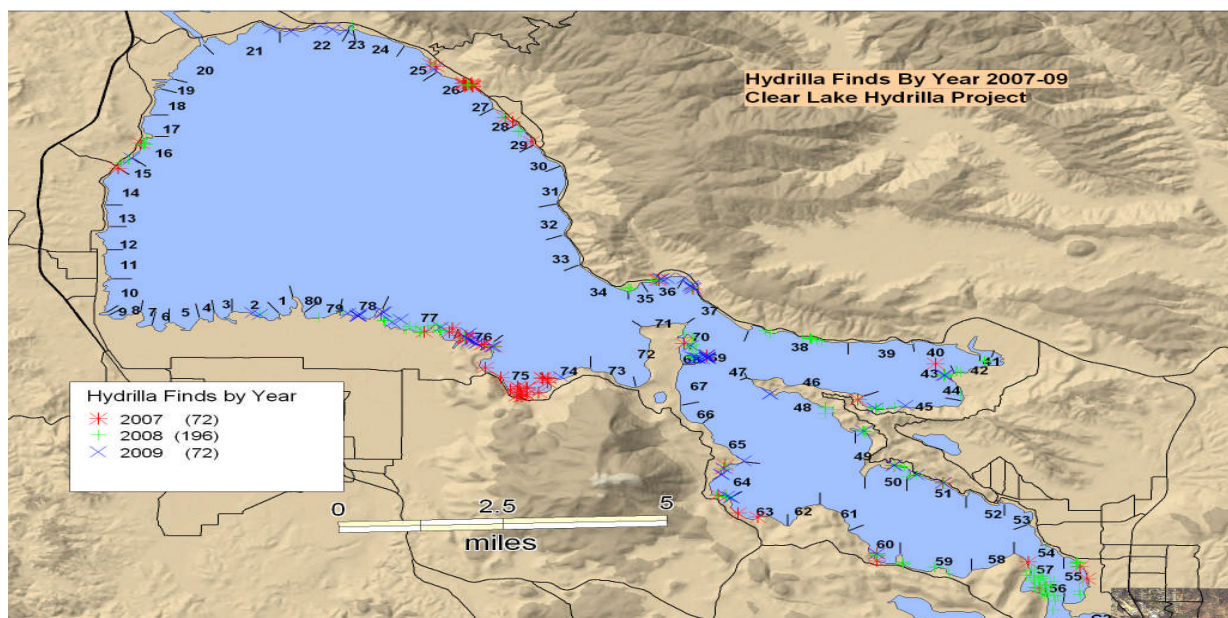


Figure 6-4 Hydrilla finds by year in Clear Lake. *Figure by CDFA Hydrilla Eradication Program.*

Along with hydrilla monitoring, the CDFA hydrilla crews monitor and map water primrose and other aquatic invasive plants.

Many CDFA activities are carried out by the county Agricultural Commissioner's office. These include trapping programs for insect pests and control and eradication of A-rated weeds. LCAD also carries out inspections of packages to local carriers, and plant shipments to local nurseries (Steve Hajik, personal communication).

The Lake County Weed Management Area (LCWMA), formed in 2001, is a group that cooperates and coordinates activities and expertise to prevent and control weed problems in Lake County. It is made up of LCAD, Lake County Public Works Department (LCPWD), the East and West Lake Resource Conservation Districts, and the local office of the USDA Natural Resources Conservation Service, along with other government agencies, local Tribes, and environmental and industry groups as partners. Its activities are "focused upon the exclusion, detection, suppression, and eradication of noxious and invasive non-native weeds" (LCWMA 2008). In 2008, LCWMA received two years of grant funding from CDFA to eradicate water primrose at selected sites along the Clear Lake shoreline and to eradicate tamarisk throughout the county. To educate the public about invasive plants, LCWMA holds an annual invasive weed tour during California Invasive Weed Awareness Week (in July).

Starting in 2001, the Water Resources Division of the Lake County Public Works Department (LCWRD) began a program to monitor and eradicate arundo and inventory tamarisk throughout the county. Funding for the program came from Proposition 13 and 50 grants and continued until March 2009. The LCWMA has

received continuing funding for arundo eradication. Results of the program so far are shown in Plate 13.

In Clear Lake, aquatic weeds are managed under the CEQA-approved Integrated Aquatic Plant Management Plan (IAPMP), approved by the Board of Supervisors in 2005 ([Section 8.10](#)). Objectives of the plan include supporting the continued multiple uses of Clear Lake, identifying effective and environmentally sound management techniques, avoiding adverse human and environmental impacts, and minimizing potential introduction of non-native species to Clear Lake (Jones and Stokes 2005).

To prevent the introduction of invasive aquatic plants to Lake County, the Board of Supervisors adopted a Non-native Invasive Aquatic Plant Ordinance in June, 2006 (Lake County Ordinance 2774). The ordinance gives the LCAD enforcement power to make the possession, sale, release, gifting, or planting of nine specific non-native, invasive aquatic plants unlawful. The LCAD inspects the various retail outlets, including nurseries and pet stores, to survey for these aquatic plants.

To prevent the introduction of invasive mussels to Clear Lake, the Lake County Board of Supervisors passed an urgency ordinance on March 25, 2008, and a permanent ordinance on May 20, 2008, requiring inspection of all vessels launched in Lake County waters. Lake County Ordinance 2866 requires inspection of all water vessels, motorized or non-motorized, prior to launching in a Lake County water body. Owners/operators of vessels launched without a valid inspection sticker may face monetary penalties, impoundment of the vessel, and in some cases, incarceration in the county jail. The ordinance also bans the disposal of live bait and any liquid that contains, or has contained, live bait into Lake County water bodies (County of Lake 2008). The county also holds public educational meetings and provides signs and informational pamphlets to educate the public on preventing the introduction of zebra and quagga mussels.

Lake County purchased mobile, fully self-contained high temperature and pressure wash stations in 2008, with a plan to locate them at the county perimeter to clean boats entering the county. The cost of operating these stations was determined to be prohibitive, but the City of Lakeport requested one of the stations to operate as a public/private partnership with local businesses. The pressure wash station is currently being operated by Lakeport Camper and Truck, and the City of Lakeport has employed a part-time park ranger to manage the station at an annual cost of \$20,000. An additional unit is being held in reserve by the county.

An Invasive Species Council (LCISC), was established by the Lake County Board of Supervisors in 2009. The LCISC has been focusing on control of invasive Eurasian mussels, such as quagga and zebra mussels. Thus far, LCISC is evaluating the inspection program, developing a calendar to track all events that bring water vessels to Lake County, and working to improve public education (Greg Giusti, personal communication).

Lake County has an Invasive Mussel Prevention Plan and Weed Management Plan that are currently in draft form. The former plan is likely to be modified by the LCISC, and the latter is in final review stages.

LCVCD monitors for the presence of WNV and controls mosquito populations in the county. LCVCD collects information on human and equine cases of WNV in the county and collects dead birds to be tested for WNV at the California Animal Health and Safety laboratory at the University of California (UC) at Davis. They monitor for the presence of WNV by collecting mosquitoes and sending them to UC Davis for testing, and by maintaining flocks of chickens near wild rice fields in Upper Lake and Anderson Marsh. Blood samples from these sentinel chicken flocks are sent periodically to the California Department of Public Health (Ryan *et al.*, 2006).

Federal agencies have programs to control invasive plant species on the lands that they manage. The Bureau of Land Management (BLM) Resource Management Plan calls for treatment (by plowing, mowing or herbicide use) of up to 50 acres per year of yellow starthistle, medusahead, Italian thistle, and Harding grass (USDI BLM 2006). In the Middle Creek Watershed, the United States Forest Service (USFS) is planning to survey and control a Scotch broom infestation along Elk Mountain Road above the Middle Creek Campground, and has been controlling two small broom occurrences southeast of the Deer Valley Campground (Lauren Johnson, personal communication).

6.5 INVASIVE SPECIES ACTIONS

6.5.1 Overall Strategy

Invasive species are a threat to Lake County's natural resources. The General Plan states that "The County shall strive to protect natural resource areas, fish and wildlife habitat areas, scenic areas, open space areas, and parks from encroachment or destruction by incompatible development and invasive species" (LCCDD 2008). Clear Lake's vulnerability to AIS is recognized. The General Plan encourages public agencies with management responsibility for Clear Lake to continue and coordinate efforts to control the spread of invasive species.

6.5.2 Develop Boat Cleaning Stations around Clear Lake

Background: Recreational boating is a major cause of the spread of AIS. Boat wash stations where boaters clean their boats as they leave Clear Lake would prevent the potential spread of AIS now present in Clear Lake, such as hydrilla, Eurasian milfoil, and Asian clams, to other water bodies. More intensive cleaning is necessary for boats arriving at Clear Lake from a lake known to have AIS such as quagga and zebra mussels. Trained and certified operators are needed to conduct high pressure and hot water (160°F at the nozzle, 140°F at the hull), or biocidal sprays, (e.g. salt or chlorine), to clean potentially contaminated boats.

Project Description: The type of boat wash facility offered would vary depending on the purpose, location, and owner of the facility. At public boat launches, wash stations for boats leaving Clear Lake would require a minimum of a water source and water collection facility. Funds to develop the stations could come from grant funding by the California Department of Boating and Waterways. Privately operated boat wash facilities might include additional cleaning options, such as soapy or deionized water.

If the number of boats arriving at Clear Lake that are identified as potential quagga or zebra mussel risks increases, it will be necessary to set up hot water or biocidal cleaning stations in addition to the mobile pressure wash station located at Lakeport Camper and Truck (Section 6.5.3 below). Local businesses with on site high temperature pressure washing equipment have been identified and would be trained and utilized as needed to clean boats that pose a risk. Providing mobile cleaning units, as well, will permit greater flexibility to set up stations at temporary locations, such as the staging areas for fishing contests. The mobile stations can also be operated without access to electricity and running water.

Key Participants: LCISC, LCLM, LCCDD, LCPSP, Clear Lake Advisory Subcommittee (CLAS), LCRDA, car wash or auto-related businesses, and commercial marinas.

Timeframe: 0-5 years.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: To be determined.

Milestones: Boat wash facilities established at major boat launches.

Effectiveness Criteria: Prevention of invasive species introductions to Clear Lake and other surface water bodies and prevention of invasive species export from Clear Lake.

6.5.3 Adaptively Manage Invasive Mussel Prevention

Background: Infestation of Clear Lake by zebra or quagga mussels has the potential to cause great harm to the lake's ecology, physical infrastructure, and boats used on the lake. A mussel infestation could disrupt the food chain and harm fish species and fishing opportunities, foul facilities such as docks and boat ramps, encrust boats and clog their engines, litter beaches with sharp, smelly shells, and clog water intake pipes, increasing maintenance costs.

LCWRD has developed a Lake County Mussel Prevention Plan (LCMPP) to prevent infestation of Clear Lake by zebra and quagga mussels. The plan includes sections on Education and Outreach, Physical Preventative Procedures, Special Interest Group Notifications and Procedures, Monitoring, Adaptive Management, and Partnering. This draft plan provided background for the March 2008 urgency ordinance and May 2008 permanent ordinance requiring screening of all vessels launched in Lake County waters. The screening enables participating businesses and agencies to determine the level of risk of that the vessel is transporting

invasive mussels. (Detailed description of screening program in Project Description below.)

Project Description: The LCMPP will continue to be managed in an adaptive and flexible manner, by responding to new information, issues, and opportunities, and by examining the full range of options for response. The LCISC will advise on the management approach. The LCMPP will become a component of the Aquatic Invasive Species Management Plan (Section 6.5.5 below).

The primary goal of watercraft interception programs must be to prevent the transfer of quagga and zebra mussels on trailered watercraft/equipment in order to safeguard natural resources, water supply, cultural uses, recreation and other important resources. The secondary objective of any long-term mussel interception program should also be to keep public and private waters open to boating to the greatest extent possible. While it may only take one infested watercraft or piece of equipment to establish a mussel population, the vast majority of watercraft is not transporting mussels. By following common sense guidelines an effective watercraft interception program can be established that will readily identify high risk watercraft so that more restrictive strategies can be focused where they are most critically needed.

The Lake County program is based on a two tiered system to achieve compliance. The first is vessel screening, which involves the vessel owner acknowledging through a signed affidavit that their vessel is not known to harbor invasive species and identifies water bodies visited within the past 30 days. The second, more intensive, tier involves a vessel inspection. This is required of any vessel that has been in contact with known infested water or is from (established by vessel registration) a county known to be infested with quagga or zebra mussels. The inspection procedures are those recommended by DFG and performed by DFG-trained, certified inspectors. Vessels considered at risk for carrying invasive mussels would be required to undergo cleaning at several locations in the Cities of Lakeport and Clear Lake or would be prohibited from launching in Lake County waters.

Key Participants: LCISC, LCWRD, DFG, UCCE, DWR, CDBW, CDFA, CLAS, Tribes, Cities of Lakeport and Clearlake, and State Department of Parks and Recreation.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: \$120,000.

Milestones: On-going management of invasive mussel prevention.

Effectiveness Criteria: Prevention of invasive mussel infestations of Lake County waters.

6.5.4 Eradicate Hydrilla from Clear Lake

Background: Hydrilla, an A-rated weed, was found in Clear Lake in 1994. It has the potential to fill the water column, choking boat engines and water intakes,

and potentially disrupting the Clear Lake ecosystem with unpredictable effects on fish and wildlife. Because Clear Lake is located upstream of the Sacramento- San Joaquin River Delta, it is important to prevent movement of hydrilla to this vital state water resource.

Project Description: CDFA will continue to monitor for hydrilla around Clear Lake, and to treat for hydrilla where ever it is found. The treatment period should be increased based on the finding that three years of treatment was not sufficient to eradicate hydrilla in some locations. It is important to continue to educate the public about hydrilla and how to avoid its spread.

Key Participants: CDFA, LCLM, and CLAS

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: To be determined.

Milestones: Eradication of hydrilla from Clear Lake.

Effectiveness Criteria: See Milestones.

6.5.5 Develop an Aquatic Invasive Species Management Plan

Background: AIS potentially threaten Clear Lake fish and wildlife. This in turn could impact recreational activities and Lake County's tourist economy. Located in the Upper Cache Creek watershed, invasive species introduced to the Clear Lake Watershed have the potential to spread downstream to the Sacramento River and Sacramento-San Joaquin River Delta.

Although AIS include a range of organisms from disease-causing microbes and algae to mollusks, arthropods, fish and plants, most of these species are spread by the same means; boats and other water gear traveling from one body of water to another. A comprehensive approach to AIS management, with an emphasis on prevention, can therefore be very effective. Approaches to prevention, detection, monitoring, and response planning are common across the range of species.

DFG recently completed a statewide "California Aquatic Invasive Species Management Plan" (CAISMP) (CDFG 2008c). The main purpose of the plan is coordination among state programs, creating a statewide decision-making structure, and sharing baseline data. The plan also provides for coordination with federal, regional, local, and private and non-profit entities. Statewide, education and ready availability of boat wash facilities are important steps to preventing the introduction of AIS not now present in Clear Lake, such as quagga and zebra mussels.

For Lake County, the CAISMP provides a template for developing a county AIS management plan, and it clarifies state and county roles in AIS management.

Project Description: A comprehensive plan for AIS management in Lake County will be developed. Likely components for the plan include:

- Cooperation and collaboration. Several state agencies have lead roles in AIS prevention and control. Several county departments also have responsibilities for different areas of AIS management. Cooperating with state agencies and among county departments, and establishing clear lines of communication will lead to the most efficient and effective control of AIS in the Clear Lake Watershed. The components described below will include definition of the roles of county departments and state agencies.
- Prevention. Activities could include maintaining a list of current AIS threats, identifying potential vectors, and developing appropriate preventive approaches such as inspection, cleaning, and enforcement.
- Early detection and monitoring. A systematic approach to monitoring for potential AIS may enable detection at a stage where the invader can be eradicated or its spread limited. Once established, monitoring the location and spread of an AIS, as well as environmental factors that influence its success, are important for control and/or eradication.
- Rapid response and eradication. One recommendation of the CAISMP is to develop and implement a state rapid response plan. Lake County should coordinate with this plan and augment it according to local conditions.
- Long- term control and management. Where established species have significant environmental, economic, human health, or other impacts, long-term control and management may be economically feasible.
- Education and outreach. Assisting the general public with understanding the threats and vectors of AIS, is an important component of prevention. When eradication and control measures are needed, outreach can be important to gain public understanding and acceptance.

Key Participants: LCISC, LCLM, CLAS, DFG, and CDFA.

Timeframe: 0-3 years.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: \$30,000.

Milestones: Plan completion.

Effectiveness Criteria: Established programs for prevention and control of AIS.

6.5.6 Complete, Adopt, and Implement a Countywide Weed Management Plan

Background: A final draft of the Lake County Weed Management Plan is under revision by LCAD, Lake County Watershed Protection District (LCWPD), and by the East and West Lake RCDs.

Project Description: Following revisions and internal review, the plan will be circulated for external review to appropriate state and federal agencies. It will then be available for public review and comment. After incorporating the comments recommended by external reviewers, the Lake County Weed Management Plan will be submitted for approval by the Lake County Board of Supervisors. LCAD will be the lead in plan implementation.

Key Participants: LCAD, LCWPD, ELRCD, and WLRCD.

Timeframe: 0-2 years.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: Regular staff time.

Milestones: Complete plan review, final draft, approval by Board of Supervisors, and plan implementation.

Effectiveness Criteria: Prevention of weed introductions to Lake County and control/eradication of invasive weeds that is present.

6.5.7 Other Actions

2.8.7 Support and Increase Watershed Education and Outreach

2.8.9 Complete the Integrated Regional Water Management Plan

8.12.3 Fully Implement the Integrated Aquatic Plant Management Plan



Clear Lake Integrated Watershed Management Plan

Chapter 7

LAKE FLOODPLAIN MANAGEMENT

7.1 INTRODUCTION

Floodplains provide important ecological services by dissipating flood waters, settling out sediment and nutrients, and contributing to groundwater recharge. Riparian vegetation along streams and creeks is important to stream function, provides vital bird and wildlife habitat, and benefits adjacent aquatic habitat. However, development has encroached on floodplains, resulting in floods, causing damage to property, and creating public health and safety hazards within the watershed. Management of development and water resources in the watershed are essential to reducing damage and public health and safety hazards resulting from flooding.

Flooding in Lake County typically results from prolonged heavy rainfall over tributary areas during the period from November through March. Flooding is more severe either when antecedent rainfall has caused saturated ground conditions or when the ground is frozen in the higher elevations and infiltration is minimal. On rare occasions, melting snow could augment runoff from general rain. Rain flooding on streams is characterized by high peak flows with durations of several hours to several days. On Clear Lake, the level can continue above flood stage for weeks.

This chapter begins with a section describing flooding on Clear Lake and within the watershed. The chapter also discusses flooding within the Clear Lake Watershed as it relates to Clear Lake. This document will only address those flood issues that affect the water resources in Clear Lake and will not address specific flooding problems within the watershed. These items are discussed in the Lake County Floodplain Management Plan (2000). A description of current actions and management are included. The chapter concludes with actions recommended to reduce the adverse impacts of flooding.

7.2 CLEAR LAKE FLOODING

Due to its size, Clear Lake responds slowly to storm events and rises to flood stage only after prolonged, high intensity storms. When this happens, Clear Lake's natural outlet, Cache Creek, is too small to allow floodwater to leave the lake as

fast as it enters. Flows in Cache Creek are limited by the Grigsby Riffle, a natural rock sill in Cache Creek near the Lake Street Bridge, which is covered with gravel deposited by Seigler Creek. Inflows to Clear Lake in excess of 50,000 cubic feet per second (cfs) have been documented, while outflows are limited to less than 5,000 cfs. Wind set may increase the depth and extent of shoreline flooding, but the most important factor is inadequate outlet capacity, which increases and prolongs high lake stages.

The level of Clear Lake has been tracked on various datums (relative elevation) over the past 150 years. Since 1913, the United States Geological Survey (USGS) has been keeping records based on the Rumsey Gage. The origin of the Rumsey Gage is clouded in history. “Zero Rumsey” is considered to be the low water level of Clear Lake; however, have historical records indicated the low point of the gravel bar at the Grigsby Riffle where flow ceased going down Cache Creek was 1.2 feet above Zero Rumsey in 1903. Zero Rumsey is equal to 1318.26 feet (1929 NGVD) (another datum, sometimes referred to by laymen as “Sea Level”).

Contrary to popular belief, the Cache Creek Dam does not cause Clear Lake to flood. The dam can release water much faster than Cache Creek can flow. It is the narrow, shallow Cache Creek Channel that slows the release of water from Clear Lake during a flood. Cache Creek Dam is designed to release water at 21,000 cfs. However, Cache Creek delivers approximately 4,700 cfs when Clear Lake is at 11 feet Rumsey, 2 feet above flood stage. The limited flow in Cache Creek causes Clear Lake to rise rapidly during heavy, prolonged rainstorms and does not lower lake levels very fast after the rains have stopped.



Figure 7-1 Pavilion at Fifth Street, Lakeport (1909?).

Table 7-1 Twenty highest recorded levels of Clear Lake.

Year	Lake Level (feet Rumsey)	Year	Lake Level (feet Rumsey)
1890	13.66	1914	11.12
1909	13.38	1958	10.86
1878	12.39	1995	10.72
1876	12.37	1915	10.68
1895	12.25	1970	10.37
1904	11.91	1881	10.25
1907	11.64	1938	10.25
1998	11.40	1880	10.08
1986	11.34	1902	9.98
1983	11.32	1893	9.70

Table 7-1 lists the 20 highest recorded lake levels since 1874. These records show that the seven highest recorded lake levels occurred between 1874 and 1913, a period when there was not a dam affecting Clear Lake. Since construction of the Cache Creek Dam in 1914, the Cache Creek Outlet Channel (the channel between the dam and Clear Lake) has been enlarged and straightened twice, in 1918-19 and in 1938. Dredging has lowered the elevation of the gravel bar at the Grigsby Riffle with a lowest elevation of approximately 1.2 feet Rumsey (1903 natural condition, Murray, Burns and Keinlen 1975) to Zero Rumsey. These channel changes significantly increase the discharge capacity of the Cache Creek Outlet Channel from 2,829 cfs to 4,700 cfs at 11.00 feet Rumsey, greatly reducing flooding (Sierra Hydrotech, Memorandum titled "Operation Studies and Associated Information for 1901-1985 Natural Conditions," November 12, 1986). Computer modeling completed in 1986 estimated that under natural conditions (no dam or channel dredging) the high lake level in 1983 would have been approximately 14.02 feet Rumsey, 2.70 feet higher than the recorded lake level of 11.32 feet Rumsey.

Operation of Cache Creek Dam and the Cache Creek Outlet Channel during flood periods are regulated by two court decrees:

The Gopcevic Decree (Milos M. Gopcevic, the Hotaling Estate Co., a corporation, and George T. Ruddick vs. Yolo Water And Power Company¹⁴, a corporation, in the Superior Court of the State of California in and for the County of Mendocino, October 7, 1920) established that Clear Lake was to be operated between 0 and 7.56 feet Rumsey. The Gopcevic Decree perpetually forbids raising the lake level above 7.56 feet on the Rumsey Gage, except during storms and floods, for longer than 10 days, and in no event over 9 feet on the gage. It is not physically possible to operate within these limits because outflow is impaired by the Grigsby Riffle, a natural restriction for the outlet channel. The Gopcevic Decree also required the

¹⁴ The Yolo Water and Power Company was purchased by the Clear Lake Water Company, which was subsequently purchased by Yolo County Flood Control and Water Conservation District.

development of an operation schedule for the Cache Creek Dam on Cache Creek. Yolo County Flood Control and Water Conservation District (YCFCWCD) must operate the Cache Creek Dam in accordance with the schedule. The operation schedule identifies lake levels for different times during the winter to which Clear Lake is allowed to fill. Selected dates and corresponding lake levels are:

Prior to January 8	5.50 Rumsey
January 16	5.96 Rumsey
January 19	6.08 Rumsey
January 24	6.27 Rumsey
February 14	7.10 Rumsey
March 15	7.56 Rumsey

When the actual lake level is below the level indicated in the schedule, no water is allowed to be released at the dam. Should the actual lake level rise above the level indicated in the schedule, the gates in the dam must be opened to lower the lake level. As the actual lake level approaches the level indicated in the schedule for that date, conditions are taken into account so that the dam operation will minimize flooding, while allowing the lake to fill to 7.56 Rumsey. There are two exceptions. When the lake is filling rapidly, water may be released from the dam when the actual lake level is within one-half foot below the level indicated in the schedule. When the lake is falling and no rain is anticipated, the dam may be closed when the actual lake level is within one-half foot above the level indicated in the schedule. Yolo operates the Cache Creek Dam and Clear Lake in accordance with the Gopcevic Decree to the extent possible, given the physical limitations.

The Bemmerly Decree (Mary E. Bemmerly and Agnes H. Bemmerly vs. The County of Lake *et al.* (including the Clear Lake Water Company), In the Superior Court of the State of California in and for the County of Yolo, December 18, 1940) forever enjoins and restrains the plaintiffs from in any manner widening, deepening, or enlarging the Cache Creek Outlet Channel so as to increase the flow of waters from Clear Lake into Cache Creek. This was in response to the dredging operation in 1939 and was intended to prevent additional flood damage to downstream property owners as a result of increased outflows from Clear Lake. In essence, the effect of the Bemmerly Decree is to prolong flood stages and prevent their rapid reduction. Flood conditions along the lakeshore may continue for as long as 90 days.

Flooding occurs around essentially the entire perimeter of Clear Lake and affects over 2,500 structures (Plate 14). Flooding can last weeks, or even months, depending on the overall weather pattern. Because of the extended period structures are subject to inundation, damage can be significant, even when depths are shallow.



Figure 7-2 Flooding along the Clear Lake shoreline in Lakeport, 1983.

Buildings erected after the county entered the National Flood Insurance Program (NFIP) in 1978, are built to Federal Emergency Management Assistance (FEMA) flood resistant standards; however, there are many older homes that are subject to repeated flooding. Ninety two homes in the Clear Lake floodplain in unincorporated portions of the county have been identified as “repetitive loss” structures (structures having two or more NFIP claims paid within a 10-year period). In the Cities of Lakeport and Clearlake 21 and 5, repetitive loss structures, respectively, have been identified in the Clear Lake floodplain. The number of flood prone homes is much greater, as this list only includes homes that had NFIP coverage at the time of the flood and have had two or more NFIP claims.

In addition to structural damage, flooding of access roads makes properties unsafe to live in and inaccessible to emergency services. Flood waters also flow into the sanitary sewer systems that serve most of the lake front areas. The resulting infiltration/inflow overloads wastewater pumping stations and wastewater treatment facilities, potentially resulting in overflows of raw and treated wastewater into developed areas and Clear Lake. In the unsewered areas, similar contamination from septic systems occurs.

Agricultural lands, primarily at the north end of Big Valley, are subject to flooding for weeks. This reduces productivity for the following season for most crops. Perennial crops, such as grapes, pears, and walnuts, can be severely impacted if inundation continues into the growing season.

The Upper Lake Reclamation Area, 1,650 acres of reclaimed land at the north end of Clear Lake, is also at risk of severe flooding, since the levees provide less than

a 4-year level of flood protection. Most of the reclaimed lands are agricultural, with wild rice, pasture, wine grapes, walnuts, and pears. Eighteen flood prone homes are located in the Reclamation Area. Also at risk of flooding are State Highway 20, the Nice-Lucerne Cutoff, and the PGandE transmission lines as they cross through the reclaimed lands. Repair and upgrade of the levees does not meet state or federal benefit-cost criteria for flood damage reduction.

7.3 WATERSHED FLOODING

Floodplain management activities in the watershed have affected Clear Lake. Activities such as channelization and levee construction have disconnected the streams from the floodplain, resulting in stream downcutting, increased sediment delivery to Clear Lake, loss of riparian and wetland habitat, and reduced groundwater recharge/storage. These impacts are discussed in more detail in the Land Use Chapter (Section 3.4.3) and contribute to the impairment of the Clear Lake ecosystem.

Channelization of tributaries and construction of levees has increased the rate of delivery of flood waters and reduced the amount of storage of floodwaters within the watershed. Both of these activities normally increase the magnitude of downstream flooding; however, due to Clear Lake's large surface area, the limited outlet channel capacity, and long duration of flooding, these activities probably have negligible impact on the magnitude of Clear Lake flood events.

7.4 MANAGEMENT

Lake County and the City of Lakeport have been participating communities in the National Flood Insurance Program (NFIP) since 1978. The City of Clearlake has been a participating community since its incorporation in 1986. (Lake County managed the program to 1986). In participating communities, property owners are eligible to purchase flood insurance for their properties. In addition, the communities must adopt and enforce building regulations that require new development and redevelopment to comply with minimum standards designed to minimize flood damage. Regulations include elevation of building floors above the 100-year base flood elevation, use of flood resistant materials, floodproofing of utilities, and restriction of development in floodways, and proper design and construction of developments. Revision of the Lake County Floodplain Management Plan will be completed in 2010.

Since 1995, Lake County has been participating in the Community Rating System (CRS) which awards points to communities for implementing floodplain development requirements which exceed the minimum NFIP requirements. Because of the county's participation in this program, persons purchasing flood insurance in unincorporated Lake County receive a ten percent discount on their flood insurance.

Lake County has actively pursued resolution to Clear Lake flooding for over 100 years. The original dam on Cache Creek was "removed" by vigilantes in response

to flooding in 1872. A replacement dam was not constructed until 1914. Shortly after its construction, a lawsuit was filed to prevent the dam operation from adversely impacting Clear Lake flood levels. A Judgment was issued (Gopcevic Decree, 1920) that attempted to balance the needs of water supply, recreation, and flood control. In 1938, Cache Creek was dredged to increase flow capacity and reduce flooding; however, a new lawsuit was filed, with judgment prohibiting further increases in flow capacity of Cache Creek (Bemmerly Decree, 1940). Beginning in the late 1940s, the county began working with the United States Army Corps of Engineers (USACE) to resolve the frequent flooding of Clear Lake and the resultant property damage. Numerous studies analyzing different flood damage reduction measures were completed. One alternative, enlargement of Cache Creek nearly tripling its flow capacity by lowering the Grigsby Riffle to -8 feet Rumsey, was proposed and designs begun; however, during the detailed design phase, it was determined the project did not meet USACE benefit-cost criteria. There were numerous objections to the impacts on riparian property owners on Cache Creek in both Lake and Yolo Counties. This channel enlargement would also require modification of the Bemmerly Decree. A subsequent Feasibility Study in 1992 reevaluated all alternatives and found that the non-structural flood control option was the only alternative that met Federal benefit-cost criteria. Non-structural alternatives included elevating homes, building floodwalls, and relocating structures. Because of the high cost and opposition to the recommended plan by the lake front property owners, the county dropped the project. Significant flood losses occurred due to lake flooding in 1995 and 1998, indicating that the original studies may have underestimated potential flood damages. New alternatives for flood damage reduction have also been proposed. At the request of the Clear Lake Rimlanders Coalition, the county forwarded a request to the California Department of Water Resources (DWR) in June 2000 to reevaluate the feasibility of flood damage reduction for Clear Lake. DWR forwarded the request to the USACE in July 2000. No additional studies by the USACE were conducted.

In 1995, USACE participation was requested to evaluate the Upper Lake Reclamation Area as an ecosystem restoration project. Ecosystem restoration plans evaluate ecosystem benefits in addition to flood damage reduction benefits when proposing a project. This area was reclaimed from Clear Lake by the construction of levees between 1900 and 1966. The levees are substandard and present a risk to the property owners “protected” by the levees from Clear Lake flooding. It is not financially feasible to repair or reconstruct levees in this area to provide a 100-year level of protection. In 1995, the USACE started investigating the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project (Middle Creek Project), and determined in 1997 that there is federal interest in pursuing the project. The project consists of acquiring the flood prone property, mitigating infrastructure flooding (roads and power lines), breaching the levees, and restoring the “reclaimed land” to a condition similar to that which existed prior to levee construction. In addition to reducing flood risk, habitat restoration and water quality benefits will be realized by the project (Section 2.8.2).

Floodplain management in the watershed is covered by the Lake County Floodplain Management Plan and is discussed in the Land Use Chapter (Section 3.4.3).

7.5 FLOODPLAIN MANAGEMENT ACTIONS

7.5.1 Overall Strategy

Floodplain management in the Clear Lake Watershed is important to minimize the adverse impacts to the watershed, quality of life, and health and safety of the community.

The Lake County General Plan outlines the goals for Clear Lake floodplain management: “To minimize the possibility of the loss of life, injury, or damage to property as a result of flood hazards.” (LCCDD 2008). Policies to protect and maintain the 100-year floodplain zones through strict limitation on land use are recommended. To carry out this policy, the following guidelines on development should be observed:

- Critical facilities (those facilities which should be open and accessible during emergencies) should not be permitted.
- Passive recreational activities (those requiring non-intensive development, such as hiking, horseback riding, picnicking) are permissible.
- New development and divisions of land, especially residential subdivisions, shall be developed to minimize flood risk to structures, risk to infrastructure, and ensure safe access during flood conditions.
- The county shall impose stringent controls on approvals of septic systems where there is a substantial likelihood of infiltration of floodwater into the systems, and/or the discharge from the systems into floodwaters.
- Flood control measures should be considered as part of an overall community development plan, and should advance the goals of recreation, resource conservation, preservation of natural riparian habitat, and scenic values of the county's streams, creeks, and lakes.

7.5.2 Pursue the Cache Creek Flow Enhancement Project

Background: The major cause of Clear Lake flooding is the flow limitation imposed by the Grigsby Riffle and the Cache Creek Outlet Channel. Increased channel flow capacity would allow earlier season storage, increased flows during flood events (provided it does not adversely affect downstream flooding), and reduced flood heights and duration of flooding on Clear Lake.

Project Description: Modification of the outlet channel by removing some of the gravel bar deposited on top of the rock outcropping would allow for improved management of lake levels, reduced flooding, and improved water storage in Clear Lake. Significantly less material is proposed for removal than proposed by

the USACE in the 1980s, and none of the rock outcropping is proposed for removal. This would allow for increased flows when Cache Creek is below flood stage in Yolo County, reducing the increase in Clear Lake level and allowing it to drop more rapidly to reduce the impacts of flooding on residential and business properties and the supporting infrastructure. With the additional flow capacity, increasing the amount of storage in Clear Lake should be considered. Modification of the Bemmerly Decree and development of a new set of operating criteria would be necessary to implement the project.

Key Participants: Lake County Watershed Protection District (LCWPD), YCFCWCD, County of Lake, City of Lakeport, City of Clearlake, and Yolo County.

Timeframe: 0-10 years.

Technical Resources Required: Staff of participating agencies and consultants.

Cost Estimate: To be determined.

Milestones: Feasibility study, Environmental Impact Report, modification of Bemmerly decree, project design, and project construction.

Effectiveness Criteria: To be determined based on project design.

7.5.3 Promote Compatible Use of the Floodplains

Background: A majority of the floodplains in the watershed are maintained as agriculture or open space. There is increased development pressure for the development of urban and suburban land uses in these areas.

Project Description: Through implementation of Lake County General Plan policies, urban and suburban development should not be allowed in areas that are at risk of flooding. Policies from the Health and Safety, Open Space and Agricultural Resources sections of the General Plan specifically address these issues.

Key Participants: LCCDD and LCWPD.

Timeframe: On-going.

Technical Resources Required: Staff of participating departments.

Cost Estimate: To be determined.

Milestones: Prevention of urban and suburban development in floodplains.

Effectiveness Criteria: Completion of milestones.

7.5.4 Reduce Flood Damage in Developed Areas

Background: Structures constructed in the floodplain are subject to flood damage, and many are subject to repetitive flooding. A majority of these structures were constructed prior to the county's entry into the NFIP in 1978, when flood resistant building standards were implemented. Structures are required to be brought up to current flood resistant construction standards if they are substantially improved (that is, if improvement/remodel increases the market

value of the structure by 50 percent or more) or if the structure is substantially damaged (damage is 50 percent or more of structure's market value). As floods are often viewed as infrequent events, owners are reluctant to expend the significant funds to retrofit a home to flood resistant building standards.

Project Description: Floodprone structures should be retrofitted, replaced, relocated outside of the floodplain, or demolished to reduce flood damages. Grant funds are available to assist homeowners and government agencies to retrofit, replace, relocate, or demolish floodprone structures, especially structures that have been repetitively flooded. In order to reduce flood losses and associated issues, Lake County should pursue grant funding to assist property owners in retrofitting, replacing, relocating, and/or demolishing floodprone structures.

Key Participants: LCCDD and LCWPD.

Timeframe: On-going.

Technical Resources Required: Staff of participating departments and consultants.

Cost Estimate: To be determined.

Milestones: Structures in floodplain retrofitted, replaced, relocated or demolished.

Effectiveness Criteria: Reduced number of buildings susceptible to flood damage.

7.5.5 Other Actions

- 2.8.2 Complete the Middle Creek Flood Damage Reduction and Ecosystems Restoration Project
- 2.8.7 Support and Increase Watershed Education and Outreach
- 2.8.9 Complete the Integrated Regional Water Management Plan
- 2.8.13 Update Cost Benefit Analysis of the Lakeport Dam
- 3.10.2 Review and Revise County Wetland Policies and Ordinances
- 3.10.4 Restore Stream Channel Hydrology and Associated Habitats
- 5.4.7 Protect Open Space



Clear Lake Integrated Watershed Management Plan

Chapter 8

LAKE MANAGEMENT

8.1 INTRODUCTION

This chapter summarizes management activities of Clear Lake. Many of these activities have been discussed in detail in previous chapters, and they are briefly reviewed here. In addition, several aspects of lake management that have not been covered in previous chapters are described in detail in this chapter. Table 8-1 indicates the chapters where different aspects of lake management are covered in detail.

Table 8-1 Chapters where different aspects of lake management are covered.

Lake Management Emphasis	Chapter(s) Where Covered
Water quality	Chapter 2, Water Resources; Chapter 3, Land Use
Water supply	Chapter 2, Water Resources
Fisheries	Chapter 4, Wildlife and Habitat Resources
Wildlife habitat	Chapter 4, Wildlife and Habitat Resources
Recreation and Aesthetics	Chapter 5, Recreation and Aesthetics
Invasive species	Chapter 6, Invasive Species
Floodplains and flood control	Chapter 7, Floodplain management
Lakebed Management	Chapter 8, Lake management
Aquatic plants	Chapter 8, Lake management
Vector control	Chapter 8, Lake management

8.2 WATER QUALITY

In the past, Clear Lake experienced frequent nuisance blue-green algal blooms. Research into the causes of these algal blooms determined that nutrients, largely contributed by increased sediment loads, were the cause of the algal blooms. These findings led to the listing of Clear Lake on the federal Clean Water Act 303d list as impaired due to nutrients, and the establishment of a Total Maximum Daily Load (TMDL) for the control of nutrients in Clear Lake in 2006 ([Section 2.2.1](#)). Since the early 1990s, Clear Lake water clarity has improved significantly and nuisance algal blooms are less frequent. One exception was during the summer of 2009, when a widespread and long-lasting algal bloom occurred. Management practices that have reduced stream channel and surface erosion are discussed in [Section 3.8](#).

High levels of mercury occur in Clear Lake, and the majority of this mercury contamination is attributed to the Sulphur Bank Mercury Mine, operated as an open pit mercury mine on the shores of Clear Lake. Excessive levels of mercury in Clear Lake have caused bioaccumulation and biomagnification in the food chain to levels that are potentially harmful to wildlife and humans consuming fish from Clear Lake. The fish mercury levels led to a 1987 Clear Lake fish consumption advisory by the California Department of Health Services (now the California Department of Public Health) and 1988 listing of Clear Lake as an impaired water body on the federal Clean Water Act 303d list. The TMDL for Control of Mercury in Clear Lake was approved in December 2002 (CVRWQCB 2002a). A description of Clear Lake mercury contamination and management is given in [Section 2.2.3](#).

Other potential Clear Lake water contaminants such as pesticides, stormwater runoff, and wastewater over-flows are discussed in the Land Use Impacts Chapter ([Section 3.4.4](#), [Section 3.6](#)).

8.3 WATER SUPPLY

Most of the water stored in Clear Lake is managed by the Yolo County Flood Control and Water Conservation District (YCFCWCD). Discussions of YCFCWCD water rights and regulation of Clear Lake's level at the Cache Creek Dam are found in [Section 2.3](#) and [Section 7.2](#).

8.4 FISHERIES

Clear Lake is a popular sport fishing destination, especially for largemouth bass, and it supports commercial fisheries for Sacramento blackfish, carp, and goldfish. Clear Lake's abundant fish populations are the food source for aquatic waterfowl and wildlife around the lake.

The California Department of Fish and Game (DFG) manages Clear Lake fisheries, and their most recent (2000) Clear Lake Fishery Management Plan had the objectives "to maintain and enhance 1) fishery resources and the habitats upon which they depend, and 2) provide and where possible, improve fishing opportunities." The DFG issues permits for bass fishing tournaments and commercial fishing on Clear Lake and enforces compliance with these permits. DFG regulates sport fishing through the issuance of licenses and enforcement of fishing regulations (CDFG 2008b). DFG fisheries biologists monitor fish populations and carry out creel surveys to determine sport fishing success. Fisheries management is covered in [Section 4.2](#) and fishing for recreation is covered in [Section 5.2.2](#).

8.5 WILDLIFE HABITAT

Clear Lake supports a wide variety of seasonal and resident water fowl, and it is a stop-over for migrating water fowl ([Section 4.2](#)). Raptors, such as osprey, rely on its fish, and the lake supports reptiles, such as the western pond turtle, and mammals including muskrats, wood rats, and raccoons. Several parks around the lake provide wildlife habitat and recreational opportunities, and wetlands are a vital resource for both fish and wildlife.

The United States Fish and Wildlife Service (USFWS) administers the Endangered Species Act to protect species and the ecosystems on which they depend, and they have a Division of Migratory Bird Management to conserve migratory birds and their habitats. DFG is the lead agency for fisheries and wildlife management in the state. Their role includes sensitive species and habitat protection, enforcement of hunting regulations, and invasive species prevention and control ([Section 4.2](#)).

8.6 RECREATION AND AESTHETICS

Swimming, fishing, boating and nature viewing are some of the popular recreational activities on Clear Lake. There are 17 public access points around Clear Lake providing some level of amenities such as boat ramps, swim areas, public restrooms, and parking, and there are an additional 46 public access points without amenities. The State of California manages the two largest parks on the shores of Clear Lake, Clear Lake State Park near Kelseyville, and Anderson Marsh State Historic Park near Lower Lake. The cities of Lakeport and Clearlake both have lakeside parks, and Lake County manages ten parks around the lake. Despite these resources, public access and amenities are insufficient on Clear Lake. Recreational opportunities on and surrounding Clear Lake are detailed in [Chapter 5](#).

8.7 INVASIVE SPECIES

The USFWS regulates importation and transport of species to prevent introduction of invasive species. DFG focuses on preventing introduction and spread of invasive aquatic animal species such as the zebra and quagga mussels ([Section 6.4](#)).

The California Department of Food and Agriculture (CDFA) is charged with preventing importation of pests and diseases and controlling pests within the state. As part of this mandate, CDFA heads efforts to control or eradicate invasive

plants in the state. Since the discovery of the invasive weed hydrilla in 1994 in Clear Lake, CDFA has had a program to eradicate it from the lake. Hydrilla is a CDFA A-rated weed, targeted for eradication, because of its ability to fill the water column, preventing boating, and clogging water intakes. During their monitoring for hydrilla, the CDFA hydrilla eradication crews also monitor for other invasive aquatic plants.

Lake County has developed an ordinance and program to prevent introduction of quagga and zebra mussels to Clear Lake. This program, initiated in March 2008, requires inspection of all vessels before they can enter Clear Lake.

The Lake County Weed Management Area, LCWMA, a group that coordinates weed control efforts in the county, has received funding to monitor for, and eradicate selected areas of water primrose on Clear Lake and another invasive plant, arundo, or giant reed, around the county. The Lake County Board of Supervisors approved the Integrated Aquatic Plant Management Plan (IAPMP) in 2005 to promote the continued multiple uses of Clear Lake using environmentally sound management techniques. The plan also includes a component seeking to minimize potential introduction of non-native species to Clear Lake. In 2006, an ordinance preventing the possession or sale of nine specific non-native, invasive aquatic plant species was passed. The Lake County Agriculture Department (LCAD) is charged with inspecting retail outlets for these aquatic plants.

8.8 FLOODPLAIN

Clear Lake is subject to flooding because its natural outlet, Cache Creek, is too small to allow floodwater to leave the lake as fast as it enters. This causes Clear Lake to rise rapidly during heavy, prolonged rainstorms and prolongs flood levels after the rains have stopped. When not overwhelmed by flood conditions, Clear Lake's level is controlled by the Cache Creek Dam, operated by the YCFCWCD, which is downstream of the natural constriction in Cache Creek called the Grigsby Riffle. The Gopcevic Decree defines operation levels of the Cache Creek Dam, and the Bemmerly Decree prevents enlarging the Cache Creek outlet from Clear Lake ([Section 7.2](#)).

Lake County and the Cities of Lakeport and Clearlake participate in the National Flood Insurance Program. Participating communities must adopt and enforce building regulations that require new development and redevelopment to comply with minimum standards designed to minimize flood damage, and in turn, property owners in these communities are eligible to purchase flood insurance for their properties.

8.9 LAKEBED

The Lakebed Management function (LCLM) of the Lake County Water Resources Division has a variety of responsibilities for managing Clear Lake, which include:

- Maintaining the public trust by issuing permits and leases for all construction below the high water mark (7.79 feet Rumsey).
- Maintaining public navigation aides.
- Maintaining swim areas and markers at county parks.
- Performing water quality monitoring.
- Providing support to agencies involved in Clear Lake management including the Lake County Sheriff's Department Marine Patrol, DFG, United States Army Corps of Engineers (USACE), the California Department of Water Resources (DWR), and State Lands Commission
- Performing lake enhancement programs such as algae management

A large part of LCLM responsibilities is managing the public trust in Clear Lake below the high water mark for the State of California. The state is responsible for managing the public trust to ensure that the lands will be used for general statewide interests in furtherance of commerce, navigation, fishing, recreation, and preservation of the land and waters in their natural state. Landowners have title to lands between the high and low water marks; however, this title is impressed with the public trust, and must be used in a way compatible with the public interest (*State of California v. Superior Court (Lyon)* 1981). The State of California owns the land below the low water mark (Zero feet Rumsey). The state conveyed management of the public trust to the County of Lake in Chapter 639 of the State Statutes of 1973. Chapter 23 of Lake County Code, the Lake County Shoreline Ordinance, was adopted in 1978 and amended in 1999 to fulfill the responsibilities described in Chapter 639 State Statutes of 1973 and to manage the public trust. This is to be carried out “by establishing minimum standards for the construction, alteration, removal, and maintenance of structures or other prescribed activities in the nearshore and foreshore of the lake¹⁵” (Section 23-1 Lake County Code).

The Shoreline Ordinance defines standards for the design, location and number of any structures to be built in the lake's nearshore and foreshore. It describes a permit process for structures, activities and uses of the lake. Structures requiring administrative encroachment permits include piers, docks, floats, boat ramps and launching facilities, buoys, jetties, breakwaters, marinas, harbors and shorezone protective structures. Permits are required to repair damage to existing structures when the repairs exceed 50% of the total current replacement cost of the existing structure. Non-compliant structures must be brought into compliance when

¹⁵ Foreshore is the area between the low and high water marks of the lake (0 and 7.79' Rumsey), and nearshore is lakeward of the low water mark.

repairs exceed 50% of replacement cost of the structure. Additions to existing structures also require permits.

Activities that require administrative encroachment permits include filling, dredging, and beach clearing. In practice, filling no longer occurs in the lake because the USACE no longer permits it (Ralph Simkins, personal communication). Beach clearing is not allowed on residential properties, and on commercial, resort, or public properties, is only allowed when planting is carried out elsewhere in the lake to achieve no-net-loss of shoreline vegetation. Administrative encroachment permits are also required for “any use, operation or activity with a significant impact on the public trust purposes,” for example, special events such as boat or Jet Ski races and water-ski competitions.

To apply for an administrative encroachment permit, payment of a fee to LCLM and an information report are required. The report must contain a description of the proposed project, wetlands in the area, project design, and pictures of the site. LCLM approves or rejects the permit application. Following approval, an additional fee is required for review by the Building Department in the Lake County Community Development Department (LCCDD). LCCDD reviews the application and determines the need for additional environmental studies and California Environmental Quality Act (CEQA) review. If the proposed project encroaches on public lands below the low water mark, the permittee must enter into an encroachment lease for these public lands. The fees for these leases are based on the area covered, and the lease term is for a period of 66 years or less.

To ensure compliance with its provisions, the Shoreline Ordinance outlines enforcement procedures. It also contains nuisance abatement provisions that require maintenance of nearshore and foreshore structures that have not been maintained or operated in a safe condition. The condition of structures in the nearshore and foreshore around the lake are inventoried once a year by LCLM personnel.

LCLM summarizes the program for managing the public trust in Clear Lake and its shoreline in an annual report to the State Lands Commission. On large projects, LCLM contacts the State Lands Commission for project approval.

The Shoreline Ordinance regulates the placement of navigation structures. LCLM maintains the 11 county-owned navigation lights. Boating regulations are enforced by the Lake County Sheriff’s Department Marine Patrol, which has boats on the lake year round.

Because they operate and maintain county-owned boats, LCLM has a variety of support responsibilities for different agencies. They are responsible for maintenance of swim buoys and swim areas at public parks. LCLM reports fish and wildlife related incidents to DFG and supports them with a boat when needed. LCLM boats are also provided to DWR for water quality sampling that is carried out ten times each year. In the past, during severe nuisance algal blooms, LCLM operated boats to break up and help sink the algal mats.

8.10 AQUATIC PLANTS

Following the increase in Clear Lake water clarity that began in the 1990s, aquatic plant growth increased, creating congested conditions along the shoreline that restrict swimming, boating and other recreational activities. Therefore, LCLM algae control activities have shifted to aquatic plant management. A study of Clear Lake submerged aquatic vegetation was carried out in 2002 as a baseline for future comparisons (ReMetrix, 2003). The 2002 study showed that submerged aquatic vegetation is present along much of the shoreline, with the exception of locations where the lake bottom is very rocky or deep (Plate 15).

The increased aquatic plant growth in Clear Lake created the need for a comprehensive approach to aquatic plant, or aquatic weed management. Responding to public demand, the Board of Supervisors initiated the development of the Integrated Aquatic Plant Management Plan (IAPMP) for Clear Lake in 2000, and the CEQA-approved IAPMP was approved by the Lake County Board of Supervisors in 2005 (Jones and Stokes 2005, LCWRD 2004). The IAPMP provides a single-point permitting process for vegetation management, and its additional objectives include:

- Supporting the continued multiple uses of Clear Lake so that reasonable and easy lake access is available to residents, recreational visitors, and traditional users of the lake.
- Identifying a range of environmentally sound and cost effective management techniques for lakefront property owners who wish to control nuisance vegetation adjacent to their property.
- Avoiding adverse impacts on human health, non-target plants, animals, and property, to the extent possible.
- Minimizing the potential for introduction of non-native plant and animal species.
- Ensuring compliance with the National Pollutant Discharge Elimination System (NPDES) permit and TMDL requirements.

The use of herbicides allowed in the IAPMP required coverage under the general aquatic herbicide NPDES permit issued by the Central Valley Regional Water Quality Control Board (CVRWQCB). Because Lake County oversees the permitting process for aquatic plant control in Clear Lake, it applied for an NPDES permit in 2002. In 2006, the United States Environmental Protection Agency (USEPA) ruled that pesticides applied directly to water to control pests present in the water, did not require NPDES permitting if the application was in compliance with Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requirements (71 Fed. Reg. 68483, Nov. 27, 2006). Despite this ruling, Lake County continues to meet the NPDES permit monitoring and reporting requirements, in order to assure that there are no negative environmental impacts from the herbicide applications.

In 2006, the Lake County Board of Supervisors adopted the Clear Lake Integrated Aquatic Plant Management Program Ordinance which defines the county's single-point permitting process for aquatic weed control (Chapter 26 Lake County Code). It requires that landowners pay for a permit and hire only licensed and registered qualified applicators to apply herbicides. These applicators must apply herbicides according to USEPA and FIFRA label instructions, and they must monitor water conditions and apply herbicides only under appropriate conditions. In addition lakefront property owners can apply herbicides to no more than 30% of the area in front of their property, and no more than 10% of the lake area with high potential for aquatic plant growth can be treated in a given year. The county tracks areas treated for aquatic plant growth. As part of the monitoring plan under the NPDES permit LCLM monitors aquatic herbicide levels before, during, and one week after application at approximately 10% of the herbicide application sites.

Lakefront landowners can also apply for a permit to mechanically harvest aquatic plants. This harvesting is prohibited by CDFA within 0.25 miles of any area where hydrilla has been found in the past six years. Mechanical harvesting must include a method to collect plant fragments and dispose of them on land above the high water mark.

To reduce the threat of invasive aquatic plants being introduced for aquariums or as landscape plants, in 2006, Lake County adopted an ordinance prohibiting the sale or introduction of non-native, invasive aquatic plants (Chapter 26A Lake County Code).

Unlike aquatic plants, wetland or shoreline vegetation on Clear Lake is protected from clearing by county ordinance (Section 23-15, Chapter 23 Lake County Code).

8.11 VECTOR CONTROL

The Lake County Vector Control District (LCVCD), formerly the Lake County Mosquito Abatement District) has a long history of monitoring and controlling nuisance, biting, and disease vectoring insects. It was organized in 1948 for the purpose of controlling both mosquitoes and the Clear Lake gnat, *Chaoborus astictopus* (Prine *et al.* 1975). Early use of DDD to control the Clear Lake gnat led to biomagnification and damage to grebe populations on Clear Lake. After additional treatments using methyl parathion, introduction of the Mississippi silversides to Clear Lake in 1967 appears to have been successful in controlling the gnat (Anderson *et al.* 1986). Along with the Clear Lake gnat, numerous chironomid midges are found in Clear Lake. These midges can be nuisances due to allergic reactions following exposure to the midges and due to egg masses deposited on buildings, boats, and vehicles (Colwell *et al.* 1998). In order to better understand the biology and control of the pest insects, LCVCD carries out a sampling program for a variety of organisms including planktonic algae, zooplankton, benthic organisms, and fish caught by beach seines and surface

trawls, as well as gut content analysis of some insects and fish (Colwell *et al.* 1998). Details of this sampling program are given in Appendix B.

LCVCD personnel monitor for mosquito larvae in water sources including Clear Lake and adjacent wetlands from spring through fall. They collect adults using a variety of traps. Currently, the material applied directly to water to treat mosquito larvae is a biological material containing the Bt toxin produced by bacteria. Adult mosquitoes are treated using ultra low volume sprayers to create a fog that covers larger areas such as the rice fields near Upper Lake or communities near the lake (Terry Sanderson, personal communication). LCVCD also monitors for West Nile Virus, which is vectored by mosquitoes.

8.12 LAKE MANAGEMENT ACTIONS

8.12.1 Overall Strategy

The Lake County General Plan recognizes that “Clear Lake is the County’s single most valuable natural resource, important for its habitat, aesthetic, and economic values” (LCCDD 2008). Lake County General Plan goals and policies to preserve and enhance Clear Lake water quality and supply ([Section 2.8.1](#)) and protect wildlife and fish habitats ([Section 4.6.1](#)), to increase recreational opportunities ([Section 5.4](#)), to prevent and control invasive species ([Section 6.5.1](#)), and to manage the lake’s floodplain ([Section 7.5.1](#)) have been discussed in previous chapters.

The Shoreline Ordinance was adopted to ensure that the state’s public trust in Clear Lake is managed “for general statewide interests in furtherance of commerce, navigation, fishery, recreation and, wherever possible and appropriate, preservation of the land and waters in their natural state” (Chapter 23 Lake County Code).

8.12.2 Update the Shoreline Ordinance (Chapter 23 Lake County Code)

Background: The Lake County Shoreline Ordinance was adopted in 1978 and amended in 1999. The Shoreline Ordinance was established to fulfill the county’s responsibilities to manage state public trust lands below the low water mark as well as the public trust in privately owned lands between the low and high water marks, and it establishes standards and enforcement guidelines for structures and activities in these areas ([Section 8.9](#)).

Project Description: The current ordinance needs to be reviewed to ensure that it is adequately fulfilling its purpose. Sections likely to require revisions include the section regarding beach clearing, which does not fully protect wetland and riparian vegetation, and sections defining permitted structures, which may require clarification.

Key Participants: LCLM, Clear Lake Advisory Subcommittee (CLAS), LCCDD, and State Lands Commission.

Timeframe: 0-2 years.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: Regular staff time.

Milestones: Ordinance review and revision, Board of Supervisors approval, and implementation.

Effectiveness Criteria: Continuing protection of the Public Trust in Clear Lake.

8.12.3 Fully Implement the Integrated Aquatic Plant Management Plan (IAPMP)

Background: The extensive aquatic plant growth now occurring in Clear Lake appears to be a sign of improved water quality, and is generally beneficial for fish and other aquatic life. At the same time it can interfere with activities such as boating and fishing. The IAPMP was approved in 2005 in order to protect the many beneficial uses of Clear Lake. When approved, it contained a list of 39 recommended strategic actions. Many of these actions have been completed, or are part of on-going programs. Completed or on-going actions include:

- Passage of an ordinance defining a single point permitting process for aquatic plant control.
- Passage of an ordinance that prohibits the sale or import of invasive aquatic plants into the county.
- Maintenance of an NPDES permit for aquatic vegetation control.
- Surveys of aquatic vegetation change carried out as part of hydrilla eradication crew activities.
- Public outreach and education.
- Weed control for public access areas.
- Programs for control of creeping water primrose and perimeter invasive plant species.

Project Description: Fully implementing the IAPMP through an adaptive management process is vital to maintaining the multiple uses of Clear Lake in an environmentally sensitive manner. Activities not yet completed include development of an Aquatic Invasive Species Management Plan for the lake ([Section 6.5.5](#)), technical advisory group meetings, documentation of lake usage types and locations, development of control strategies by specific lake area, protection of native tule habitat, and investigations of aquatic vegetation and fish population interactions.

Key Participants: LCLM, CDFA, DFG, LCISC, and CLAS.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: \$500,000.

Milestones: Hold semi-annual Technical Advisory Group meetings, complete study of lake usage types, develop of location-specific control strategies, and complete study of aquatic vegetation and fish interactions.

Effectiveness Criteria: Management of aquatic plants in Clear Lake that maintains the lake's multiple uses in an environmentally sensitive manner.

8.12.4 Other Actions

- 2.8.2 Complete the Middle Creek Flood Damage Reduction and Ecosystems Restoration Project
- 2.8.3 Improve Understanding of Clear Lake Limnology
- 2.8.4 Implement Site Remediation at Sulphur Bank Mercury Mine
- 2.8.6 Develop a Comprehensive Clear Lake Watershed Monitoring Program
- 2.8.7 Support and Increase Watershed Education and Outreach
- 2.8.8 Develop County Interdepartmental Coordination Strategy
- 2.8.9 Complete the Integrated Regional Water Management Plan
- 3.10.2 Review and Revise County Wetland Policies and Ordinances
- 4.6.2 Research and Develop a Management Plan for Native Clear Lake Fish
- 4.6.3 Protect and Restore Lake and Shoreline Habitats
- 5.5.2 Improve Lake Access and Public Amenities
- 5.5.3 Promote a Private Boat Tow Service on Clear Lake
- 6.5.2 Develop Boat Pumpout stations around Clear Lake
- 6.5.3 Adaptively Manage Invasive Mussel Prevention
- 6.5.5 Develop an Aquatic Invasive Species Management Plan
- 7.5.2 Pursue the Cache Creek Flow Enhancement Project



Clear Lake Integrated Watershed Management Plan

Chapter 9

CLIMATE CHANGE

“Climate change is already affecting California.” Along with rising sea levels, the state has seen “increased average temperatures, more extreme hot days, fewer cold nights, a lengthening of the growing season, shifts in the water cycle with less winter precipitation falling as snow, and both snowmelt and rainwater running off sooner in the year” (CNRA 2009) (Figure 9-1).

Information on climate change is available at the regional (e.g. Northern California) and statewide levels. Much of this information is the result of Executive Order S-3-05 issued by Governor Arnold Schwarzenegger in July 2005. This order establishes goals for greenhouse gas (GHG)¹⁶ reductions and requires reports on “the impacts to California of global warming, including impacts to water supply, public health, and agriculture, the coastline, and forestry.” The order also requires plans to mitigate and adapt to the impacts.

This chapter discusses statewide climate change information and predictions and attempts to “downscale” them to the Clear Lake Watershed. It ends with statewide adaption strategies to climate change that are applicable to the Clear Lake Watershed and describes how they are being met by local policies and proposed actions in this plan.

¹⁶ The term greenhouse gas refers to gases that absorb and emit infrared radiation (heat). These gases trap some of the heat from the earth’s surface that would otherwise radiate out to space.

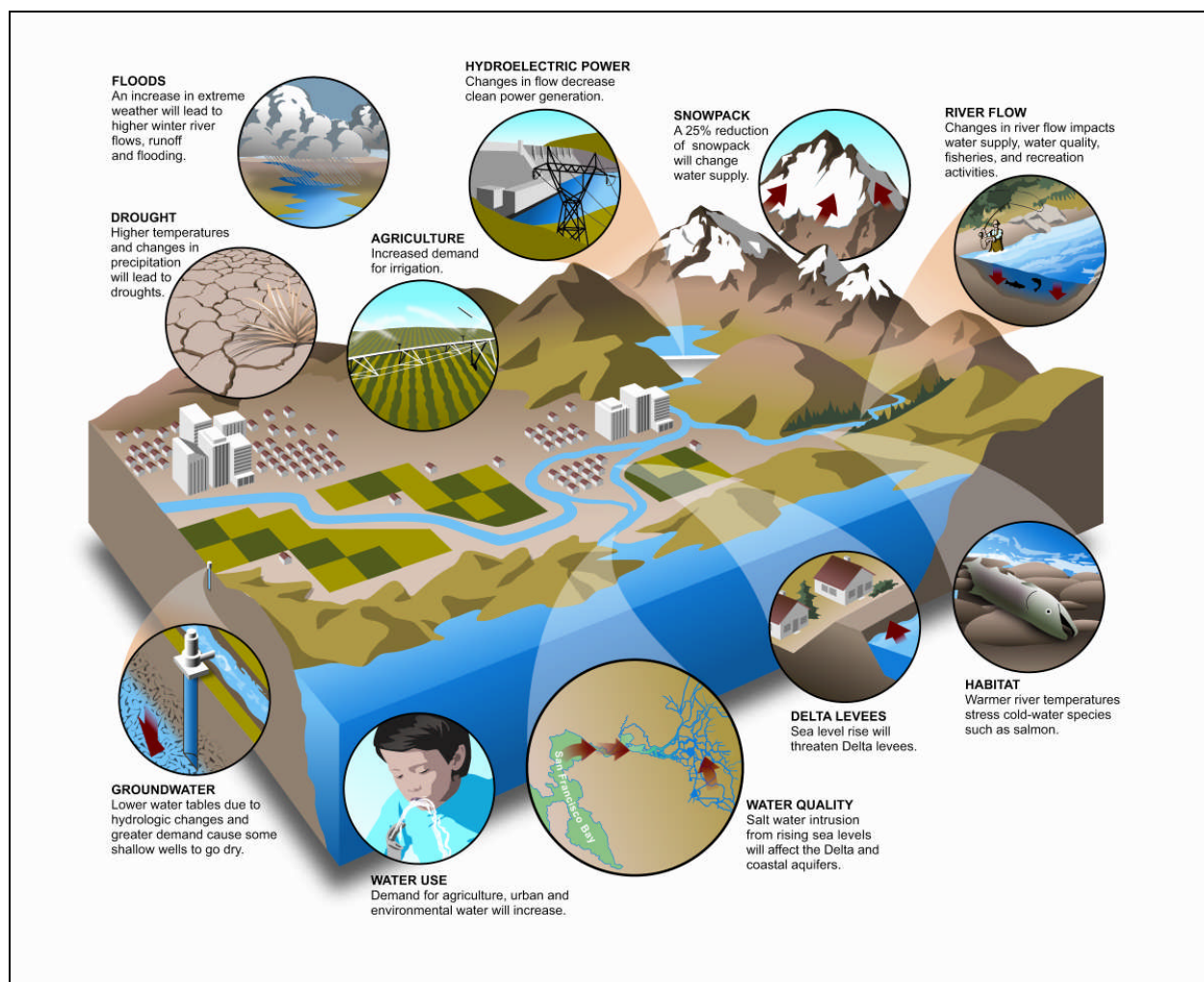


Figure 9-1 Statewide impacts of climate change on water resources. Impacts on hydroelectric power generation and snowpack runoff are not likely to be significant in the Clear Lake Watershed. Impacts on the Sacramento-San Joaquin River Delta are outside the Clear Lake Watershed. Source: DWR

9.1 CHANGES IN CLIMATE AND WATER RESOURCES

One way to predict future climate change as the result of GHG emissions is to look at past changes during a period when GHG emissions were rising. Changes in California's climate over the past century were described in a report titled "Progress on Incorporating Climate Change into Planning and Management of California's Water Resources" (State Progress Report) issued by the California Department of Water Resources (DWR) in 2006. The report describes the following trends during the past century;

- Statewide average temperatures have increased about 2°F.
- This increase has been greater in the southern part of the state (about 3°F) compared to the northern part of the state (about 1°F).

- Statewide, there is no change in total annual precipitation for the period from 1890-2000, although there is apparently a slight upward trend from 1970-2000.
- Precipitation appears to have increased slightly in the northern part of the state (latitude >39°) from 1890-2000.
- The variability in average annual precipitation has increased.
- The variability in annual peak flows (three day discharge) has increased.
- The size of annual peak flows (three day discharge) has increased.
- Average annual runoff has increased in the Sacramento River system and in North Coast rivers.
- Average annual runoff has decreased slightly in the San Joaquin River system.
- April-June runoff (the time period most influenced by melting of the snow pack) has decreased as a percentage of total runoff for the Sacramento and San Joaquin River systems.

Based on the statewide information, changes that are inferred to have occurred in the last century in the Clear Lake Watershed are summarized in Table 9-1 below and are discussed in the following paragraphs.

The increase in temperature at a regional and statewide area is not in dispute. Regionally, however, there are differences. For example, daily maximum temperatures have warmed less in the Central Valley compared to other regions of the state. This difference is probably due to an increase in the area of irrigated agriculture during the past century (CEC 2009). Areas in Lake County that have experienced a similar increase in irrigated agriculture may have shown a similar effect.

Almost all climate models agree that temperatures will continue to increase over the next century. However, depending on the scenarios used for population growth and technological advances, simulated temperature changes by 2100 vary widely. Temperature is important as a factor that forces change in other climate variables. Higher temperatures may also lead to increased human heat illness and death, and to effects on natural ecosystems.

Table 9-1 Changes in climate variables likely to have occurred in the Clear Lake watershed over the past century.

Climatic Variable	Trend
Temperature	Increase
Annual Precipitation	Slight increase
Variability in Annual Precipitation	Increase
Variability in Peak Flows	Increase
Size of Peak Flows (three day discharge)	Increase
Average Annual Runoff	Increase
April to June Runoff	No change

Statewide total annual precipitation did not change significantly over the past 100 years; however, the year to year variability in total precipitation increased statewide during the past century. Two long-term (approximately 80 year) records of precipitation in Lake County also show increasing variability in total annual precipitation. In both Lakeport and Cobb, there was a slight trend toward increasing annual precipitation from about 1920 to 2000 (Figure 9-2). The year to year variability in rainfall also increased significantly (Figure 9-3). Assuming that inter-annual variation continues in the future, water management in the Clear Lake Watershed could become more challenging. Both drought years, and years with heavy precipitation and the potential for stream and lake flooding would become more common.

The increase in variability and size of peak flows (three day discharge) found in the State Progress Report may not be as significant in the Clear Lake Watershed as for the rivers discussed in the State Progress Report. Northern California rivers included in the report were the Feather, American, and Eel Rivers, all of which have watersheds with a significant snowpack. Some of the increase in size and variability of peak flows on these rivers may be due to warm rains falling on snowpack, or from receding snowpack leaving a larger area from which direct runoff can occur.

If climate change does lead to higher peak flows in the Clear Lake Watershed, it will correspond to greater flood potential for Clear Lake tributaries. Clear Lake flooding generally occurs following prolonged, heavy rainfall occurring over a longer period than three days, so the three day discharge is only a partial contribution to lake flooding.

It is likely that the change in April-June runoff during the past century was minimal in the Clear Lake Watershed (Table 9-1) because there is relatively little contribution of snowpack to runoff in the watershed.

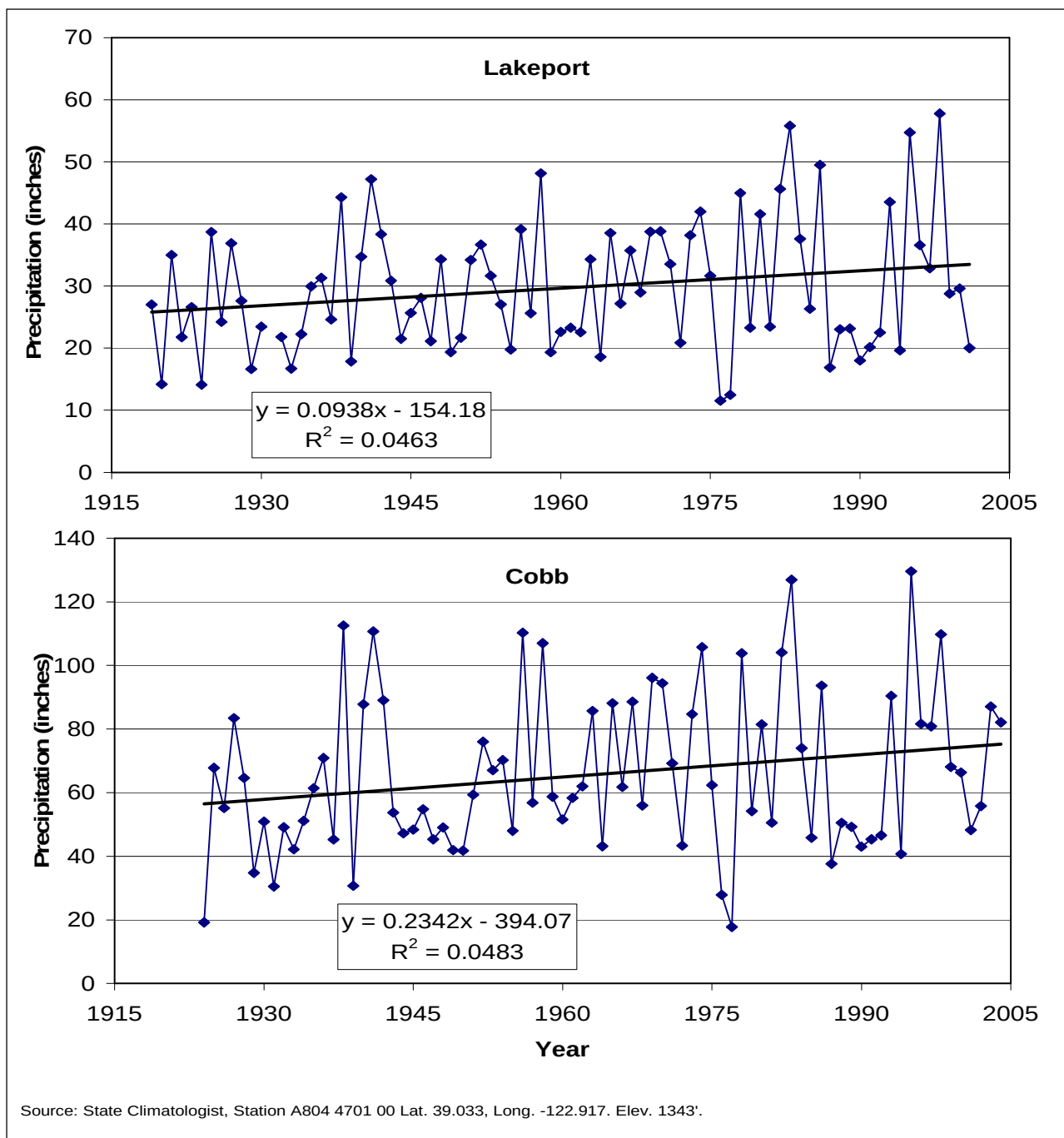


Figure 9-2 Total annual precipitation at Lakeport and Cobb, California.

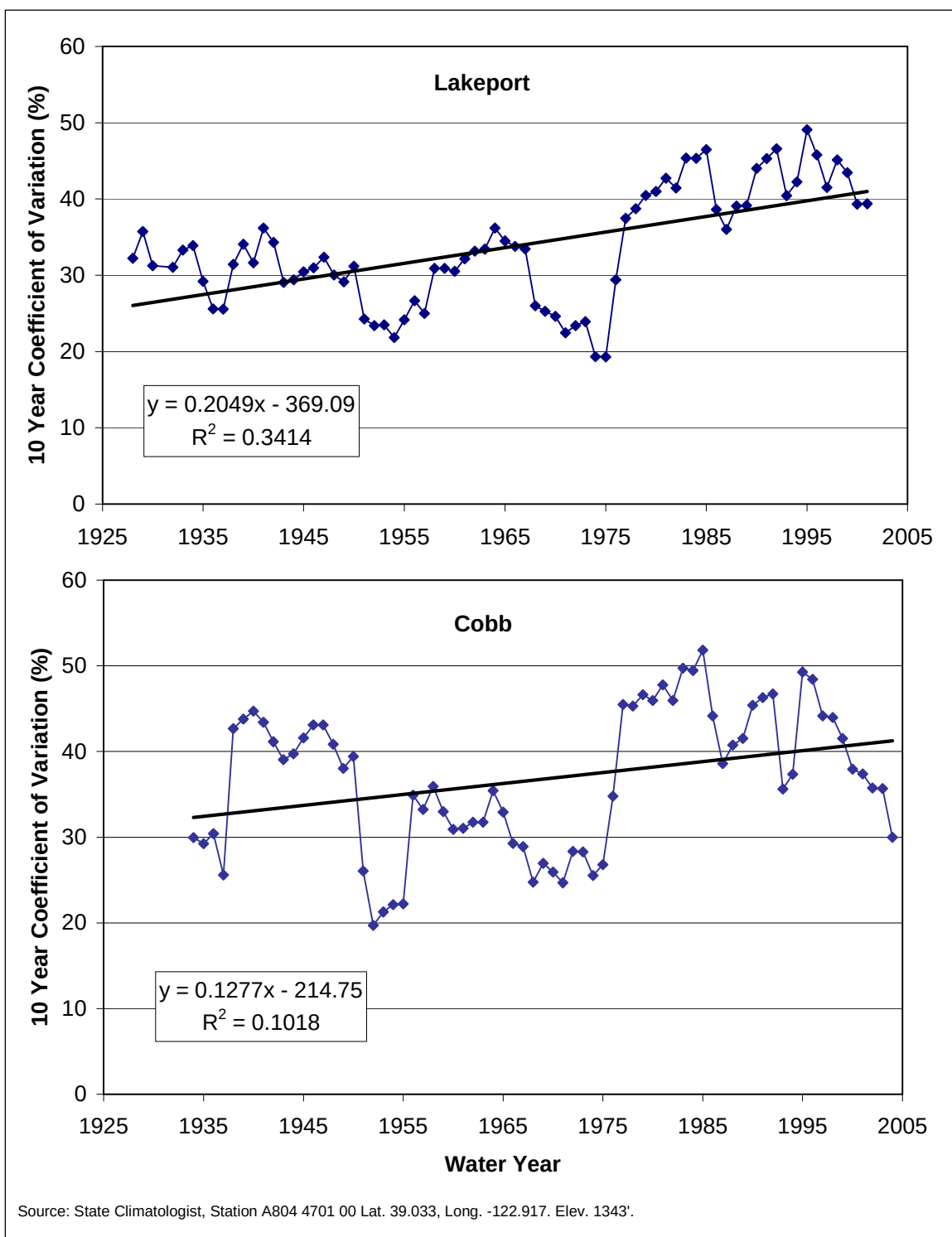


Figure 9-3 Coefficient of variation based on the 10 year running average of precipitation for Lakeport and Cobb.

Computer modeling can also be used to predict future climate change. In a recent report, scientists use six global climate models to evaluate two emissions scenarios (CNRA 2009). The two scenarios include a higher-emissions scenario, where little is done to reduce global GHG emissions, and a lower-emissions scenario. This approach gives a range of outcomes that can be used to look for general trends. To apply the global models to California, the scientists “downscale” the global models to regional and small-scale projections. Results of this modeling approach found;

Temperature Changes:

- Average temperatures are predicted to rise 2.5-8.5°F by 2100.
- Temperature changes over the next 30-40 years are already determined by past emissions. However, after 2050 potential temperature increases will be greater under the low than high emissions scenario.
- Average temperature increase is expected to be greater in summer than winter.
- Warming is likely to be greater in inland areas, such as Lake County, than in coastal areas.
- Extreme temperature events, such as the July 2006 heat wave, are expected to become more common, and under the high emissions scenario, could become annual events by 2100.
- The previous changes are based on predictions of gradual change. There are numerous possible “tipping elements” that could lead to rapid change. Examples include reduced Arctic sea ice leading to more sunlight absorption and more rapid Arctic warming, and release of methane, a potent GHG, due to warming of frozen Arctic ground (CNRA 2009).

Water Resource Changes:

- Eleven of the twelve models predict an overall decrease in precipitation of 12-35% by mid-century. In addition, evaporation increases at higher temperatures, creating a generally drier climate.
- Statewide, precipitation falling as snow will decrease. Because snow pack is important for statewide water storage and management, this will force changes in statewide water management.
- Periodic intense rainfall events may cause increased flooding. This is expected to be a more serious issue where there is a transition from snow to more rainfall. The minimal snow pack in the Clear Lake Watershed reduces the likelihood of this potential effect.
- Temperature rise will increase water demand for agriculture, urban areas and natural ecosystems.
- Sea level rise is predicted to increase over historical rates under all the scenarios. The highest predicted rise is 55 inches.

- Levees and water resources infrastructure in the Sacramento-San Joaquin Delta, the source of much of the State's freshwater supply, will be threatened by sea level rise and potentially greater flooding.
- Droughts are predicted to be more frequent and last longer in the 21st century.

9.2 IMPACTS ON TERRESTRIAL AND AQUATIC ECOSYSTEMS

A report by the California Energy Commission discusses some of the effects of increasing temperatures and other climatic changes on California ecosystems and wildlife. There is already evidence that the ranges of Sierra Nevada wildlife have shifted north and higher in elevation. The ponderosa pine forest in the Sierra Nevada range has shifted upward by about 637 feet since it was surveyed in 1934 (CEC 2009). Statewide wildfires have increased in frequency, duration and size. While some of this increase is due to a century of fire suppression, warmer temperatures and a longer dry season also have increased wildfire risk. Prescribed burning is an important tool to reduce destructive impacts from wildfires (CNRA 2009).

Warmer temperatures could increase water temperatures of Clear Lake and its tributaries. Warm water has a lower capacity to hold dissolved oxygen than cold water. In addition, biological activity, and therefore oxygen demand, increases as temperature increase. Because fish and other aquatic organisms require dissolved oxygen, warmer water conditions could be harmful to them. Potential impacts of increasing water temperatures in the Clear Lake Watershed might be a reduced area with streams suitable for cold water fish such as trout, and a greater potential for fish kills in Clear Lake.

Statewide harmful algal blooms that can produce toxic compounds appear to be increasing in duration and intensity. Reasons for the increase are likely to be both increased temperatures from climate change and nutrient runoff (CNRA 2009).

An increase in the frequency and/or severity of droughts is harmful both to aquatic and terrestrial organisms. Dry winter and spring conditions reduce streamflows needed for spawning migrations of Clear Lake hitch and other fish species. Decreases in the length of perennial streams eliminates habitat for fish, amphibians, and reptiles, and water sources for many animals.

At the statewide level, resource managers are concerned that vernal pool and freshwater lake species will be more susceptible to extirpation because they are unable to emigrate should changes in temperature or water availability/quality affect their habitats (CNRA 2009). There is also concern that invasive species will benefit from ecosystem disturbance because they generally are able to survive under more varied conditions than are locally adapted species.

9.3 Management of Greenhouse Gas Emissions

In Lake County, developments and projects meeting the requirements for California Environmental Quality Act (CEQA) review are assessed for environmental impacts, including GHG emissions. Guidelines currently being used for GHG emissions review are “CEQA and Climate Change: Addressing Climate Change Through California Environmental Quality Act (CEQA) Review,” a technical advisory from the California Governor’s Office of Planning and Research (GOPR 2008).

9.4 CLIMATE CHANGE ACTIONS

9.4.1 Overall Strategy

The state strategy for climate change was used as a guide for this plan (CNRA 2009, DWR 2008). The state strategy involves both mitigation, by reducing GHG emissions, and adaptation to inevitable climate change. Most of the strategies and actions described in this section promote adaptation to climate; however, policies and projects also need to be evaluated for their potential impacts on GHG emissions (Action 9.3.2 below).

9.4.2 Minimize Greenhouse Gas Emissions

Background: There are many ways to reduce GHG emissions. Major examples include improving energy efficiency of vehicles, buildings and appliances, and use of renewable energy sources in place of fossil fuels. Examples of the latter approach are recently completed solar installations at LACOSAN Northeast and Southwest wastewater treatment facilities that meet 91% of energy requirements at these sites.

Potential significant changes in GHG emissions also need to be considered when designing projects or revising/developing policies and regulations. In some situations, for example policies that encourage water conservation, GHG emissions reductions are likely to be an additional benefit. In other cases, for example short term increases in GHG emissions to construct a project with long-term ecosystem benefits, trade-offs between GHG emissions and desired project benefits need to be considered.

Project Description: When designing projects, policies, and regulations for this plan, efforts will be made to minimize short and long term GHG emissions.

Key Participants: Federal and state agencies, Tribes, county departments, City of Lakeport, City of Clearlake, and local NGOs.

Timeframe: On-going.

Technical Resources Required: Staff of participating agencies.

Cost Estimate: To be determined.

Milestones: Projects and policies developed with reduced GHG emissions.

Effectiveness Criteria: Reduction in GHG emissions.

9.4.3 Water Resources Actions

The California climate change adaptation strategy for water resources includes seven strategies that are relevant to the Clear Lake Watershed (CNRA 2009, DWR 2008). The seven strategies, and the actions in this plan relevant to the strategies, are described below.

1. Fund and Fully Develop Integrated Regional Water Management Plans

Completion of the IRWMP for this region, tentatively titled the Westside IRWMP, is a high priority component of the Clear Lake Integrated Watershed Management Plan (CLIWMP) described in specific action:

Section 2.8.9 Complete the Integrated Regional Water Management Program (IRWMP).

2. Aggressively Increase Water Use Efficiency

Increasing water use efficiency is covered in the overall strategy for water resources (Section 2.8.1); it is a high priority of the IRWMP (Section 2.8.9), and it is addressed in the following specific actions:

Section 2.8.11 Increase Water Conservation

Section 2.8.10 Increase Reuse of Treated Wastewater

3. Practice Integrated Flood Management

Integrated floodplain management includes better use of natural floodplain processes. This is achieved by low density land uses, such as agriculture and wildlife areas, which lessen flood peaks while reducing sedimentation, recharging aquifers, and restoring environmental flows (DWR 2008). Specific actions in this plan that address this strategy include:

Section 2.8.2 Complete the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project.

Section 3.10.4 Restore Stream Channel Hydrology and Associated Habitats.

Section 5.4 Protect Open Space.

At the state level integrated flood management also includes establishing a System Re-operation Task Force. System reoperation in Lake County will be addressed in the IRWMP (Section 2.8.9).

Other practices for floodplain management include low-impact development to promote water infiltration and store runoff, covered in Increase Water Conservation (Section 2.8.11) and flood-resistant design requirements for building, covered in Section 7.5.4 Reduce Flood Damage in Developed Areas. The state climate adaptation

strategy also recommends citing new developments outside of undeveloped floodplains unless they have a 200-year level of flood protection, and addressing flood risks posed by climate change in county General Plans. These recommendations have not yet been met in Lake County.

4. Enhance and Sustain Ecosystems

Enhancing and sustaining ecosystems will increase their capacity to adapt to new stresses and uncertainties caused by climate change. The state strategy recommends protecting and reestablishing contiguous habitat and migration corridors for plant and animal species related to riparian and wetland ecosystems, reestablishing natural connectivity to floodplains, and restoring upper watershed forests and meadow systems that are important in water storage. These strategies are addressed in the following CLIWMP actions:

Section 2.8.2 Complete the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project

Section 3.10.4 Restore Stream Channel Hydrology and Associated Habitats

Section 5.4 Protect Open Space

Section 4.6.3 Protect and Restore Lake and Shoreline Habitats

Section 4.6.5 Develop a Tree Management Plan

Restoration of Eight Mile Valley in the upper watershed, discussed as part of the action to Restore Stream Channel Hydrology and Associated Habitats, will help increase groundwater storage, thereby improving water supply availability and riparian habitats downstream.

5. Expand Water Storage and Conjunctive Management of Surface and Groundwater Resources

The Lake County and Big Valley Groundwater Management Plans provide for sustainable groundwater use through groundwater monitoring, interagency and department cooperation, water well and groundwater policies, and groundwater recharge and conjunctive use projects (CDM and DWR 2006a, LCFCWCD 1999).

Two actions in this plan with potential to expand water storage and conjunctive management are:

Section 2.8.12 Complete the Adobe Creek Conjunctive Use Project

Section 7.5.2 Pursue the Cache Creek Flow Enhancement Project

Additional opportunities for water storage and conjunctive management will be investigated during the completion of the Integrated Regional Water Management Plan (Section 2.8.9).

6. Fix Delta Water Supply, Quantity and Ecosystem Conditions

Because the Clear Lake Watershed is part of the larger watershed draining to the Sacramento-San Joaquin Delta, the objectives of this plan, to improve water quality and supply, have the potential to positively impact the Delta.

7. Preserve and Increase Monitoring, Data Analysis, and Management

The state strategy discusses monitoring for factors related to water supply, e.g. temperature, precipitation, evapotranspiration, and streamflow. Improved coordination of surface and groundwater quality and supply monitoring is the objective of the action to develop a comprehensive Clear Lake Watershed Monitoring Program (Section 2.8.6).

9.4.4 Terrestrial and Aquatic Ecosystem Actions

As part of the state climate change adaptation strategy for biodiversity and habitat, portions of the strategy for management of wetland, habitat, and ecosystem restoration are relevant to the Clear Lake Watershed (CNRA 2009).

The state action for Field Restoration and Improved Protection recommends:

- Eliminating or controlling invasive species.
- Restoring natural processes as appropriate.
- Maintaining natural disturbance regimes.
- Reducing unnatural sediment flows.
- Removing barriers to terrestrial and aquatic species movement.
- Reducing risks of catastrophic wildfire.
- Reducing pollution from runoff and flooding.

Some of the recommendations of the state action to Restore Aquatic Habitat are:

- Protecting cold water resources.
- Maintaining habitat complexity.
- Connecting river/streams to floodplains.
- Restoring sloughs and marshes.

Specific actions of this plan that contribute to the state actions are:

2.8.2 Complete the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project

3.10.4 Restore Stream Channel Hydrology and Associated Habitats

5.5.7 Protect Open Space

4.6.3 Protect and Restore Lake and Shoreline Habitats

4.6.5 Develop a Tree Management Plan

3.10.10 Implement the Lake County Community Wildfire Protection Plan

6.5.5 Develop an Aquatic Invasive Species Management Plan

The California climate change adaptation strategy for biodiversity and habitat also reiterates the state resources action 4, Enhance and Sustain Ecosystems, described in Section 9.3.3 above.