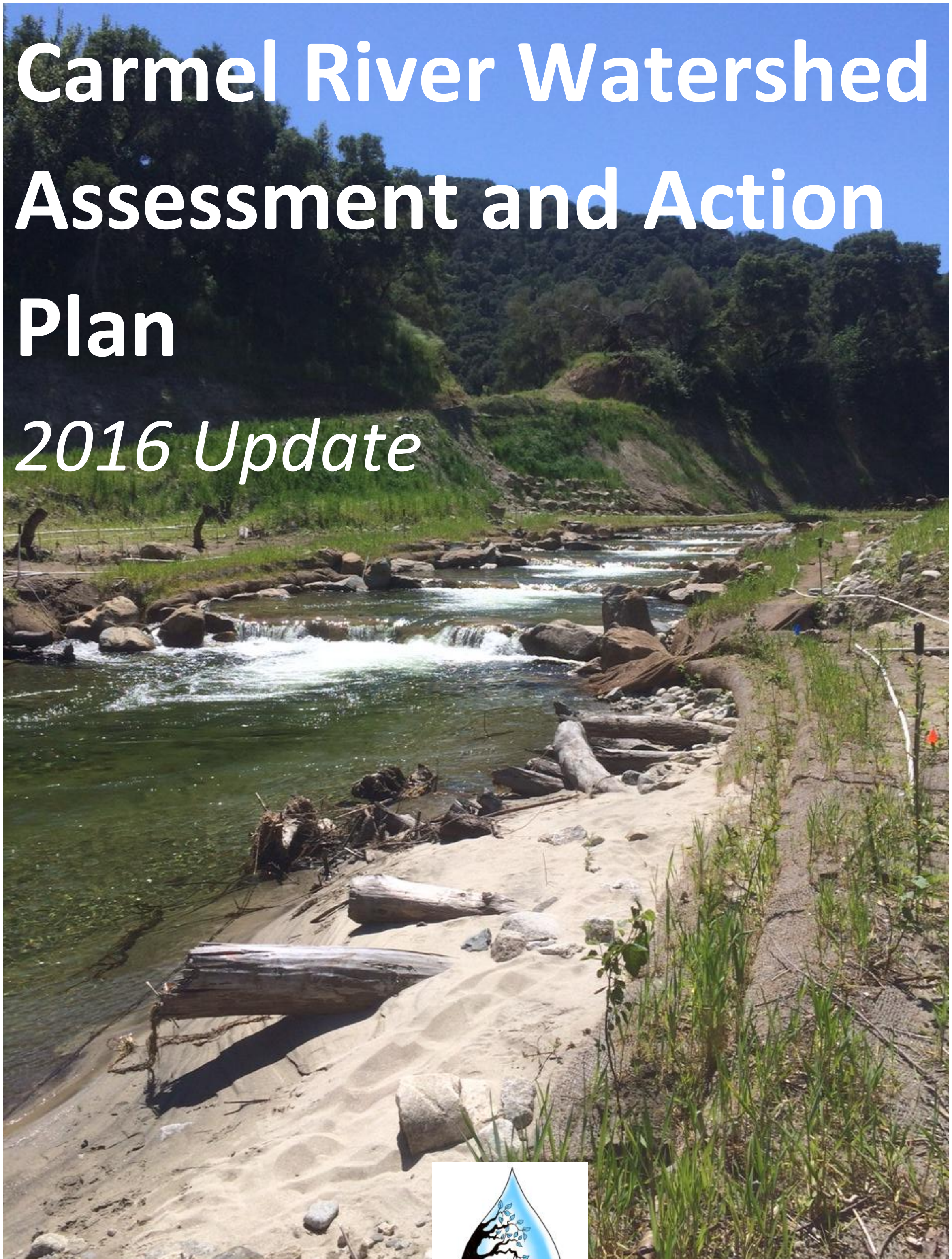
Carmel River Watershed Assessment and Action Plan

2016 Update



RESOURCE CONSERVATION DISTRICT OF MONTEREY COUNTY

Carmel River
Watershed Conservancy

Monterey Peninsula Water Management District

The Carmel River Watershed Assessment and Action Plan 2016 is an update to the 2005 *Watershed Assessment and Action Plan for the Carmel River* developed by the Carmel River Watershed Conservancy and many stakeholder agencies, non-profits and individuals. In 2004 the Conservancy received a $250,000 grant from the State Water Resources Control Board to conduct a thorough assessment of the watershed, which was completed and published in 2005. A major contribution came from the Watershed Institute of the California State University at Monterey Bay (CSUMB), with teams led by Drs. Doug Smith and Fred Watson. In addition, the Conservancy's Acting Executive Director at the time, Clive Sanders, performed many of the tributary creek assessments with assistance from CSUMB graduate students.

It is also a compilation of the 2005 Plan with the assessments that were conducted to support the 2005 Plan as well as other assessments and local planning documents conducted since then. As such, it incorporates text, graphics and data from many documents, which we did our best to acknowledge in context and in the references section, but it behooves us to list those principal resources up-front as well. We are very grateful for the contributions of the many researchers, agency staff and scientists that give this document a firm foundation for understanding the complexities, values and needs of the Carmel River Watershed.

Environmental and Biological Assessment of Portions of the Carmel River Watershed. 2004. Monterey Peninsula Water Management District.

Physical and Hydrologic Assessment of the Carmel River Watershed. 2004. CSUMB Watershed Institute (Smith, Newman, Watson & Hameister).

A Vision Plan for the Carmel River Parkway. 2005. Kasey T. and S. Peterson for the Big Sur Land Trust.

Wetland Habitat Types of the Carmel River Lagoon. 2006.CSUMB Watershed Institute (Casagrande).

Carmel River Lagoon Enhancement Project: Water Quality and Aquatic Wildlife Monitoring, 2005-6. 2007. CSUMB Watershed Institute (Larson, Watson, Casagrande, and Pierce).

Carmel River Lagoon Enhancement Project: Water Quality and Aquatic Wildlife Monitoring, 2006-7. 2007. CSUMB Watershed Institute (Perry, Watson, Casagrande, and Hanley).

Proposed Scope of Work to Conduct Habitat Typing, Identification and Implementation of Priority Projects to Enhance California Red-Legged Frog habitat in the Carmel River Watershed. 2007. Coastal Watershed Council and Ecosystems West Consulting Group.

Monterey Peninsula, Carmel Bay, and South Monterey Bay Integrated Regional Water Management Plan. 2007. Water Management Group.

Supplemental Carmel River Watershed Action Plan. 2007. Phillip Williams and Associates with Ecosystem Management International.

Carmel Lagoon Water Quality and Steelhead Soundings: 2007. CSUMB Watershed Institute (Anderson, Clark, Croyle, Maas-Baldwin, Urquhart, & Watson).

Ten-Year Summary of the Monterey Peninsula Water Management District's Bioassessment Program on the Carmel River. 2010. Monterey Peninsula Water Management District.

The Carmel River Bird Conservation Plan. 2013. Point Reyes Bird Observatory and Big Sur Land Trust.

Carmel River Watershed Assessment and Action Plan: Update 2016. Shihadeh, Rami; Christensen, Thomas; and Carmel River Task Force members. Resource Conservation District of Monterey County, Monterey Peninsula Water Management District, and Carmel River Watershed Conservancy. Monterey County, CA.

Table of Contents

APPENDICES

1. INTRODUCTION

The Carmel River watershed is a unique and remarkably beautiful landscape that has supported diverse peoples, plants and wildlife. It is home to many species of land mammals, reptiles, birds and fish. Nearly half the bird species of North America have been spotted in this region. The watershed also provides sanctuary to several federally protected species, notably the South-Central California coast steelhead (SCCCS) and California red-legged frogs (CRLF).

During the last two centuries, the watershed's rich natural resource base has sustained a local agricultural community, a thriving urban center, and supported lumber, mining and recreational fisheries. Today, the watershed has a resident population of approximately 15,000 people, mostly clustered along the mainstem of the Carmel River and its tributaries, and in the southern portion of the city of Carmel-by-the-Sea (Water Management Group 2007).

Past and present human activities in the watershed have had significant cumulative impacts on water quality, water quantity, habitats, and species, resulting in a need for comprehensive watershed management. Among the activities that have affected the watershed are development in the floodplain, water extraction, roads, agriculture, recreation, mining, water impoundments and the creation of large-scale reservoirs and dams. Federal, state, and county agencies, as well as others, including the Monterey Peninsula Water Management District (MPWMD), Big Sur Land Trust (BSLT), and Carmel River Watershed Conservancy (CRWC), have dedicated countless hours to the protection and restoration of the watershed.

The CRTF was established in 2005 as an advisory committee to guide the implementation of the original *Watershed Assessment and Action Plan of the Carmel River Watershed 2004.* The CRTF is a collaboration of participants and stakeholders representing the community and local, state and federal agencies (Table 1-1). The CRTF met throughout the development of both plans to advise and inform the process, contribute and review information, and assist in evaluating the accuracy of existing conditions.

This revision and update of the *Watershed Assessment and Action Plan of the Carmel River Watershed 2004* is supported by a Watershed Coordination Grant from the California Department of Conservation, Integrated Watershed Restoration Program funding from the State Coastal Conservancy and by contributions of time from members of the Carmel River Task Force (CRTF). The purpose of the revision is to develop a comprehensive and technically sound watershed management plan based on technical and local input to identify limiting factors in the watershed and prioritize restoration activities to restore watershed function within current and foreseeable land use, water supply, and other constraints in the watershed. The update is a collation and reorganization of existing information into a more accessible format for proponents of watershed management, restoration planning, and South-Central California coast steelhead (SCCCS) recovery in the Carmel River watershed.

This updated watershed management plan builds upon existing research, management, and restoration work in the watershed. The recommendations present multiple ways to address limiting factors and conserve and improve physical processes and ecological conditions in the watershed. The information presented describes how environmental events and human activities affect ecological processes in the watershed, identifies critical issues, and includes an *Action Plan* component that provides recommendations that address the critical issues identified in the watershed plan.

The foundation of this plan is based primarily on three documents: Physical and Hydrologic Assessment of the Carmel River Watershed (Smith et al. 2004), Environmental and Biological Assessment of Portions of the Carmel River Watershed (Monterey Peninsula Water Management Districtand Carmel River

Watershed Conservancy 2004), and the Watershed Assessment and Action Plan (Monterey Peninsula Water Management District and Carmel River Watershed Conservancy 2004). Additional sources of information are listed in Table 1-2. Because many organizations and agencies continue to gather environmental data on the Carmel River Watershed, the information presented here should be considered a baseline in understanding and assessing the watershed.

The Carmel River, once designated as one of America's top ten most endangered rivers, is now on the road to recovery with over 50 projects underway in its watershed. The Carmel River Task Force, comprised of all the governmental and non-governmental agencies with authority over or an interest in the Carmel River watershed, developed the Action Plan that is appended to this document. Subsequently that Task Force prioritized the Action Items can agreed on the following highest priority actions:

1. Increase off-stream water storage for higher in-stream flows.
2. Remove fish passage barriers in Carmel River and its tributaries.
3. Add large or small woody debris to the river channel.
4. Support the Lower Carmel River Floodplain Restoration Project.
5. Augment gravel in river channel.
6. Restore riparian vegetation.
7. Remove non-native vegetation in watershed.
8. Create and fund a volunteer coordinator role.
9. Evaluate the future of the Los Padres Dam

1.1 Purpose of and need for a watershed management plan

The Carmel River watershed (Figures 1-1A & 1-1B) has complex patterns of land use, physical conditions, and natural resources that provide countless benefits to wildlife and people living within the watershed as well as to its neighbors in the greater Monterey Peninsula region. The Carmel River is 36 miles long, and drains 255 square miles of National Forest, range, farm, and urban lands (Water Management Group 2007). It flows northwest from its headwaters in the conjoined uplands of the Santa Lucia Mountains and the Sierra de Salinas, and enters Carmel Bay near the town of Carmel-by-the-Sea.

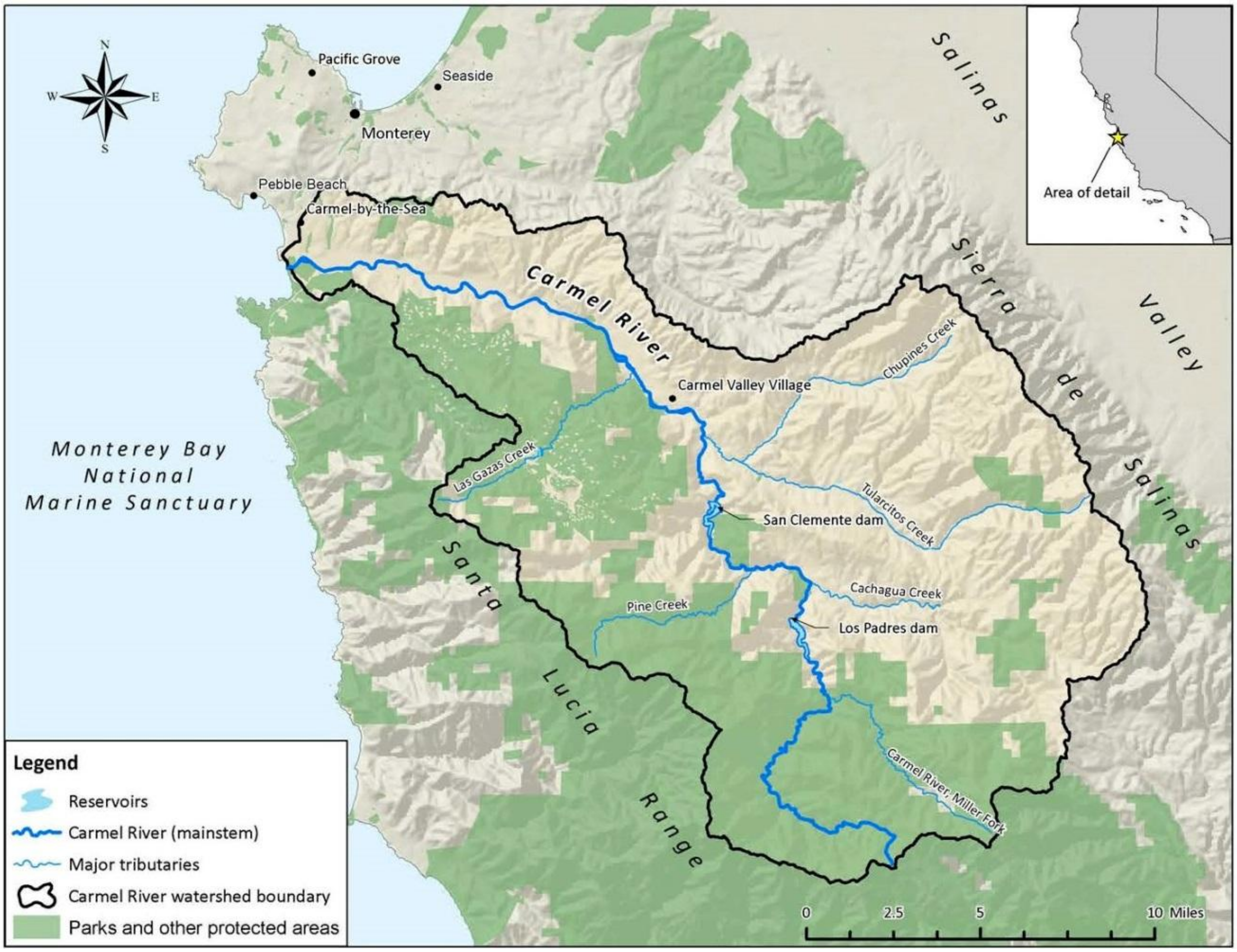


Figure 1-1A. Watershed Map (National Marine Fisheries Service 2013).

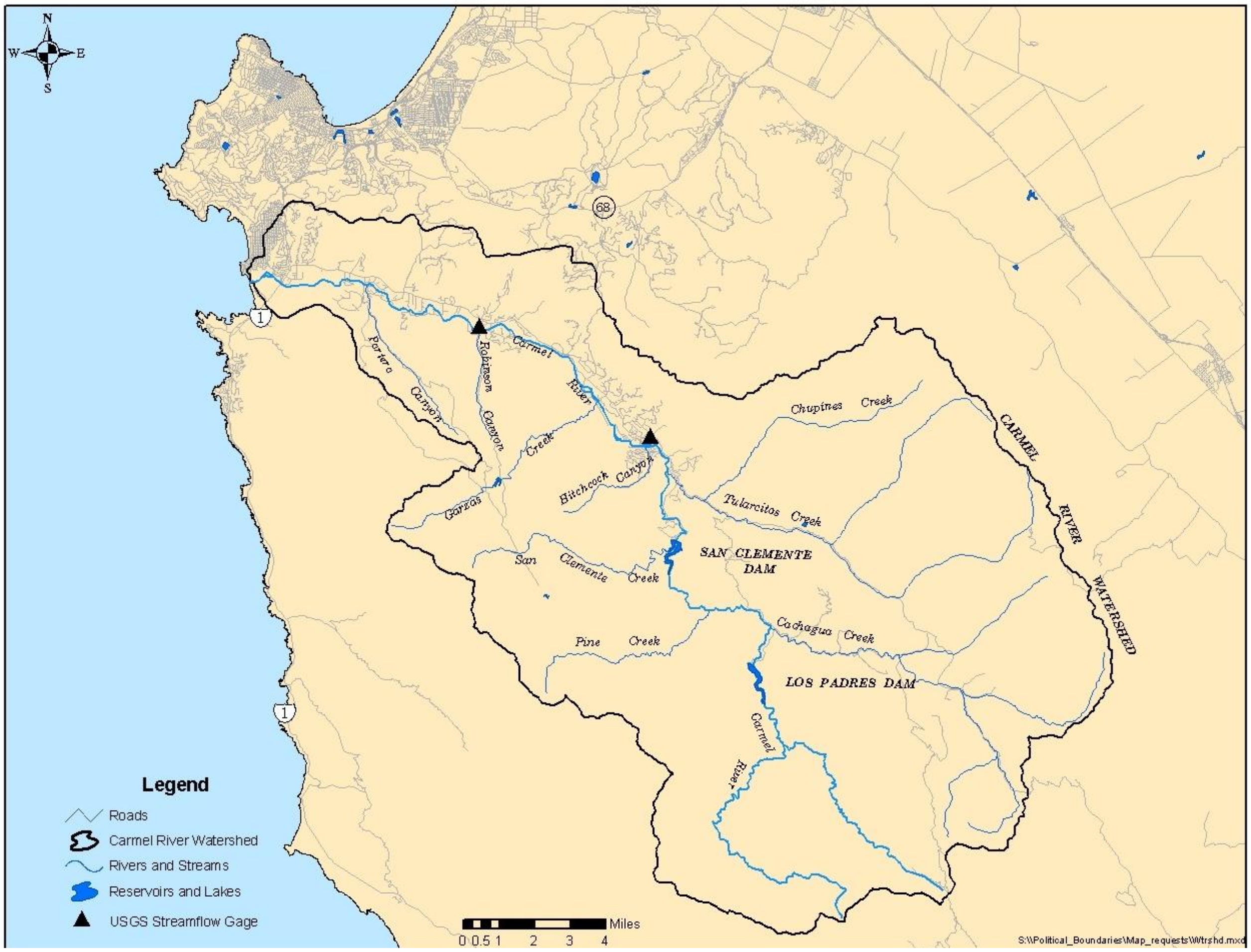


Figure 1-1B. Watershed Map (MPWMD)

Despite its limited size, the watershed's significance extends far past its geographic boundaries. Over sixtypercent of all the potable water used in the Monterey Peninsula region is extracted from the Carmel River watershed by private wells and water companies (Water Management Group 2007). In fact, water from the Carmel River has been exported to the Monterey Peninsula since 1883 when the first dam on the Carmel River was built. As the demand for water increased, two more dams were subsequently built. The San Clemente Dam was constructed in 1921, with a capacity of 1,300 acre feet. Las Padres Dam, with 3,200 acre feet of storage capacity, was completed in 1949. As of 2013, the San Clemente Dam is functionally non-operational and is in the process of being removed. Upstream, the Los Padres Dam's future is also uncertain as its capacity has diminished from siltation. Currently, Los Padres Dam is operated solely for habitat management.

The impact of San Clemente and Los Padres dams, combined with groundwater withdrawals along the lower Carmel River, changes in land use, modifications to the river, and other factors, have negatively impacted the ecological and physical character of the river and the aquatic, avian, amphibian and terrestrial wildlife that it supports. A combination of natural and man-made events that included increased groundwater extraction, extreme drought and flood events in the 1970s, 1980s and 1990s impacted property, threatened species and degraded riparian habitat in the watershed. Despite these impacts, the Carmel River continues to show many signs of recovery and stabilization (Monterey Peninsula Water Management District 2004).

The watershed is home to many rare and endemic species, including two federally threatened species, the South-Central California Coast steelhead (SCCCS), *Oncorhynchus mykiss*, and the California red-legged frog (CRLF), *Aurora draytonii*. The Carmel River watershed is considered “critical habitat’ for CRLF. Steelhead (*Oncorhynchus mykiss irideus*) found in the Carmel River watershed belong to the South-Central California coast Distinct Population Segment (SCCCS DPS), which includes most streams in Monterey, San Benito, Santa Clara, Santa Cruz, and San Luis Obispo counties (National Marine Fisheries Service 2013**).** The Carmel River has historically supported one of the largest populations of steelhead populations in the region. Perennial flow in most years, suitable instream habitat conditions (riparian cover and spawning substrate), and few physical barriers contribute to the success of this species in the watershed (National Marine Fisheries Service 2013). While the population is relatively strong compared to other streams, the numbers of adult fish returning to the Carmel River watershed have declined by about 50%-75% since the mid-1970s (Monterey Peninsula Water Management District 2004). This decline is believed to be related to several historical factors, but paramount was the effect of dam construction, reservoir operations, out-of-watershed exports, and extensive well pumping from the alluvial portions of Carmel Valley.

Federal involvement in water resource management within the watershed increased in the late-nineties after the listing of both CRTF & SCCCS as threatened under protection of the Federal Endangered Species Act (Water Management Group 2007). In response to concerns about water quantity and existing water quality and habitat conditions for steelhead and other species of concern in the watershed, federal, state and local advocacy groups identified limiting factors for these species, and began implementing coordinated efforts for habitat restoration projects and research in the watershed (National Marine Fisheries Service 2013).

1.2 Goals & objectives

Development of a comprehensive watershed management plan and action plan will assist management efforts and support the following goals and objectives. The following goals and objectives were identified by stakeholders at Carmel River Task Force meetings during a three-year period between 2011 and 2014:

- Identify and incorporate updated physical and biogical information about the watershed from reports and studies.
- Identify and update critical issues.
- Identify and prioritize actions to address limiting factors for steelhead, California red-legged frogs, and other species of concern.
- Recommend actions that will improve aquatic and wildlife habitat.
- Provide opportunities to educate the community on watershed conditions and ecological processes.
- Build local support for and participation in watershed conservation and restoration.
- Provide a document that will support and assist community groups, nongovernmental organizations, and agencies when seeking funds for projects, such as the Department of Fish and Wildlife’s (CDFW) Fisheries Restoration Grant Program (FRGP).
- Increase summer and fall instream flows.
- Continue restoration efforts in the floodplain, lagoon, and riparian corridors.
- Reduce Fine Sediment Delivery to the Carmel River and tributaries.
- Conserve and Protect Open Spaces and Existing Land Uses.
- Remove Barriers to Fish Passage.
- Fill key data gaps.

1.3 Watershed management planning history

In 2001, the Carmel River Watershed Conservancy (CRWC) received a $198,200 grant from the State Water Resources Control Board (SWRCB) to carry out a watershed assessment of the Carmel River. The resulting document is the *Watershed Assessment and Action Plan of the Carmel River Watershed 2004.* Development of the assessment and action plan was a collaborative effort of public agencies, non-profit groups, and commercial entities that operated and lived in the Carmel River watershed. The role of stakeholders in formulating the watershed assessment was central to the success of its development and implementation. Stakeholders met periodically to contribute historic and current information, disseminate information and updates to watershed residents and stakeholders, assist in reviewing the accuracy of information, and provide comments. The Carmel River Task Force (CRTF) and others were actively involved in the review, and provided input to the watershed assessment.

The outcome of this effort resulted in the completion of three docuements in 2004: The Physical and Hydrologic Assessment of the Carmel River Watershed, the Environmental and Biological Assessment of Portions of the Carmel River Watershed**,** and the Watershed Assessment and Action Plan. In 2007, the Planning and Conservation League Foundation created the Supplemental Action Plan that focused on the removal of San Clemente Dam. Because infromation was contained in four separate documents the watershed management and action plan did not read like other traditional watershed assessments. For this reason, the Carmel River Task Force took the initiative to update and consolidate the most relavent information about the watershed and re-model the structure of the management and action plans.

1.3.1 Stakeholder involvement in the watershed management plan

Although stakeholders have been actively involved in watershed activities for decades, interest and restoration activity did not increase until the late 1980's. when the numbers of returning steelhead adults hit a low, and the run was declared to be nearly extinct by the California Department of Fish and Wildlife (CDFW) (McEwan and Jackson 1996). Shortly thereafter, the State of California declared SCCCS and CRTF as threatened species. After the listing of steelhead as a threatened species, private citizen groups and public agencies came together and identified the need for watershed assessments and planning to provide comprehensive solutions and guidance for voluntary actions in the watershed. Resource agency representatives responsible for recovering steelhead trout populations began to acknowledge the need to consolidate and unify these various efforts and provide a strategic and scientifically-based plan for improving steelhead habitat in the Carmel River watershed.

In January 1999, Congressman Sam Farr, of 17th District, called a meeting in response to federal agency concerns about enforcing terms of the Endangered Species Act. Congressman Farr's goal was to bring together federal, state and local interests to develop a meaningful, enforceable policy based on a community response. Monterey County Fifth District County Supervisor David Potter was charged to help form a watershed council for the Carmel River (CRWC 2004). Supervisor Potter then facilitated a series of public meetings where residents of the watershed participated in identifying stakeholders and prioritizing issues. The most important issues identified by the public outreach process included water quality and quantity, riparian habitat for native species, erosion, sediment transport, infiltration and runoff, communication, flooding/drainage, education, cultural resources, and quality of life. An advisory committee of twelve individuals was formed in December 1999, each representing one of the following interest groups: 1) hospitality, 2) ranching 3) agriculture, 4) resource management, 5) environment, 6) recreation, 7) homeowners, 8) educational and cultural resources, 9) business,10) Cachagua residents and businesses (includes National Forest Lands, a dam & reservoir, residences), 11) ranches and vineyards, and 12) water suppliers.

The SWRCB grant (2001) provided funding for the CRWC and the Planning and Conservation League Foundation (PCLF) to facilitate the coordination of stakeholder meetings to solicit input on watershed goals and objectives. Stakeholders appointed a Technical Advisory Committee (TAC) comprised of representatives from stakeholders, including the Water Management Group, California State University at Monterey Bay (CSUMB), CRWC, Monterey Bay National Marine Sanctuary (MBNMS), City of Seaside, Carmel River Steelhead Association (CRSA), the Planning and PCLF, and Pebble Beach Company. The

TAC refined a set of goals and objectives that the stakeholder group considered prior to adoption of the 2004 assessment and action plan. The following goals and objectives were included in the 2004 assessment:

1. Identify critical areas of the river and surrounding watershed areas needing restoration work.
2. Conduct assessment of physical characteristics of the river channel, including flow regimes and sedimentation studies.
3. Conduct assessment of riparian functioning and conditions, of the Carmel River & the main tributaries using Properly Functioning Conditions (PFC) a process developed under collaboration with Bureau of Land Management (BLM), U.S. Forest Service & Natural Resources Conservation Service.
4. Conduct biological assessment of fish and amphibian populations.
5. Conduct assessment of water quality conditions in river and lagoon using existing data
6. Conduct benthic macroinvertebrate analysis of Carmel River. Collect benthic macroinvertebrate samples from three sites along the mainstem and selected tributaries.
7. Produce GIS database and maps. All data layers will be supplied on CD-ROM in electronic GIS format. Maps in Poster form covering A) location of Carmel River; B) towns, roads & rivers; C) Land Use; D) Geology, E) Soils; F) Points of Interest.
8. Conduct series of four workshops to educate stakeholders, resource managers and community members on the assessment process, development of the assessment and participation in the Action Planning process.
9. Prepare a Watershed Action Plan as a cooperative effort among Council Stakeholders, agency representatives and the general public.

The outgrowth of this process included the development of the *Watershed Assessment and Action Plan of the Carmel River Watershed 2004* and the *Supplemental Watershed and Action Plan 2007*, and the formation of a technical advisory committee. A technical advisory committee (Carmel River Task Force) was formed in 2006 to support the completion of the Carmel River Watershed Action Plan. The group meets quarterly to support the implementation of watershed improvement projects in Carmel Valley, including supporting the development of the watershed management and action plan.

The 2004 assessment and action plan includes assessments conducted by the CRWC, MPWMD and the PCLF. The report assesses the functionality and stability of the Carmel River and tributary creeks, and the quality of steelhead spawning habitats that lie within the creeks. Water quality monitoring and aquatic invertebrates assessments were conducted and analyzed to assess habitat, water quality, food for steelhead (invertebrates), and the presence of steelhead. The 2004 assessment concluded that many of the creeks in the Carmel River Watershed are not functioning properly. The majority of the creeks assessed lack adequate vegetation and large woody debris (LWD) to properly dissipate high water flow energies, filter sediment, reduce erosion, and develop root masses to stabilize stream banks. The assessment identifies concerns in the sub-watersheds that have impacted biodiversity and the stability of creek banks.

Table 1-1. List of participants and stakeholders.

Name	**Organization**
Kera Abraham	Monterey County Weekly
Gabriela Alberola	California State University, Monterey Bay
Joyce Ambrosius	National Oceanic and Atmospheric Administration Fisheries
Shawn Atkins	Monterey County Public Works
Steve Bachman	California State Parks
Jennifer Bodensteiner	Monterey County Water Resources Agency

Barbara Buikema	Carmel Area Wastewater District
Trish Chapman	California Coastal Conservancy
Debie Chirco-Macdonald	Coastal Watershed Council
Thomas Christensen	Monterey Peninsula Water Management District
John Dalessio	Carmel River Advisory Committee
Joanna Devers	Big Sur Land Trust
Martha Diehl	Monterey County Planning Commission
Sam Davidson	Trout Unlimited - Sportsmen's Conservation Project
Regina Doyle	Monterey Peninsula Water Management District
Denise Duffy	Denise Duffy & Associates, Inc.
Ken Ekeland	Monterey County Water Resources Agency
Jack Ellwanger	Pelican Network
Lisa Emanuelson	Monterey Bay National Marine Sanctuary
Frank Emerson	Carmel River Advisory Committee
Laura Engeman	California Coastal Commission
Linda Ferrasci	Carmel Valley resident
Chris Fischer	Santa Lucia Conservancy
John Ford	Montery County Resource Management Agency
Tim Frahm	Trout Unlimited - Sportsmen's Conservation Project
David Frisbey	Monterey Bay Regional Air Pollution Control District
Mike Fuzie	California State Parks
Tom Gandesbery	California Coastal Conservancy
Elizabeth Geisler	Monterey Peninsula Regional Parks District
Seth Gentzler	URS Corp
Paula Gill	US Army Corps of Engineer
Paul Greenway	Monterey County Public Works Department
Norm Groot	Monterey County farm Bureau
Larry Hampson	Monterey Peninsula Water Management District
Sarah Hardgrave	Big Sur Land Trust
Erin Harwayne	Denise Duffy & Associates, Inc.
Josh Harwayne	Denise Duffy & Associates, Inc.
Chris Hauser	Santa Lucia Conservancy
Carl Holm	Monterey County Resource Management Agency
Bridget Hoover	Monterey Bay National Marine Sanctuary
Thomas House	Carmel River Advisory Committee
Monica Hunter	Planning and Conservation League Foundation
Alison Imamura	Denise Duffy & Associates, Inc.
Marjorie Ingram	Carmel River Advisory Committee
Tim Jensen	Monterey Peninsula Regional Parks District
Mark Johnsson	California Coastal Commission
Robert Johnson	Monterey County Water Resources Agency

Dana Jones	California State Parks
Pat Krone-Davis	California State University, Monterey Bay
Jeff Kwasny	US Forest Service
Robert LaFleur	Natural Resource Conservation Service
Kathleen Lee	District 5 Board of Supervisors
Brian LeNeve	Carmel River Steelhead Association
Lorin Letendre	Carmel River Watershed Conservancy
Larry Levine	CSA-50
Marc LosHuertos	California State University, Monterey Bay
Dirk Madema	Monterey County Planning Dept
Jacob Martin	US Fish and Wildlife Service
Rachel Martinez	Monterey Peninsula Water Management District
Raul Martinez	Monterey County Dept of Public Works
Mibs McCarthy	Carmel Valley Association
Donna Meyers	Big Sur Land Trust
Matthew Michie	California Department of Fish and Wildlife
Nina Miller	California American Water Company
Chad Mitcham	US Fish and Wildlife Service
Jayne Mohammadi	Congressman Farr's Office
Lance Monosoff	Carmel River Advisory Committee
Tom Moss	Monterey County Resource Management Agency
Edward Muniz	Monterey County Planning Dept
Jackie Nelson	Monterey Peninsula Regional Parks District
Nikki Nedeff	Biological consultant
Mike Novo	Monterey County Planning Dept
Seth Parker	Monterey FireSafe Council
Jacqueline Ociano	RMA - Planning Department
Margaret Paul	California Department of Fish and Game
Jacqueline Pearson-Meyers	National Oceanic and Atmospheric Administration Fisheries
Greg Pepping	Coastal Watershed Council
Peter Perrine	California Wildlife Conservation Board
Frank Pierce	Frank Pierce & Associates
Carol Reeb	Stanford University
Dawn Reis	Biological consultant
Margaret Robbins	Carmel River Advisory Committee
Paul Robins	Resource Conservation District of Monterey County
Tanja Roos	MEarth, Carmel Middle School
Richard Rosenthal	Save Our Peninsula
Laura Ryley	California Department of Fish and Wildlife
Enrique Saavedra	Monterey County Public Works Department
Clive Sanders	Carmel River Watershed Conservancy

Rachel Saunders	Big Sur Land Trust
Rami Shihadeh	Resource Conservation District of Monterey County
Nancy Siepel	California Department of Transportation
Doug Smith	California State University, Monterey Bay
Mike Stake	Ventana Wildlife Society
Catherine Stedman	California American Water Company
Richard Svindland	California American Water Company
Kevan Urquhart	Monterey Peninsula Water Management District
Vincent Voegeli	Hastings Preserve
Fred Watson	California State University, Monterey Bay
Mike Watson	California Coastal Commission
Michael Waxer	Carmel River Watershed Council
Noelle White	Assemblyman Bill Monning's Office
Kristina Barry	US Forest Service

1.3.2 Related studies and management actions in the watershed

As referenced earlier, the *Carmel River Watershed Assessment and Action Plan of 2004* and the *Supplemental Watershed Action Plan of 2007* are two sources utilized for the development of this plan. The synthesis of existing watershed conditions in this watershed plan update utilized additional data from watershed management and restoration studies compiled and collected by researchers and stakeholders in the Carmel River watershed (Table 1-2). The 2004 and 2007 documents are described briefly below. All are available as complete documents at the Carmel River Watershed Conservancy website: http://carmelriverwatershed.org/work/action-plans/

Fisheries and aquatic habitat information was taken from the Environmental and Biological Assessment of Portions of the Carmel River Watershed (2004); Ten-Year Summary of the Monterey Peninsula Water Management District's Bioassessment Program on the Carmel River; Monterey Peninsula Water Management District's Mitigation Program Reports, 2000-2013; and NOAA's South-Central California coast Steelhead Recovery Plan. Additional materials used in the completion of this section are referenced in the following table and included in the reference section.

Table 1-2. Related Studies (Monterey Peninsula Water Management District 2004).

SOURCE	**DATE**
Environmental and Biological Assessment of Portions of the Carmel River Watershed, Monterey County, California. Prepared by Monterey Peninsula Water Management District, under Contract with Carmel River Watershed Conservancy	12/8/2004
Physical and Hydrologic Assessment of the Carmel River Watershed, California. The Watershed Institute, California State University Monterey Bay	11/1/2004
Assessment and Action Plan of the Carmel River Watershed, California 2004	3/31/2005
Supplemental Carmel River Watershed Action Plan, 2007. PWA Associates	6/30/2007
Monterey Peninsula, Carmel Bay, and South Monterey Bay Integrated Regional Water Management Plan. The Water Management Group	11/19/2007

Supplemental Carmel River Watershed Action Plan. The Planning and Conservation League Foundation In Partnership with The Carmel River Watershed Conservancy	3/1/2007
Ten-Year Summary of the Monterey Peninsula Water Management District's Bioassessment Program on the Carmel River	11/1/2010
Santa Rosa Creek Watershed Management Plan, Central Coast Salmon Enhancement	2/1/2012
South-Central California coast Steelhead Recovery Plan. NOAA	12/1/2013
Mitigation Annual Reports. 2000-2013. MPWMD	2000-2013

1.3.3 Projects in the watershed

A number of watershed management and restoration projects have been and are being conducted in the Carmel River watershed. A description and map of past, present and future projects are in Appendix 1 and Appendix 2.

1.4 Overview of the watershed

The Carmel River watershed contains a diverse assemblage and mosaic of plant and animal species. The wide range of topography, rainfall patterns, soils, geologic processes, episodic wild fires and landslides, and proximity to marine air in the region has created ideal conditions for endemism and localized genotypic variations in plant and animal species (Matthews 2006). The watershed encompasses portions of the Monterey Bay National Marine Sanctuary, the Los Padres National Forest and the Ventana Wilderness, and includes Carmel Bay, an Area of Special Biological Significance (ASBS).

The watershed is a highly dynamic system, experiencing large seasonal variability in flow levels and variation in sediment transport from the upper watershed to the estuary and ocean. The system is composed of terrestrial, riparian, freshwater aquatic, and coastal estuarine habitats that support many important wildlife species, including migratory and resident birds, at-risk species such as Pacific lamprey, western pond turtle, California tiger salamander (CTS), SCCCS and CRLF. The SCCCS, CTS and CRLF are currently listed as threatened at both the federal and state levels. The decline of these key species is indicative of the overall decline in ecosystem viability and the fragmentation of the environment in the lower 27 miles of the river that requires intensive management efforts. Refer to Figure 1-2 for a map of River Miles.

Figure 1-2. River Mile Map (CSUMB)

Recent surveys of riparian-wetland areas in the upper watershed, along the 9-mile reach upstream of Los Padres Reservoir, show these areas are the least impacted by human influences and remain sustainable. Between Los Padres Dam and the Carmel Valley Village, a distance of approximately 15 miles, flow releases from the dams are required in summer to maintain aquatic habitat. Despite this, riparian areas are in reasonably good condition, although channel degradation (incision into sediment deposits) is evident immediately downstream of both dams. The lower 10 miles of the river (RM 1-10), where the impacts from water extraction are concentrated, requires irrigation and maintenance of streamside vegetation, reconstruction of streambanks after high winter flows, annual CRLF and SCCCS rescues, habitat enhancement activities, and extensive monitoring. Additionally, regulatory water extraction from the watershed is in effect under orders from the California State Water Resources Board (Order No. 95-10 and subsequent related orders). A program to mitigate for the effects of water extraction on the mainstem is carried out locally by MPWMD under its Mitigation Program (MPWMD 2000-2013).

Previous studies (CRWC 2004, Smith et al. 2004; Monterey Peninsula Water Management District 2004) have evaluated the functional condition of portions of the Carmel River Watershed. These studies suggest that the majority of reaches upstream of RM 10 (upstream of the Carmel Valley Village) are capable of providing high quality, productive habitat for many terrestrial and aquatic species, including SCCCS and CRLF. However, from the Village area downstream to the Carmel River Estuary, the aquatic habitat is considered “functional at-risk” (Monterey Peninsula Water Management District 2004). The reduced physical and ecological functioning of the lower Carmel River and estuary are the result of the cumulative effects of several factors, including:

- Groundwater pumping from the riparian aquifer by Cal-Am and private wells and associated Carmel River water diversions
- San Clemente Dam (RM 18.6) and Los Padres Dam (RM 27) influence downstream river conditions and affect the connectivity of habitats
- Seasonal breeching of the Carmel River Estuary sand bar
- Erosion and polluted runoff from developed landscapes
- Constraints on the natural river processes by levees, river control walls, bridges, roads, and other human infrastructure that reduce the ability for river to geomorphically function (2007 Supplement).
- Extensive urbanization exists within the regulatory 100-year floodplain and in the dam-failure inundation zone.

In the lower mainstem of the river, the Carmel River State Beach, including its adjacent lagoon area and wetlands, serves as an important refuge for sensitive aquatic species and is a dynamic interface between marine and fresh water river systems. The floodplain area adjacent to the river supports some of the highest densities of migratory songbirds in California (DiGaudio 2013). The Carmel River lagoon, which forms a seasonally brackish lagoon environment above sea level at the mouth of the Carmel River, is subject to frequent emergency actions in many winters in order to reduce the potential for flooding of nearby low-lying structures. Essentially, tidal forces at the mouth of the river frequently build the barrier beach up across the mouth to a level that is higher than some of the surrounding homes and infrastructure. When the lagoon rises from wave over-wash or Carmel River inflow, the beach must be breached mechanically in order to lower the water level. These actions result in a loss of aquatic habitat and undesirable consequences to fish and wildlife, including impacts to the federally threatened steelhead (SCCCS) and California red-legged frogs (CRLF). In addition to impacts from winter breaching, in almost all years, Carmel River diversions in the dry season (June 1 to November 30) significantly reduce the volume of flow to the lagoon and decrease the quality and quantity of aquatic habitat at the lagoon (MPWMD 2000-2013).

In general, the Carmel River environment is in better condition today than it was in 1990. This improvement is evidenced by biological/hydrologic indicators such as consistent steelhead adult spawner counts of several hundred fish in recent years as compared to zero to five fish per year when the Mitigation Program began in 1991; improved densities of juvenile steelhead in quantities that reflect a healthy seeded stream; consistently balanced bird diversity in MPWMD restoration project areas compared to control areas; fewer miles of dry river in summer and fall than in the past; and higher water tables in the Carmel Valley alluvial aquifer at the end of each water year.

The comprehensive MPWMD Mitigation Program is an important factor responsible for this improvement. Direct actions such as fish rescues and rearing, and riparian habitat restoration literally enable species to survive and reproduce. Indirect action such as conservation programs, water augmentation, ordinances/regulations and cooperative development of Cal-Am operation strategies result in less environmental impact from human water needs than would occur otherwise. The MPWMD's comprehensive monitoring program provides a solid scientific data baseline, and enables better understanding of the relationships between weather, hydrology, human activities and the environment. Better understanding of the MPWRS enables informed decision-making that achieves the MPWMD's mission of benefiting the community and the environment.

It is acknowledged that there are other important factors responsible for this improved situation. For example, between Water Years (WY) 1991 and 2012, the Carmel River has received normal or better runoff in 16 out of 21 years. Actions by federal resource agencies under the Endangered Species Act (ESA) or the SWRCB under its Order WR 95-10 and follow-up orders have provided strong incentive for Cal-Am and other local water producers to examine and amend water production practices to the degree feasible, and for the community to reduce water use. Except for one year in 1997, the community has complied with the production limits imposed on Cal-Am by the SWRCB since Order 95-10 became effective in July 1995.

Despite these improvements, challenges still remain due to human influence on the river. The steelhead and red-legged frog remain listed as threatened species under the ESA. At least several miles of the river still dry up each year, harming habitat for fish and frogs. The presence of the two existing dams, flood plain development and water diversions to meet community and local user needs continue to alter the natural dynamics of the river. Stream bank restoration projects may be significantly damaged in large winter storm events, and some people continue to illegally dump refuse into the river or alter their property without the proper permits. Thus, the Mitigation Program (or a comprehensive effort similar to it) will be needed as long as significant quantities of water are diverted from the Carmel River and people live in close proximity to it.

2. SYNTHESIS OF WATERSHED CONDITIONS

2.1 Historical watershed conditions

Prior to European settlement along the California coast, the Carmel River watershed was relatively undisturbed, with minor impacts associated with the hunting, gathering, and land management practices (burning of vegetation) of the local indigenous peoples. Conditions in the watershed were greatly altered in the early 1800s when clearing of the land in support of agricultural activities (cattle ranching, crop cultivation, and logging) caused significant changes to rainfall-runoff relationships as trees, shrubs, and deep-rooted native perennial grasses were degraded by agriculture, development and other changes in land use. Starting in the mid 1850's, a period of population growth and land development occurred in the region, resulting in the construction of the first dams. This sequence of events began the process of water and habitat degradation that continues to affect the watershed today.

By the mid-1900's, suburban development, groundwater pumping and other natural events including fire and drought, created conditions that resulted in extensive bank erosion, riparian habitat degradation, incision in the river channel, and a reduction of the rate at which groundwater infiltrates into the soil and recharges the aquifer. These conditions directly impacted groundwater, and adversely impacted property and wildlife habitat in the watershed. The origins of this instability are complex, and have been traced to a variety of causes in addition to those already mentioned that include the particular terrain and flow regimen of the Carmel River, impoundment of water and sediment retention at San Clemente and Los Padres Dams, fire suppression in the surrounding watershed, and periodic floods and droughts. In summary, over a two hundred year period, the watershed has been disrupted by extensive damage to the physical environment, adversely affecting private property, fish and wildlife resources, visual quality and recreational values.

These activities directly impacted steelhead and other aquatic and terrestrial species. To protect steelhead in the Carmel River, in 1995, the State Water Resources Control Board (SWRCB) issued an Order which limited California American Water Company (Cal-Am) to 11,285 acre-feet of diversions from the Carmel River Watershed. As a result, direct diversions from surface storage in Carmel Valley are no longer used to meet municipal supply. Instead, stored water is released from Los Padres Reservoir during dry periods to meet instream flow requirements and partially offset environmental damage from groundwater extraction farther downstream. Thus, the region is mostly dependent on a system of wells in Carmel Valley and in the Seaside Groundwater Watershed to meet municipal demand for potable water. The shallow Carmel River aquifer has been over-pumped by approximately 11,000 acre-feet per year since 1995 (SWRCB 1998).

Stakeholders and government agencies are currently assessing the possibilities of a seawater desalination plant in the region. The desalination plant would improve water supply reliability in the service area, particularly in dry years, by augmenting the Carmel River groundwater aquifer that is currently relied upon and overdrawn.

2.1.1 Cultural history

The Ohlone Tribe controlled the area stretching from San Francisco to Point Sur and inland to the Coast Ranges (Breschini and Haversat 2004). The Spanish referred to the Ohlone as the Costanoans, or "Coastal People". Though estimates vary widely, the Ohlone population likely consisted of 7,000 to 10,000 people (Henson & Usner 1993; Levy 1978). The Ohlone tribe often resided in coastal areas with deep harbors. Consequently, the Ohlone were some of the first tribes in California to interact with the Europeans. When the Mission system was established, large numbers of Ohlone were converted to Christianity and began to work for the missionaries. The local Ohlone band in the Monterey Peninsula was known as the Rumsen. The Rumsen ranged from areas currently known as the cities of Monterey and Carmel, inland along the Carmel River toward the Carmel Valley Village (Breschini and Haversat 2004).

The tribes throughout this region commonly set fires in the landscape. It is theorized that human induced fires encouraged the growth of oak trees and grasslands. Native Americans frequently utilized fire to manage their landscape and environment (Keeley 2002; Anderson 2005; Syphard et al. 2007). The high-frequency, low-intensity fires likely resulted in little mortality of mature trees, low but continuous tree recruitment (Mensing 1991), and an open understory.

Native people burned the oak woodlands throughout California for many reasons. Often their fires were purposeful and directed to manage particular species. Certainly lightning fires in the coastal oak woodlands and those along the Sierra Nevada were common, and could burn for hundreds of miles if conditions were right. With the arrival of Europeans, fires were suppressed. After 200 years of fire suppression, and with warmer summer temperatures and drier years, fires have become frequent and large in California's wildlands.

For a chronological history of the watershed from 1603-2000, please see Appendix 3 (CRWC).

2.2 Land use

The Carmel River watershed is located almost entirely within the unicorporated area of Monterey County, where land use decisions and planning are governed by the county's General Plan. The majority of the 255-square mile watershed is rural, with primary land use activities consisting of cattle ranching, limited agriculture, viticulture, recreation (golf courses and park areas), and national forest and open space.Urban development is concentrated along the riparian corridor and floodplain of the Carmel River. Table 2-1 summarizes the physical and land use characterieistics of the watershed.

Table 2-1. Physical and Land Use Characteristics of the Carmel River Watershed (National Marine Fisheries Service 2013).

PHYSICAL CHARACTERISTICS				
Watershed	Area (acres)	Area (sq.mi.)	Stream Length (miles)	Ave. Ann. Rainfall (inches)
Carmel River	162,286	254	248	19.8
LAND USE CHARACTERISTICS				
Total Human Population	Public Ownership	Urban Area	Agriculture/Barren	Open Space
17,020	31%	4%	0.6%	95%

Human population density is moderate to high and concentrated in the lower and middle portions of the Carmel Valley, including the towns of Carmel and Carmel Valley. Population density averages 70 persons per square mile. Although less than four percent of the watershed is classified as urban, well over 50 % of the watershed is privately-owned. The lower Carmel Valley, through which the mainstem flows, is surrounded by public parks, extensive ranches and areas of rural land use. Less than 1 % of the watershed is under cultivation (National Marine Fisheries Service 2013).

Many key properties are in public ownership and available for the local community to utilize these resources for recreation and exploration. A number of adjacent private property owners have been receptive to parkway planning and have expressed interest in collaborating toward a goal for public benefit. An ambitious wetland and floodplain restoration project is in progress at the mouth of the CarmelRiver. The restoration efforts are already showing benefits to wildlife and to the health of the wetlands.

Benefits that may result from public lands include the protection and restoration of endangered habitats and species, improved water quality of the Carmel River aquifer, alternative transportation routes, improved flood management, and the implementation of outdoor environmental education programs.Figures 2-1and 2-2 illustrate land use functions and floodplain functions in the watershed. (Please note that these images are from a Vision Plan that was prepared for Big Sur Land Trust in 2005 as an analysis of opportunities and constraints, and that has not been adopted by any agency and does not have an binding effect.) Figure 2-3 delineates federal and non-federal land ownership in the watershed.

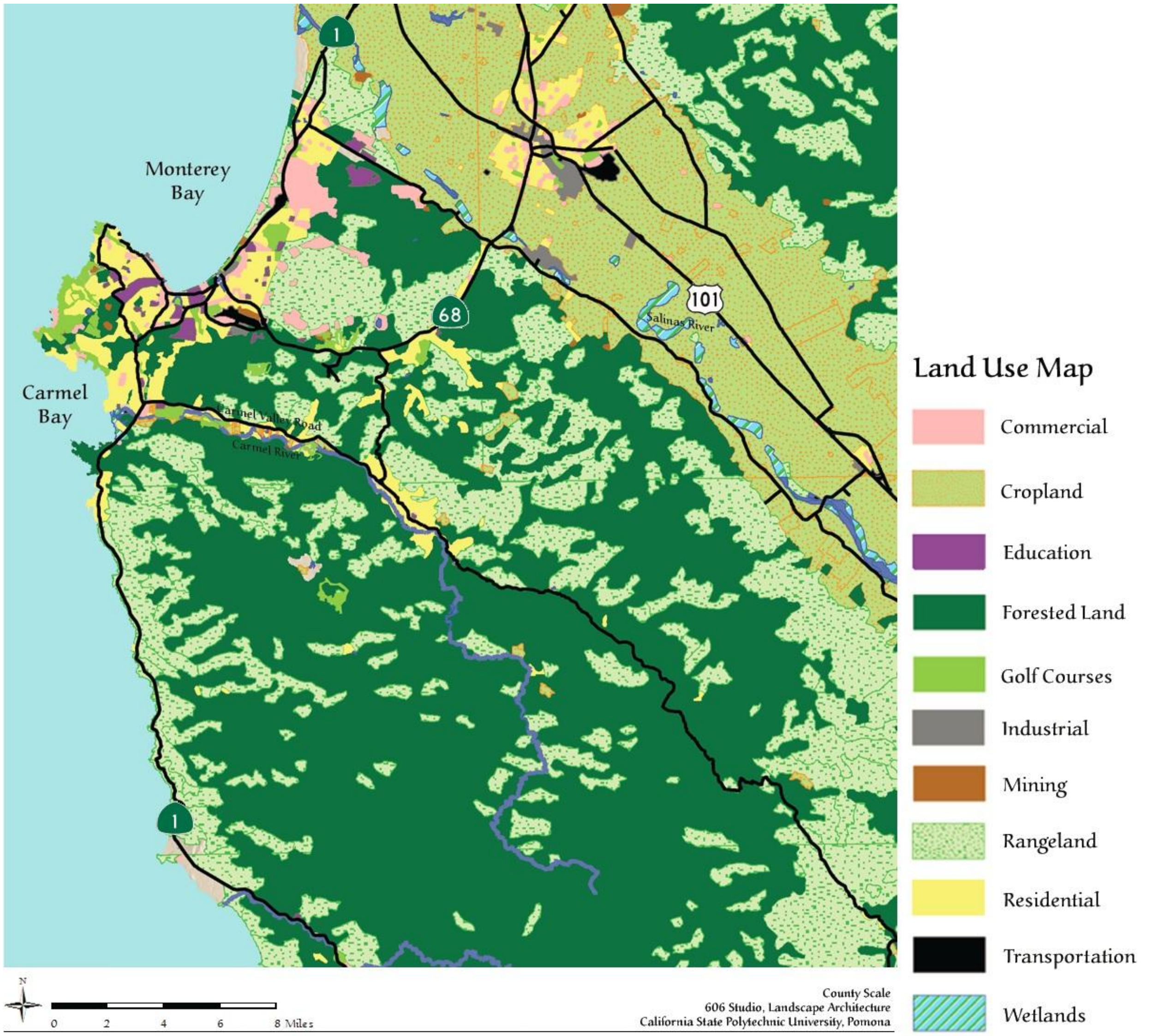


Figure 2-1. Land-use functions map in the lower carmel River, and surrounding areas (Kasey and Peterson 2005).

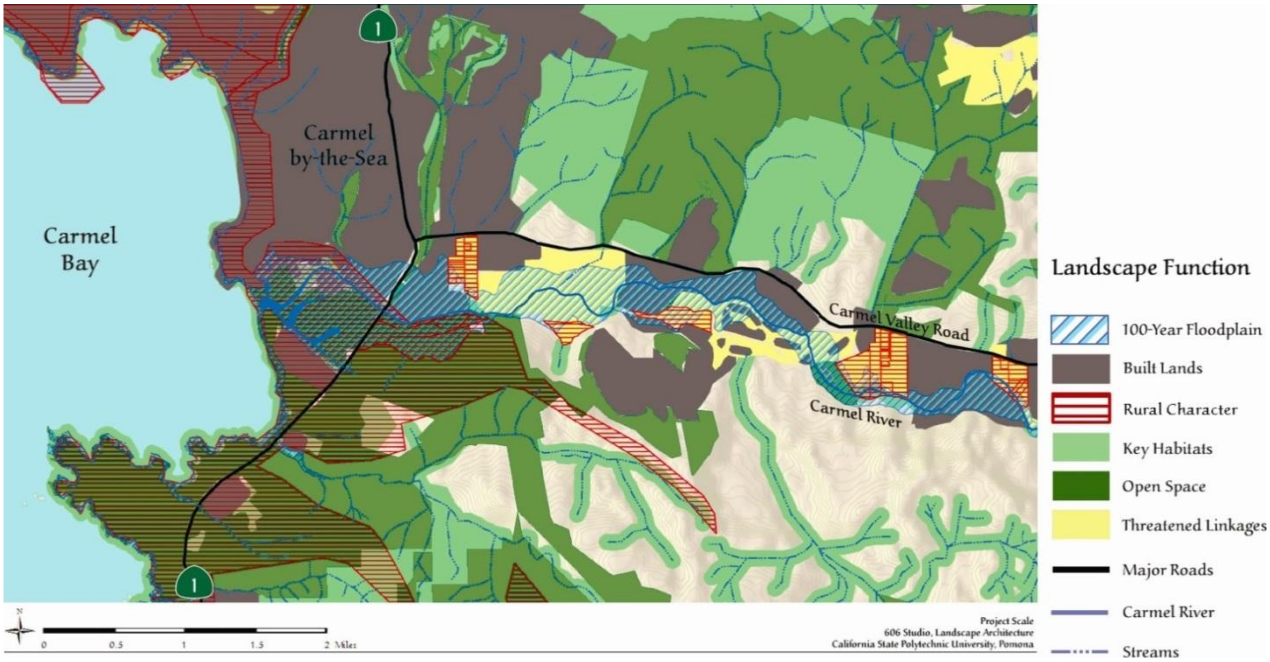


Figure 2-2. Landscape function map for the Lower Carmel River (Kasey and Peterson 2005).

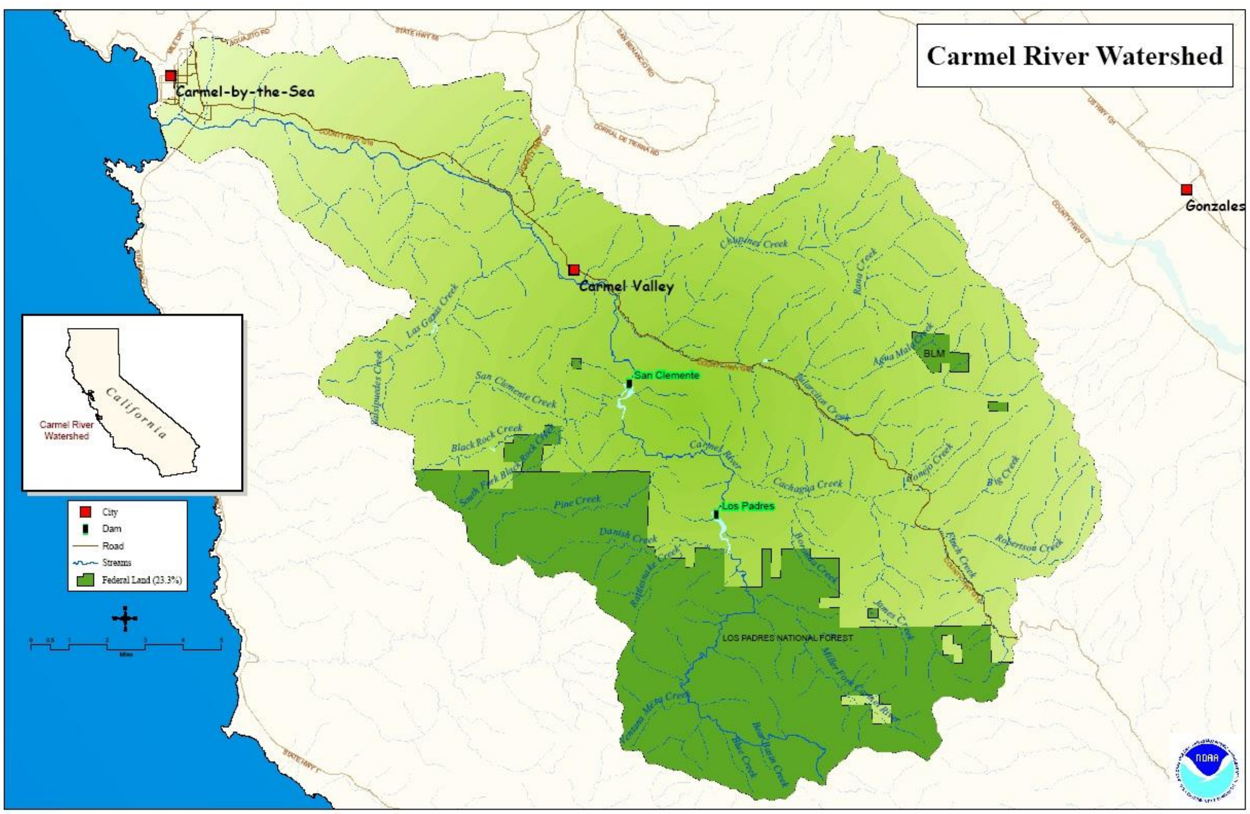


Figure 2-3. Federal & non-fed land ownership within the Carmel River Watershed (National Marine Fisheries Service 2013).

2.2.1 Growth trends

The economic base in the watershed is made up of tourism, recreation and agriculture. According to a 2001 report prepared by the Association of Monterey Bay Area Governments (AMBAG), over the next 20 years, population and housing in Monterey County is projected to increase by more than 30%. Monterey County is projected to see a slightly higher percentage increase in population and housing than in jobs. However, growth in both the unincorporated areas and cities may be constrained by limited water supplies and levels of service on local roads in the watershed and surrounding area (Water Management Group 2014).

According to the Comprehensive Fiscal Analysis of the Proposed Incorporation of Carmel Valley (June 9, 2006), approximately 11,700 people reside in the valley portion of the Carmel River watershed. According to the Monterey County General Plan Update completed in 2004, estimates for the Cachagua area indicate that the population is slightly less than 2,000 residents. Development constraints may limit future population growth in this area to about 4,000 residents (Water Management Group 2014). Figure 2-3A illustrates population density in the region. Population growth in this area over the next 20 years is difficult to estimate. However, population growth in this area may be similar to incorporated portions of Monterey County (i.e. declining slightly), as development constraints are similar between the two areas.

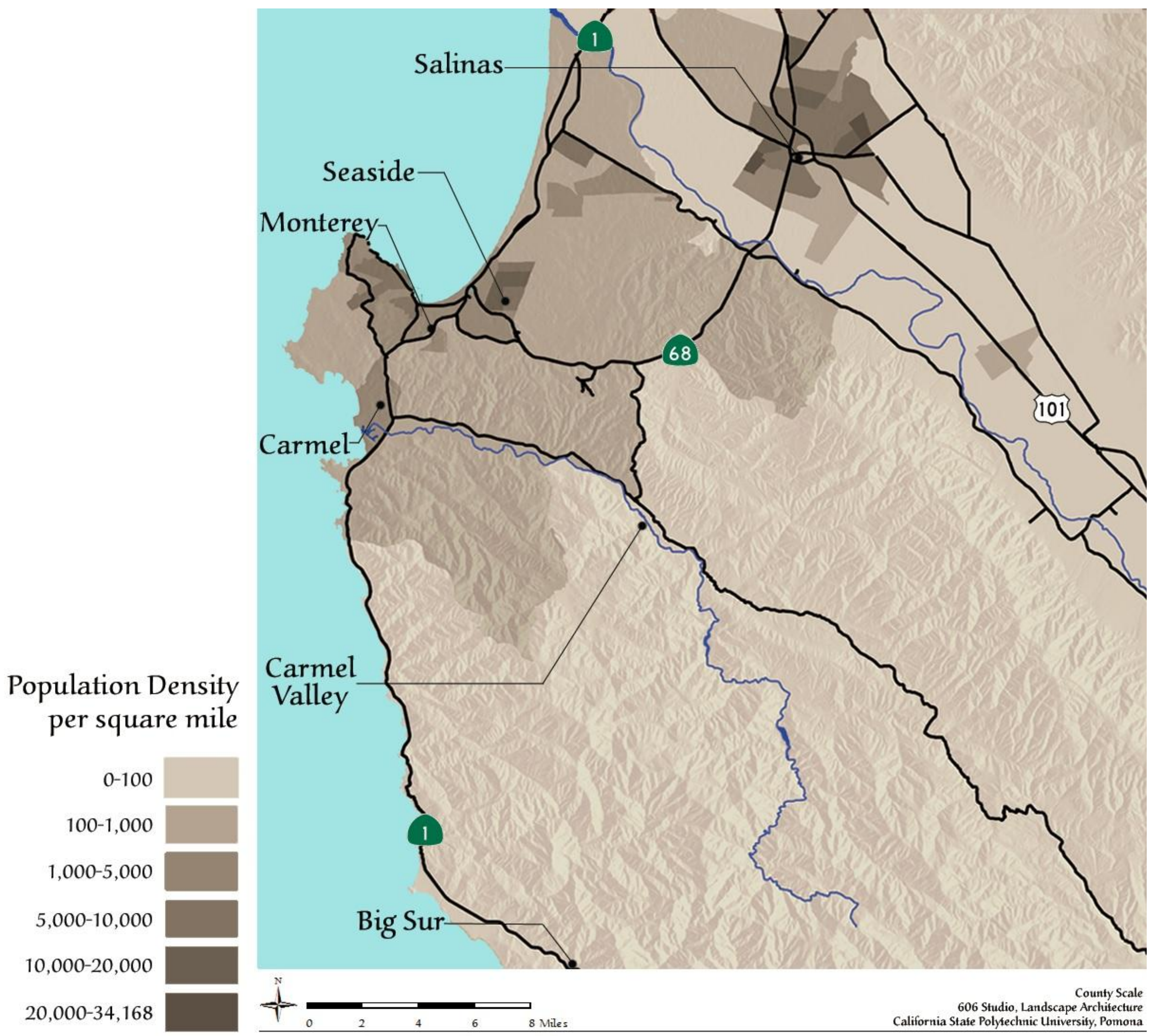


Figure 2-3A. Population density per square mile (Kasey and Peterson 2005).

2.2.2 Land Use Analysis Summary

Lack of water resources has limited large-scale growth throughout past decades. Roadway capacity is currently strained by existing traffic patterns. Land use policy is contentious in the region, as has been demonstrated by the delayed adoption of a new County General Plan. Local residents have successfully fought proposals for new dams, freeways, and developments (Kasey and Peterson 2005).

The State of California has mandated the local water utility company to find alternative sources of water in order to save the Carmel River from further decline. This coastal region is not immune to the growth pressures facing the rest of the state. Sound land use strategies should be employed to keep new sources of water from spawning unsustainable growth (Kasey and Peterson 2005).

2.3 Climate

The region's watershed climate is considered Mediterranean, exemplified by dry summers and wet winters, with considerable variation in levels of precipitation and surface runoff from year to year. Average annual precipitation (Figure 2-4) falls mainly as rain, and varies between 14 inches at the mouth and 41 inches in the Santa Lucia Mountains (Rosenberg 2001).

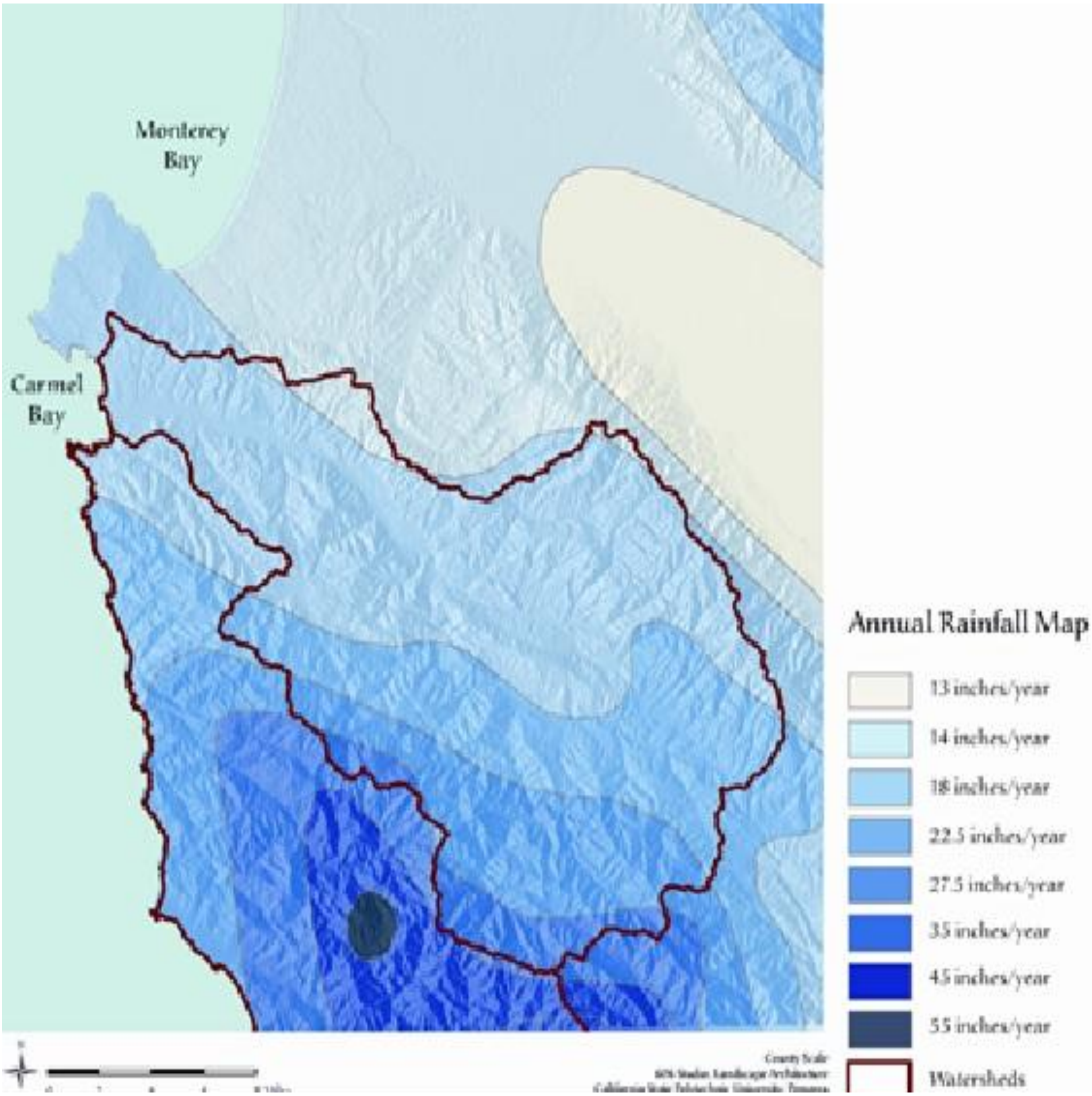


Figure 2-4. Average rainfall contours in the watershed (Rosenberg 2001, Smith 2004)

About 70% to 80% of the surface runoff in the Carmel River watershed is generated from rainfall within the Los Padres National Forest and Ventana Wilderness (Water Management Group 2007). The average annual runoff on the Carmel River at the USGS gauge Near Carmel (3.56 RM upstream of the Pacific Ocean) was 78,190 acre-feet (AF) for the period of record 1962-2006 (USGS 2006). Three subwatersheds (Pine, Garzas, and Black Rock/San Clemente creeks) produce 27% of the annual Carmel flow, but compose only 15% of the Carmel watershed area. The Santa Lucia region of the Carmel watershed is the major source of water reaching the lower valley, presently making it the major water source for the greater Monterey Peninsula. An index of historic rainfall variability in the watershed is the long-term record maintained at San Clemente Dam since 1922 (Figure 2-5).

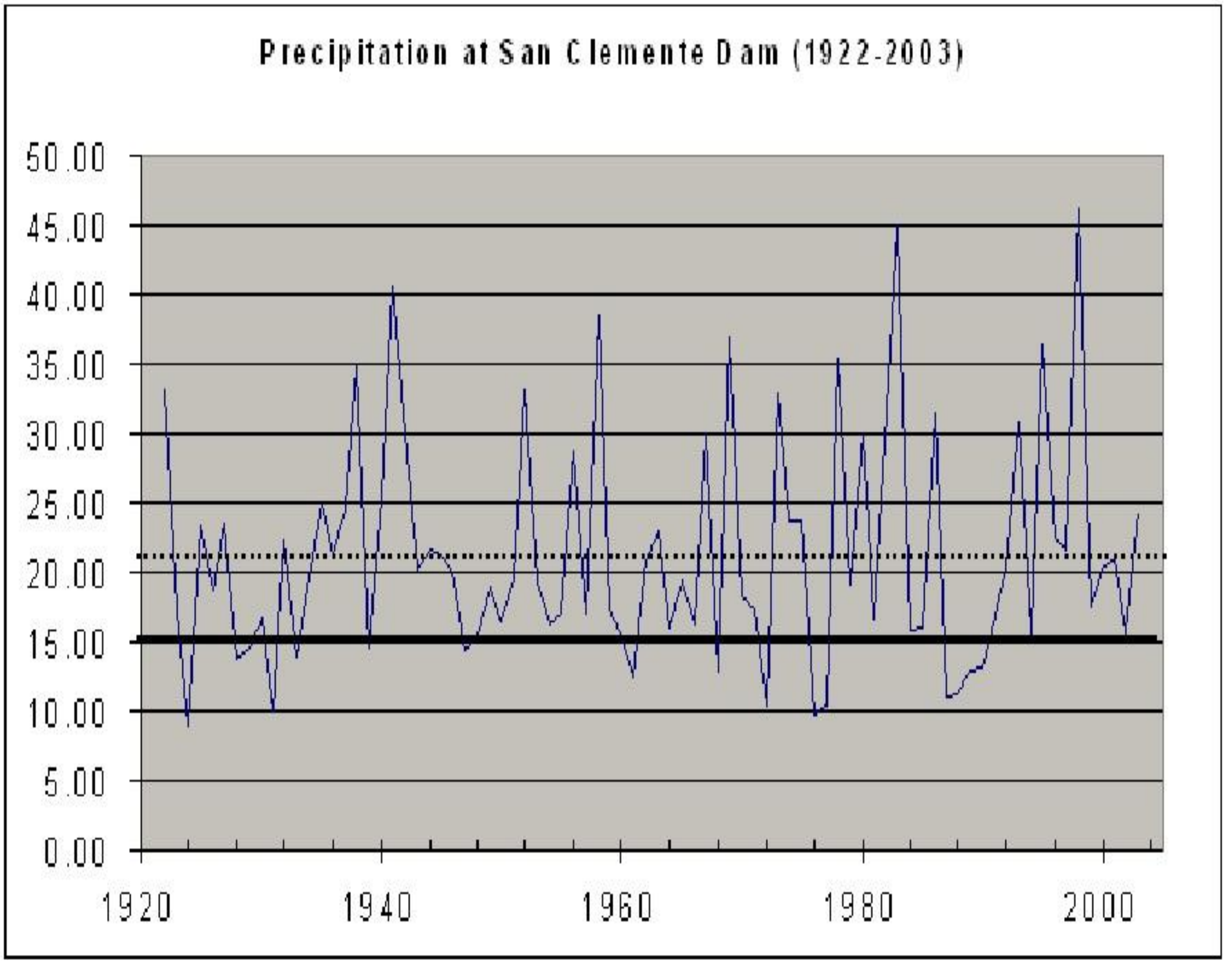


Figure 2-5. Rainfall at San Clemente Dam since 1922. Dotted line is average (21.37 inches). Bold line approximates the level of rainfall giving rise to hydrologically "dry years" reported in James (2009). Rainfall values below that line approximately correspond to hydrologically "critically dry years." Cal-Am data from James (2009) (Smith 2004).

Analysis of this and other records indicate that the Carmel Valley has endured seven droughts since 1902, where drought is defined as two or more successive years of dry or critically-dry conditions (James, 2009). Analysis of this and other records indicate that the Carmel Valley has endured six droughts since 1902, where drought is defined as two or more successive years of dry or critically-dry conditions (James 2009). The State Water Resources Control Board has included the Carmel River to its list of seasonally fully-appropriated streams, noting that, "In normal and wet years, supply exceeds demand, but the area is subject to climatic variability and the impact of multi-year droughts. Since 1976, the Peninsula has endured two extended periods of mandatory rationing; 18 months in 1976 to 1977 and 28 months in 1989 to 1991 (Smith et. al. 2004).

2.3.1 Climate change

The Carmel River is considered a seasonal, fully appropriated stream, which is currently being pumped in excess of its mandated limit, and has little room to withstand added strains of drought cycles. Climate change has the potential to profoundly affect both terrestrial and freshwater ecosystems in the Carmel River watershed (Maurer et al. 2010; Bakke 2008; Barbour and Kueppers 2008; Schindler et al. 2008). Regional climate projections for the South-Central California watersheds suggest a future of longer, hotter summers, with a potentially higher incidence of fog along the immediate coast. These projections also suggest more extreme heat waves and droughts, and more severe precipitation events (Karl et al. 2009, 2008; Cayan et al. 2008a; Snyder and Sloan 2005; Snyder et al. 2002) to which South-Central Coast populations of steelhead appear to have evolved a flexible, opportunistic survival strategy. An important factor for coastal steelhead populations is the continuing role of the ocean in moderating coastal climates due to its high heat capacity. These predictions suggest that coastal steelhead populations at the southern extent of the range will have a more predictable future despite changing climate condition (National Marine Fisheries Service 2013).

The potential negative effects of climate change on steelhead and their freshwater and estuarine habitats are of particular significance. In central and southern California the change in precipitation timing is expected to lead to increased winter runoff, decreased summer stream flow, and changes in the frequency and/or intensity of severe storms, droughts, wildfires, and flooding. In addition, global climate change is expected to result in sea-level rise along the California coast from 3–5 feet by the year 2100. In the Carmel River watershed, such a rise in sea-level would put new areas at risk of flooding, increase the likelihood and intensity of floods in areas that are already at risk, and accelerate shoreline recession due to erosion (Heberger et al. 2009). Many of these effects could be exacerbated by the human response to climate change, particularly as a result of the increase competition for limited freshwater supplies.

The impact of sea level rise on wetlands and lagoons is significant for the Carmel River watershed because if the rate of sea level rise exceeds the rate of wetland accretion, or if wetlands cannot transgress (migrate up and inland), large tracts of critically important habitat, such as the Carmel River lagoon, will become permanently submerged (Heberger et al. 2009; Largier et al. 2010). In the upper watersheds, natural creeks and managed conveyance will see higher flow rates leading to increased erosion and flooding. Regional river levees will provide less protection during higher storm flow events, and coastal levees and control structures will be undersized to manage the combined influences of higher river flows and sea level rise. According to the California Water Plan Update 2009 (Volume 3), failure to take into account the impacts of climate change may lead to the underestimation of areas inundated by 100-year flood (National Marine Fisheries Service 2013).

2.4 Geology and soils

The Carmel watershed is the northernmost of a series of northwest-southeast trending valleys dissecting the rugged Santa Lucia Mountains of the California Coast Ranges. The Sierra de Salinas forms the northeastern divide of the watershed and the northern terminus of the Santa Lucia Mountains forms the southwestern divide. The general physical attributes of the Carmel Watershed drainage area are described in Table 2-2 (Smith et al, 2004).

Table 2-2. Physical attributes of the Carmel (Smith 2004).

Watershed Drainage area	656 km^2 (256 mi^2)
Axial trend	315°
Length	43 km (25.8 mi)
Highest peak (South Cone)	1514 m (4965 ft.)
General divide elevation	1200 m (4000 ft.)
Mouth elevation	Sea level at mouth of Carmel submarine canyon
Relief	1200 m (4000 ft.)
Average slope	3%

Land-use	Wilderness, grazing, viticulture, golf-courses, sparse residential, suburban, urban, and light industrial.
Vegetative Ecosystems	Dominated by chaparral, grasslands, and oak woodland. Local conifer and redwood forests present.
Soil Series	Wide range

The Carmel Watershed is divided into 25 subwatersheds (Fig. 2-6**).** Subwatersheds are separated by the major hydrologic divides (ridges) within the watershed, and named for the principal tributaries or river that drains the region. Each of these Subwatersheds contributes water, sediment, large wood, and organic matter to the Carmel River, lagoon, and Monterey Bay National Marine Sanctuary (Smith et al. 2004).

Figure 2-6. Subwatersheds map (Smith 2004).

West of the San Andreas Fault is the Salinian Block, from which the Carmel River Watershed was shaped. The Salinian Block is a granitic core, or piece of crust, extending from the southern extremity of the Coast Ranges to the north of the Farallon Islands. This area encompasses the Santa Lucia Range and Sierra de Salinas. The southern divide of the Carmel River watershed is the Santa Lucia Mountains, which range from around 4,000 feet up to 5,862 feet. The Sierra de Salinas forms the divide along the northeastern portion of the watershed. These two prominent mountain ranges surrounding the Carmel River Watershed are considered young landscapes. Both ranges have experienced substantial uplift rates for the past two million years.

The physical strength of the rocks and soils determines the flow of rivers and streams, aquifer recharge potential, and landslide probability, therefore affecting land use decisions. Early settlement was deterred by the steep topography, which prevented rapid growth during the 1900s, leaving the Carmel region a rural coastal area when much of coastal California was experiencing large-scale settlement.

Geology plays a first order role in determining the physical condition of the watershed. The geology of the watershed is composed of a complex quilt of igneous, metamorphic and sedimentary rocks in part stitched together by faults of varying ages and other kinds of contacts. The Carmel Watershed is carved into the Salinian Block, a piece of crust that began its existence near the Mojave Desert and moved northward, dragged by the Pacific plate for the past 20 million years (Smith et al. 2004).

The physical strength of the rocks and soils determine the erodibility, landslide potential, and ecosystem and land-use potential. The rocks hold a significant water resource in upland aquifers. The combination of a large range of annual precipitation in the watershed and complex geology gives rise to a complex distribution of soil types, erosion rates, landslide potential, aquifers, recharge areas, ecosystems and human land use (Smith et al. 2004). A major source of bedload in the Carmel Watershed is the fractured granitic rocks in the steep headwaters above Los Padres and San Clemente dams. These sediment sources have reduced the capacities of San Clemente and Los Padres dams by 90% and 50%, respectively (Entrix 2000).

The Carmel watershed lies within the Santa Lucia Mountains at the apex of several fault zones (Figure 2-7). It is underlain by poorly consolidated marine sediments as well as metamorphic and granitic formations with a drainage area of 255 square miles (Smith et al. 2013). The watershed ranges in elevation from slightly greater than 4,000 feet to sea level. The central California coast has a Mediterranean climate with moderate year-round temperatures. Virtually all precipitation falls between November and April, with 60% falling between December and February (Kondolf and Curry 1986). The Carmel River watershed developed into a highly dynamic system, experiencing large seasonal variability in flow levels with subsequent variation in sediment transport from the upper watershed to the lagoon and ocean (PWA 2007).

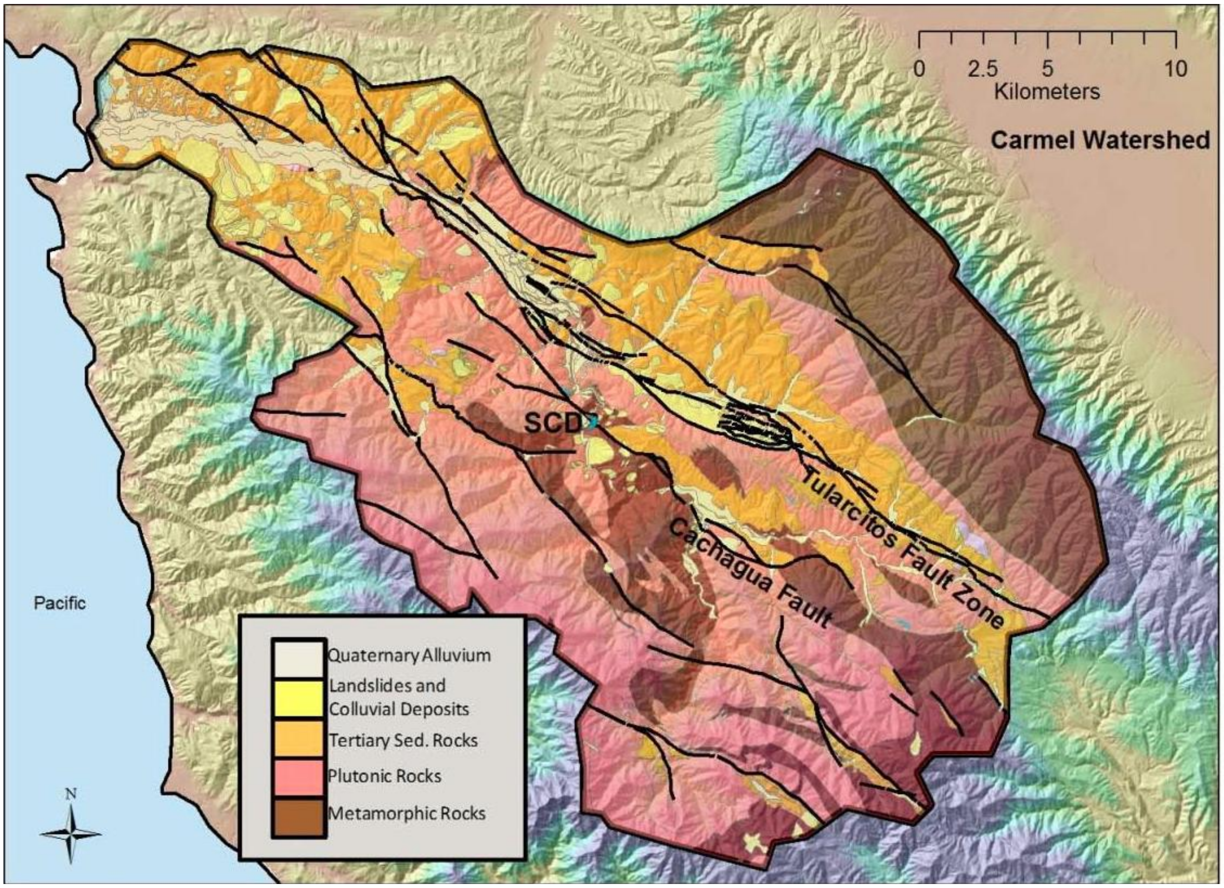


Figure 2-7. Geologic map of the Carmel River watershed (CSUMB 2012)

2.5 Geomorphology

Human settlements have altered the Carmel River systems by way of floodplain development, dams, levees, roads and bridges, all of which confine the river's course. The gentle slopes of the valley floor created by yearly runoff have also been the lands most easily cultivated and built upon throughout the valley's history. While the Carmel River was once a depositing river, building soils and alluvial aquifer storage space, it has now become a deeply incised channel, which intensifies the velocity of water flows along the river's course requiring bank stabilization in an attempt to save property from erosion and floods. Figures 2.8A and 2.8B show the Carmel River's alluvial aquifer, 100-year floodplain and riparian vegetation.

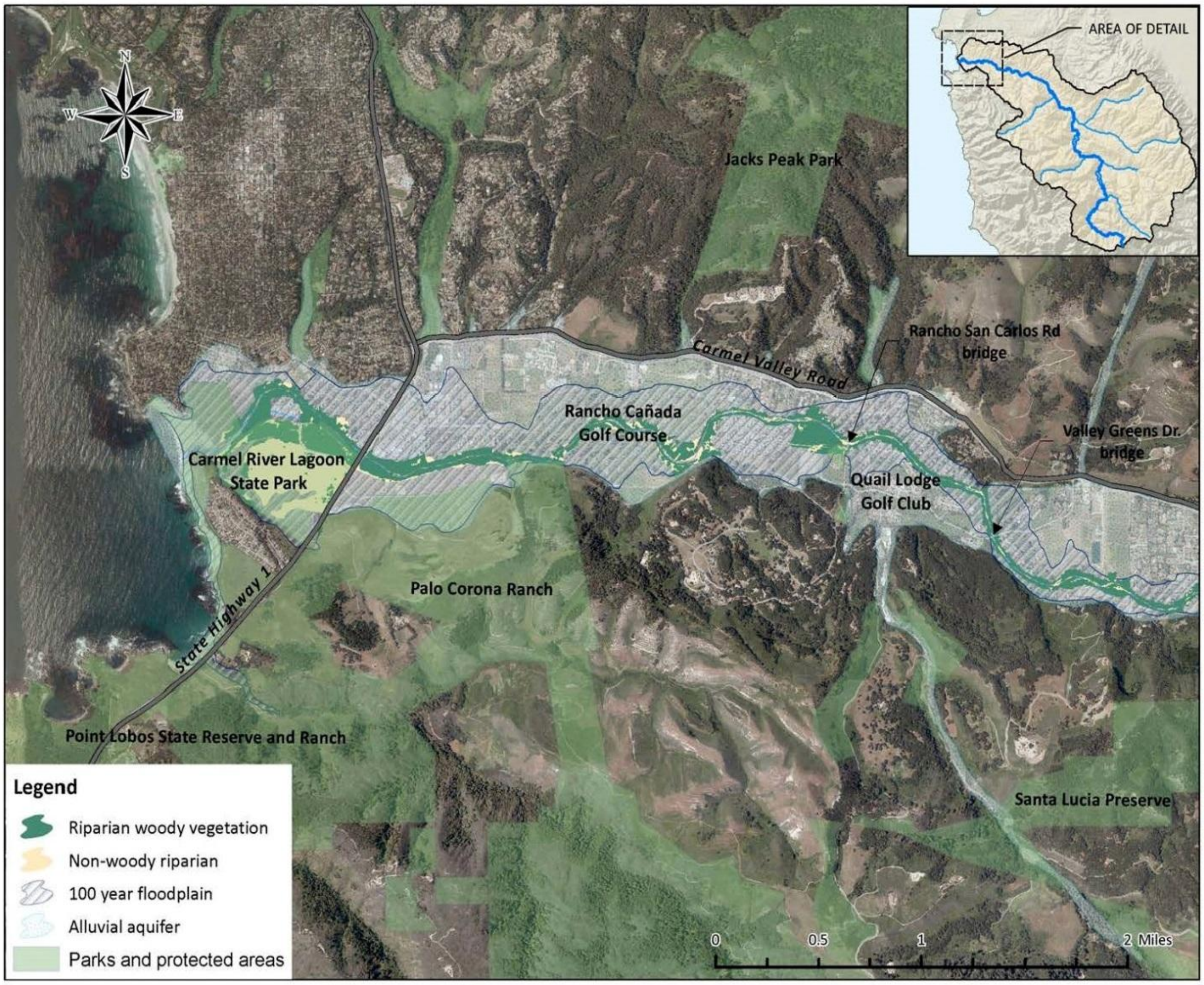


Figure 2.8A. Carmel River's alluvial aquifer, 100-year floodplain and riparian vegetation (Kasey and Peterson 2005),

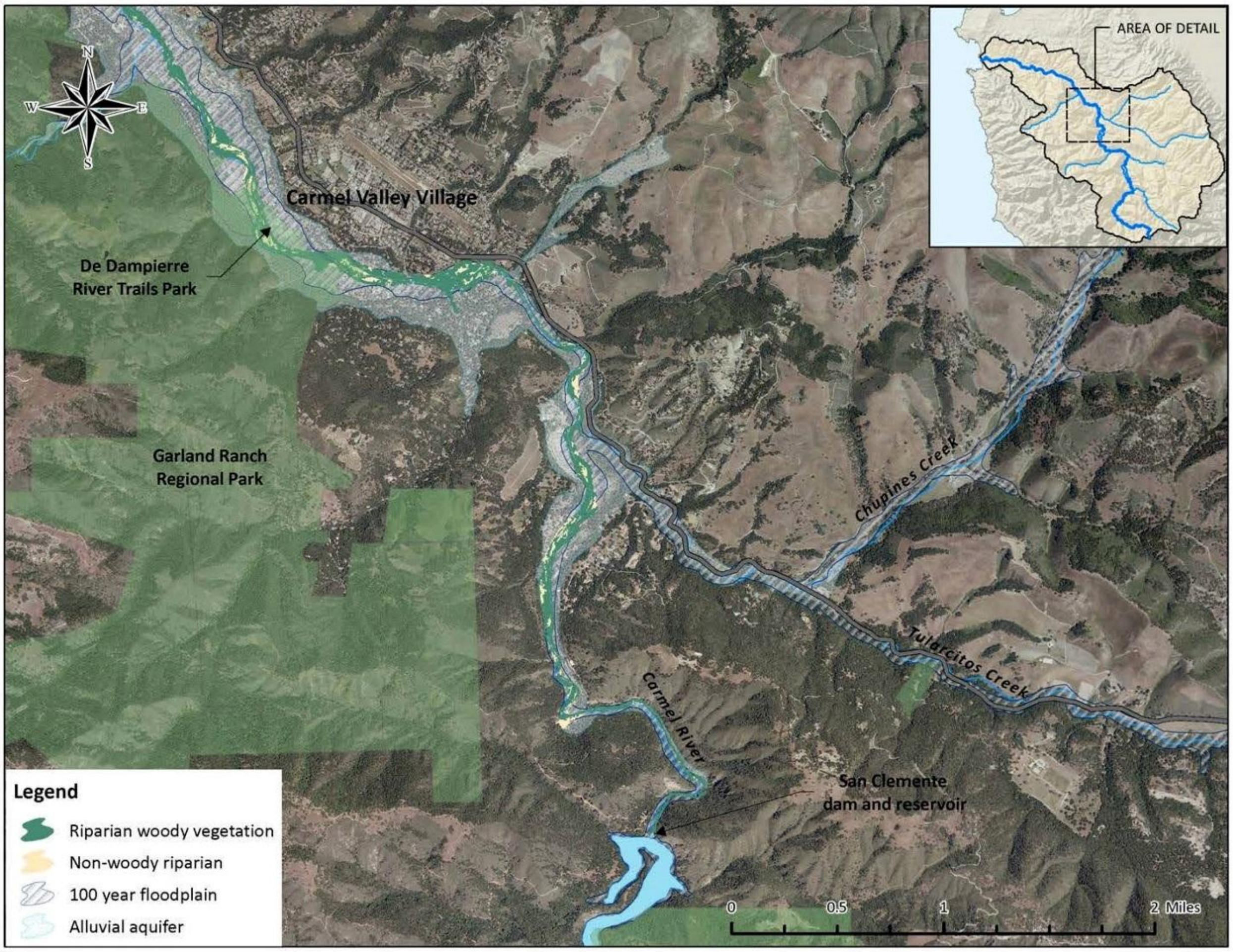


Figure2.8B. Carmel River's alluvial aquifer, 100-year floodplain and riparian vegetation (Kasey and Peterson 2005).

2.5.1 Mainstem and tributaries

The Carmel River flows through the alluvium-filled Carmel Valley, where sediment depths range from 50 to 75 feet before emptying into the Carmel Lagoon (Kondolf and Curry 1986). The river channel has stretches of meandering flow, steep constrained reaches of bedrock, and a few short braided reaches (Kondolf 1996). River valley width and slope are two contributing factors to river behavior that are of particular interest in the mainstem of the Carmel River (Smith et al. 2004).

Dams on the Carmel River have contributed to the incision of the mainstem by trapping sediment, resulting in isolated channels and increased bank instability. In many places, the seasonal sediment regime of sand and gravel has been replaced by coarse cobbles and boulders and a hardening of the downstream river channel. The loss of natural sediment supplies from the headwater areas reduces the availability of spawning gravels below the dams. Hardening of the channel that results from the diminished sediment supply creates lower flushing hydraulic conditions that are less able to maintain spawning gravels. Both effects reduce the actual amount of spawning habitat available for fish reproduction below the dams. Over time, the coarsened and hardened channel bed becomes less mobile during large flows, and the more static and incised river bed loses much of its habitat-forming capacity (PWA 2007).

Vegetation is another key element determining river pattern and profile through processes of bank stabilization and sediment capture (Urquhart pers. comm.). The lower Carmel reaches are characterized by more stable meanders versus braided mid-river reaches, largely due to sustained erosion control by a combination of structural protection and vegetation (Hampson pers. comm.).

2.5.2 Lagoon and estuary

The lagoon and estuary (figure 2-9) are seasonally closed to the ocean by a sandbar which results in extensive inundation of the surrounding low-lying coastal plain at the mouth of the Carmel River. Upstream base flows of the Carmel River, in combination with periodic tidal inundation of the estuary, create seasonal brackish water conditions. The sandbar is naturally eroded on the seaward side by long-shore currents and winter wave action and over-topped and breached by storm related Carmel River flow (National Marine Fisheries Service 2013).

Figure 2-9: Lagoon Aerial Photo (MPWMD 2009).

Following this initial, artificial breaching, the beach berm generally remains open and the river flows to the ocean through the winter and early spring. During this period, the lagoon closes and opens (either naturally or by artificial breaching) multiple times depending on variable ocean and river conditions (Watson 2008). As inflows recede in spring or summer, the river mouth eventually closes for the remainder of the season until the next significant rainy period repeats the process (James 2005).

2.5.3 Carmel River State Beach

The Carmel River State Beach, governed by the California Department of Parks and Recreation, is one mile long and extends between two granodiorite outcrops from Abalone (Carmel) Point to Granite Point. The beach receives the majority of its sediment from the Carmel River during winter storm events. The beach has historically experienced sediment loss through anthropogenic processes along the Carmel River. Between the 1920's and 1970's, sand and gravel mining depleted sediment from both the river and the beach. Construction of the San Clemente Dam in 1921 and the Los Padres Dam in 1949 further interrupted sediment supply, which is evident through the mound of impounded sediment behind the dam. Floodplain development in the watershed and bank stabilization projects has also reduced sediment supplied to the beach by the river (Smith et al. 2012).

2.6 Erosion and sediment

The Carmel River region has naturally high erosion and sedimentation rates due to the principal rock types previously discussed. During storm events, large sediment loads are carried in rivers and streams. Naturally occurring fires can also contribute to the high sedimentation rates. Historically, this erosive landscape deposited rich alluvial sediments with each successive flood. This naturally occurring cycle created prime farmlands within the Carmel River's alluvial valley.

Human activities and development have hindered the natural sedimentation processes. Today levees interrupt flood cycles, depriving the historical floodplain of sediment. At the same time, disturbed riverbanks and abandoned dirt roads contribute to excessive sedimentation rates. Two upriver dams have also interrupted deposition patterns and stream ecology throughout the lower reaches of the river. This has caused significant impacts on native vegetation and wildlife. Changes in gravel composition, in particular, can severely damage Carmel River steelhead trout and other amphibian habitats.

In the future, levees may be adjusted or removed to better accommodate the natural flow cycles. Removal of the San Clemente Dam will provide a unique opportunity to restore more natural stream conditions and sediment cycles.

Some of the major erosion and sediment problems in the watershed are summarized below, in no particular order (Smith et al. 2004):

- Demand for water far exceeds water supply, leading to many related subordinate problems.
- Extensive urbanization exists within the regulatory 100-year floodplain and in the dam-failure inundation zone.
- Excess sediment is generated from a very large number of dirt roads, some of which are abandoned, some of which out of compliance with grading ordinances, but most of which are clearly within regulations.
- Nearly all sub-road drainage culverts are undersized, leading to downstream erosion, whether related to dirt roads, paved roads, or highways.
- Excess sediment is generated by many bare road cuts on dirt roads, paved roads and highways.
- Excess sediment is generated in tributary drainages by soil slip, gullies, unstable stream banks, and roads. Many of those issues are related to cattle impacts.
- Excess sediment is generated in a great number of incised streams that have tall, exposed banks.
- Los Padres Dam is rapidly infilling with sediment and is also close to active faults.

• Watershed impairment is the result of incremental, permitted, changes that have a large cumulative impact on the watershed.

2.6.1 Erosion

The chief erosive processes in the Carmel Valley are bedrock landslides, shallow soil slips, rock fall, stream incision and widening, and slope gullying. Regions undergoing rapid tectonic uplift, like the Carmel Watershed, maintain steep, rugged landscapes whose slopes are perennially at the threshold of failure. Grading for roads and buildings locally over-steepens these slopes, greatly accelerating the rate of slope failure and erosion. For this reason, nearly the entire Carmel Watershed is rated as highly susceptible to erosion (Figure 2-10).

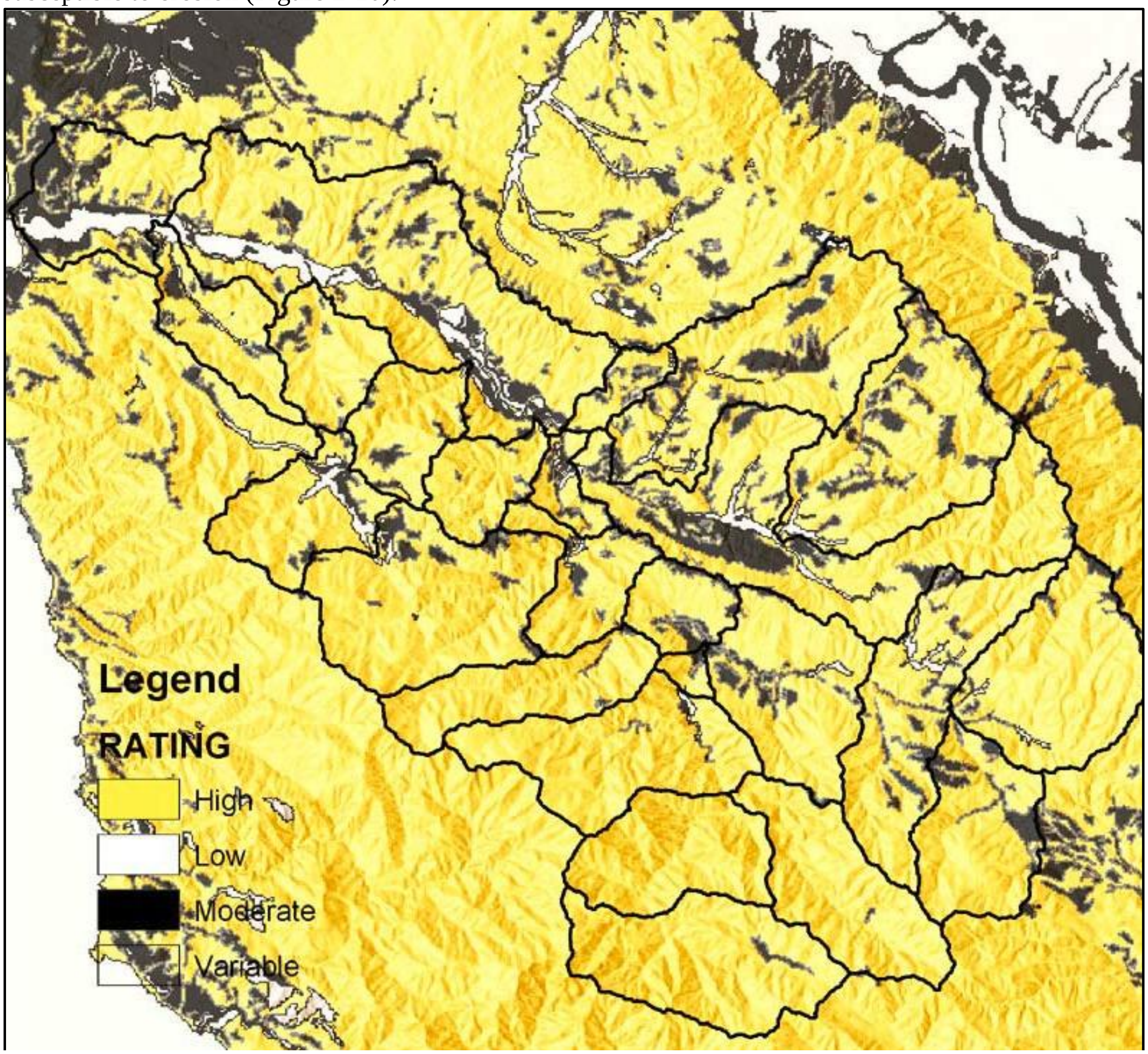


Figure 2-10. Erosion susceptibility in the Carmel Watershed (Rosenberg, 2001) (Smith 2004).

Physical processes and ecological conditions in the Carmel River watershed have been affected by historical land uses, groundwater pumping, dam construction, urban development, bank revetment, land management practices, and road building. These activities increase erosion and the delivery of a fine sediment supply to tributaries and the mainstem, exacerbate low flows in the summer and fall, degrade riparian and aquatic habitat conditions, create barriers to fish migration, decrease water and sediment quality, and introduce non-native invasive species (Monterey Peninsula Water Management District 2004).

During and after large storm events, storm water related erosion, drainage problems, and flooding occurs throughout the watershed, especially in the lower mainstem and estuary. The combination of steep topography, lack of adequate drainage facilities, and location of many parcels in the 100-year flood zone results in localized poor drainage and flooding of residences, buildings, and roadways during storm events. Storm water related flooding and erosion in the lower watershed are primarily the result of a combination of factors including estuary management, high river flows, and ocean conditions (high tide, storms). The lower Carmel reaches are characterized by more stable meanders versus braided mid-river reaches, largely due to sustained erosion control by a combination of structural protection and vegetation (Hampson pers. comm.). Channel erosion have degraded riparian habitat, impacting aquatic and terrestrial biota (Monterey Peninsula Water Management District 2004).

Despite concerns about erosion caused by infrastructure and channel modifications, streambanks in the Carmel River mainstem presently appear to be relatively stable during average water years (MPWMD 2000-2013). A noticeable change to the channel bottom is the obvious continued degradation (i.e., the river channel is incising into floodplain deposits). Downcutting into channel deposits has both positive and negative aspects. On the plus side, it is clear that sand and fine material has been winnowed out in the past few years, exposing gravel and cobble layers that provide improved spawning habitat for steelhead and suitable substrate for the food web that steelhead depend on. However, a lack of a natural supply of sediment from the upper watershed (due to the presence of mainstem dams) means that the river must remove material from the channel bottom and streambanks to make up for this deficit. The river system downstream of Los Padres Dam remains "sediment starved."

Because approximately 35% of the streambanks downstream of Carmel Valley Village have been altered or hardened over the past 40 years, most of the current sediment supply comes from scouring of the channel bottom, which results in exposing the base of streambanks, bridge piers and abutments. Without corrective measures to balance the sediment load with the flow of water, streambanks will begin to collapse and the integrity of bridges will be threatened. A comprehensive, long-term solution to overall environmental degradation requires a significant increase in dry-season water flows in the lower river, a reversal of the incision process, and reestablishment of a natural meander pattern. Reversal, or at least halting, of channel incision may be possible if the supply of sediment is brought into balance with the transport capacity of the river. Although sediment flows are projected to slowly increase after the dam is removed, it may not be enough to halt the incision process. Over the long term, an increase in sediment supply downstream of Los Padres Dam could help reduce streambank instability and erosion threats to public and private infrastructure (CDWR 2012).

2.6.2 Sediment

The sediment transport characteristics of the Carmel River and its tributaries have been studied extensively. Figure 2-10A depicts the stability of soils in the watershed. The combination of the most severe drought on record in 1976-77 and an extremely wet period between 1978 and 1983 caused unusually high amounts of sediment to be discharged into the riverbed. Sediment measurements conducted during the wet period most likely reflect a short to medium term condition in which a large amount of sediment was moved. Many of the homes in Carmel Valley are built on a broad terrace deposited by large floods in 1911 and 1914 (Kondolf 1983). The terrace is a reminder that floods, sedimentation, and related channel stability are of serious concern seasonally in the watershed (CDWR 2012).

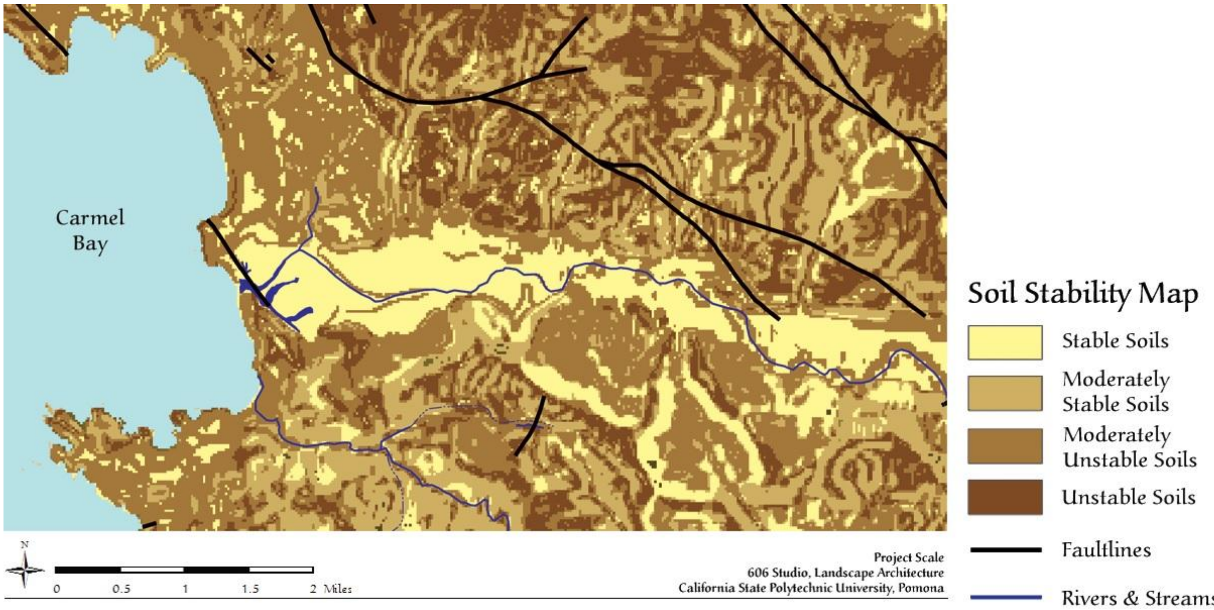


Figure 2-10A. Soil stability map (Kasey and Peterson 2005).

Sediment derived from the watershed can be divided into bedload, which is too large to be bounced high off the stream bottom, and suspended load, which is fine material suspended by water turbulence (Leopold et al., 1964). Bedload of the proper amount and grain size is required to maintain channel stability and spawning habitat, but too much or too little can change both the habitat quality (Dettman, 1989) and the stability of a river channel. Such changes are typical downstream from dams, which impede the natural flow of watershed sediment (Kondolf and Curry 1986; Kondolf 1997; Kondolf and Metzer 1999; Watson et al. 2003).

Large volumes of both bedload and suspended load sporadically leave the Carmel watershed (Smith et al. 2004). Krebs (1983) estimated that the Carmel River passed 1.9 million tons of sediment in the wet winter of 1982-1983, far in excess of the normal load of the Carmel River. Bedload was about 22% of that mass. Over half of the bedload was passed in just 1.5% of the time, while water discharge was above 3000 cfs. On the other hand, less than 1% of sediment load was passed when river was flowing less than 200 cfs, which occurred 66% of the time of the study. This strong dependence upon high flows suggests that the watershed generates and stores sediment during normal or low-flow years, leaving it poised for extremely high transport rates during wet years. This behavior is also observed in Arroyo Seco (Watson et al, 2003), and may be typical of the Mediterranean climate (Kondolf and Smetzer 1999).

Both bedload and suspended load sediment are being generated from all the tributaries feeding the Carmel Valley. Bedload estimates from some tributaries in the watershed are included in Table 2-3 (See Figure 2-4 for tributary locations)**.** As is almost universally the case in North American watersheds, it is unclear how much of this bedload material is from natural background erosion, and how much might be reduced if human impacts were reduced.

Table 2-3. Estimated tributary bedload sediment yield from select Carmel River tributaries**.** Data modified from MEI (2002). Note that unit yield was incorrectly reported in MEI (2002). Average annual sediment yield (tons) (Smith et al. 2004).

Location	Drainage area (sq. mi.)	Bed material load	Unit yield (tons/sq. mi.)
Tularcitos, Chupines, and Rana Creek	52	915	18

Hitchcock Creek	4.5	542	120
Garzas Creek	13.2	392	30
Robinson Creek	5.4	521	96
Potrero Creek	5.2	99	19

Sediment "unit yield" is the rate of sediment eroded per unit of area in the watershed, so it can be used as one index of disturbance (Table 2-3). Hitchcock Creek stands out as a watershed that has a high proportion of bare soil to vegetated soil, perhaps associated with housing or road construction.

The estimated high sediment unit yield shown in Table 2-3 for Robinson Canyon may have three chronic sources. First, Robinson Canyon Road is very typical of canyon roads leaving the Carmel Valley; there are numerous sites with eroding road cuts that are mostly devoid of vegetation that would typically control erosion in this area. Second, road cuts high in the canyon, not far from the divide, have over steepened very weathered sandstone of the Chamisal Formation, leading to large gully formation and shallow landslides. Third, housing and road construction in the canyon, which typically results in increased slope erosion (Smith et al. 2004).

The Tularcitos watershed stands out among the lowest in terms of estimated unit yield, despite locally high erosion rates. The relatively low sediment yield here reflects the relatively drier conditions, and consequently lower water yield in this part of the watershed (Fig. 2-11). Of note is that estimated sediment-rating graphs show that Tularcitos Creek moves a disproportionately high sediment load with relatively little flow, and then, as water flow increases, the sediment rate is comparable to other tributaries Fig. 2-12 (Smith et al. 2004).

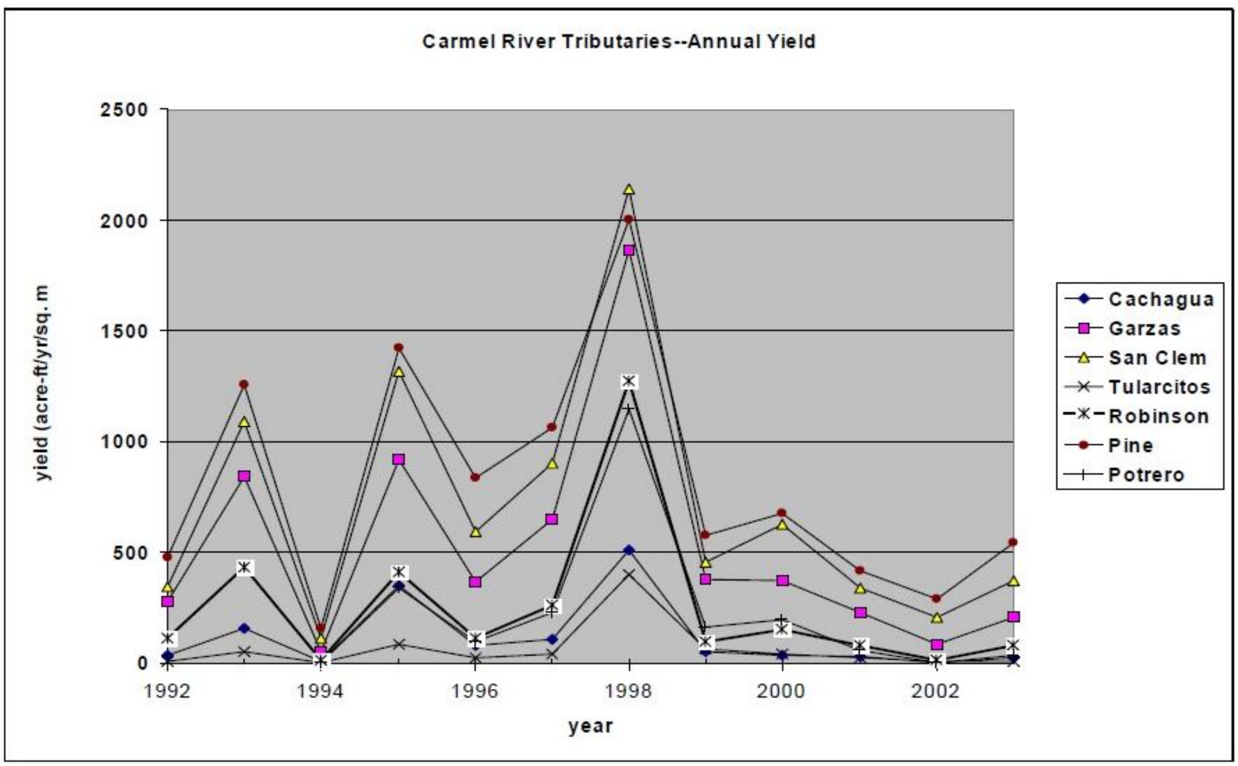


Figure 2-11. Annual water yield of gauged tributaries in acre-feet/year/mi2 (Smith 2004).

The inflection in the Tularcitos graph indicates that there is an overabundance of sediment, but that it is mostly very fine grained bedload material that is easily flushed downstream with relatively low flows. Once the fines are removed, the Tularcitos sediment rating is comparable to other channels, up to a discharge value of approximately 200 cfs (Figure 2-12) (Smith et al. 2004). Although Figure 2-12 suggests significant sediment measurement data exist, including measurements at over 1000 cfs, it is clearly based upon synthesis of data from very few studies, and at much lower flows (MEI 2002). As sediment yield is one obvious barometer of watershed condition and departure from optimum conditions, frequent bedload and suspended load monitoring should be implemented to improve future watershed management capabilities (Smith et al. 2004).

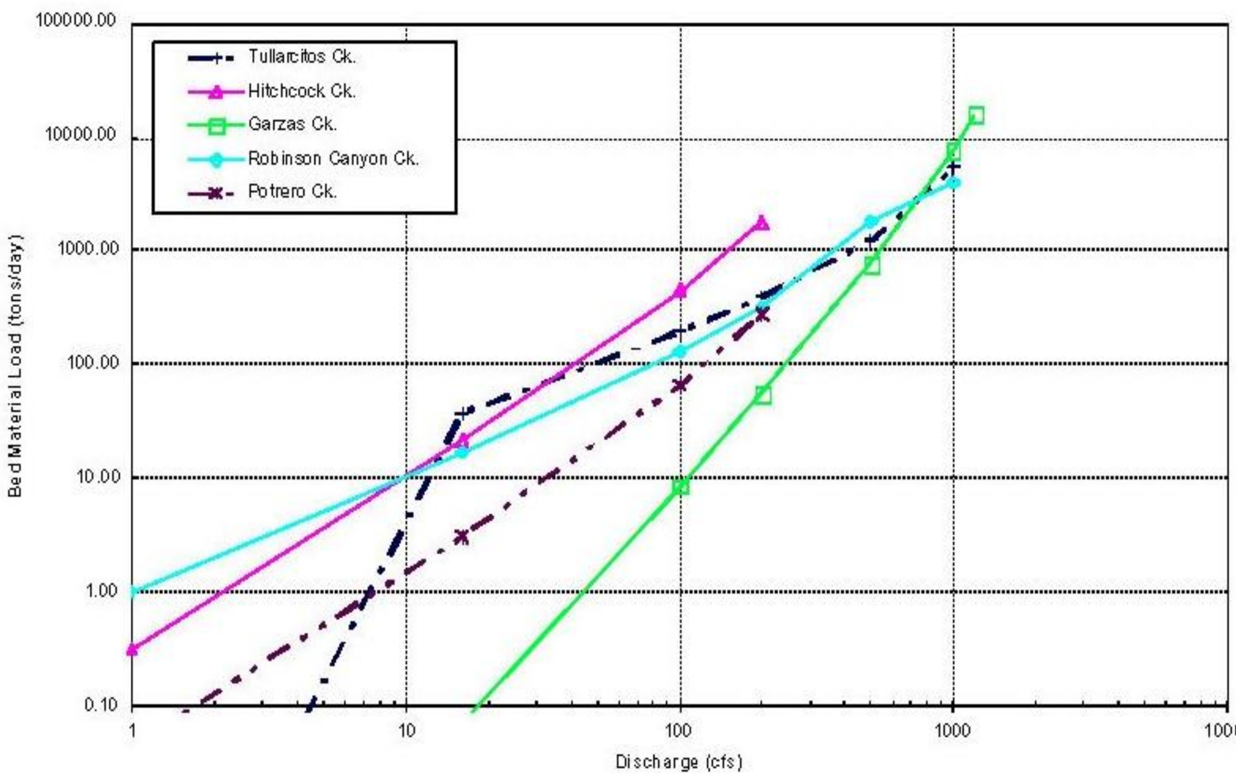


Figure 2-12. Estimated sediment rating relations for select tributaries to the Carmel River (MEI 2002). Bottom axis is water discharge (ft3/s); Vertical axis is bed material load (tons/day) (Smith et al. 2004).

2.7 Contributors of erosion and sediment

2.7.1 Fire

Wildfire is a significant part of the Central Coast landscape and the Carmel River Watershed natural history, with an estimated pre-1900 fire frequency of 21 years in the Santa Lucia Range (Matthews 1989). Large fires are known to have occurred in the watershed in 1927 (Miller Canyon Fire), 1977 (Marble Cone Fire), 1999 (Kirk Complex Fire) and most recently, in 2008 (Basin Complex Fire). According to recent research, there is evidence that periodic fire has occurred in the region for the past several thousand years, and that ecosystems in the region developed under the influence of these natural and man-made fires. For the past 100 years, however, fire frequency has decreased, and most fires have been suppressed. Fire suppression has led to increases in surface and crown fuels, invasion of woody vegetation in the understory, and increased tree density (Purcell and Stephens 2005). A combination of fire suppression and development in the urban-wildland interface altered both the spatial and temporal pattern of the fire regime.

In central California, fire is an important episodic natural disturbance, necessary for the germination of many chaparral species found in this region. Several native plant species in the area (e.g. manzanita) reproduce most abundantly following fire. However, fire poses direct threats to public health and safety including airborne ash and infrastructure damage. In addition, the sediment response following fire can dramatically change the morphology of a watershed and lead to damages associated with flooding (Hecht 1977). In the Carmel River Watershed, an important and well-documented effect of wildfires is the increased sediment loads that enter the river as a result of all the debris and erosion from fire impacted areas, and from fire suppression activities, particularly if a wildfire is followed by a strong rainy season (Smith et al. 2004).

Other impacts include increases in flood risk, reduction of reservoir capacity, and increases in the erosion, transportation, and deposition of massive amounts of fine sediments into watercourses containing coarser-grained spawning gravels, destruction of riparian vegetation, and facilitation of the spread of non-native plant and animal species (National Marine Fisheries Service 2013).

Part of the Carmel River Watershed is located within the Los Padres National Forest, where an average 25,000 acres are burned annually by seasonally occurring wildfire (Smith et al. 2004). Following the large Marble Cone Fire of 1977, high sediment yields entered the Carmel River stream in the Los Padres watershed, and this single event contributed to a large part of the capacity loss at the Los Padres reservoir (Smith et al. 2004). In 2008, two large fires took place in the Los Padres National Forest: the Indians Fire and the Basin Complex Fire. The Basin Complex Fire was caused by lightning, and merged with the "Indians Fire" which had been burning for a month; combined, the two fires burnt over 240,000 acres, making it one of the largest fires in the history of California (De Santis et al. 2010). Sediment erosion rates are typically elevated following fires. Debris flows are the greatest potential source of reservoir-filling sediment in the steep erodible sub-watersheds above Los Padres Reservoir. The elevated risk of slope failure and debris-flow generation diminishes in the first few years following a fire.

2.7.2 Landslides

The seismically active Santa Lucia Range is prone to landslides. Relatively rapid geologic uplift of the range created deep, V-shaped canyons with sharp dividing ridges (Smith et al. 2004). Rosenberg (2001) assessed the Monterey County region for landslide susceptibility, including the Carmel River watershed. The study area includes landslide susceptibility ranging from moderate to high, particularly in the steep abutments of the upper watershed and downstream slopes. Landslides are also currently a significant source of sediment in the watershed (Smith et al. 2004). The largest active landslide in the Carmel subwatershed is located upstream of the San Clemente Dam (Smith et al. 2004). Willis *et al.* (2001) mapped over 1500 landslides along Highway 1 between San Capoforo Creek and Point Lobos, just near the mouth of the Carmel Valley, suggesting that slope-failure processes are a common occurrence in the region. Rosenberg (2001) assessed Monterey County region for landslide susceptibility including Carmel Watershed (Fig 2-13) (Smith *et al.* 2004). Fig. 2-13 indicates that approximately 57% of the landslides in the watershed are restricted to three specific rock types: Monterey Shale, Tertiary Sandstone and a granitic rock type called Porphyritic Granodiorite of Monterey. Over 85% of all past mapped landslides occurred on slopes less than 30% grade (Smith et al, 2004). Of note is that County ordinances and the Carmel Valley Master Plan prohibit grading on slopes greater than 30% grade (MCRMA 2013).

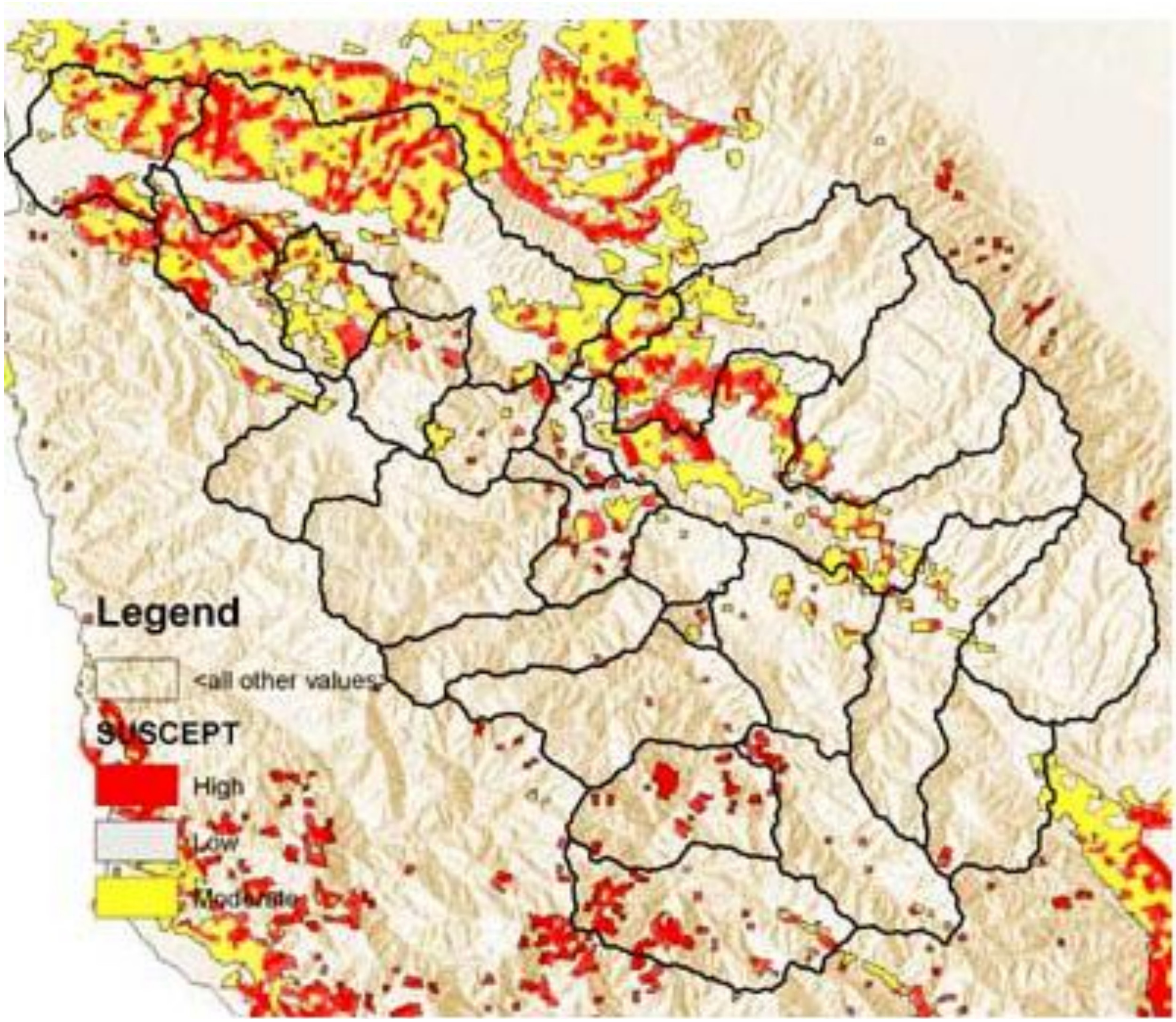


Figure 2-13. Landslide susceptibility in the Carmel Watershed (Rosenberg, 2001, Smith 2004)

Reconnaissance work conducted by Smith in 2004 indicated generally good agreement between the susceptibility map (Fig. 2-13) and the present distribution of large landslides. However, it should be noted that there is a high risk of creating landslides on any steep slopes of the watershed if roads and structures are poorly constructed. Landslides presently are a significant source of both natural and anthropogenic sediment in the watershed. A digital geologic map of the watershed (Rosenberg 2001) was used to further assess the conditions for landslide potential in the watershed. By cutting the geologic layer using the mapped Quaternary landslides as the cutting shape, it was determined that both the rock formations **(**Fig. 2-14) and slope angles that are most conducive to producing large landslides (Smith *et al.* 2004).

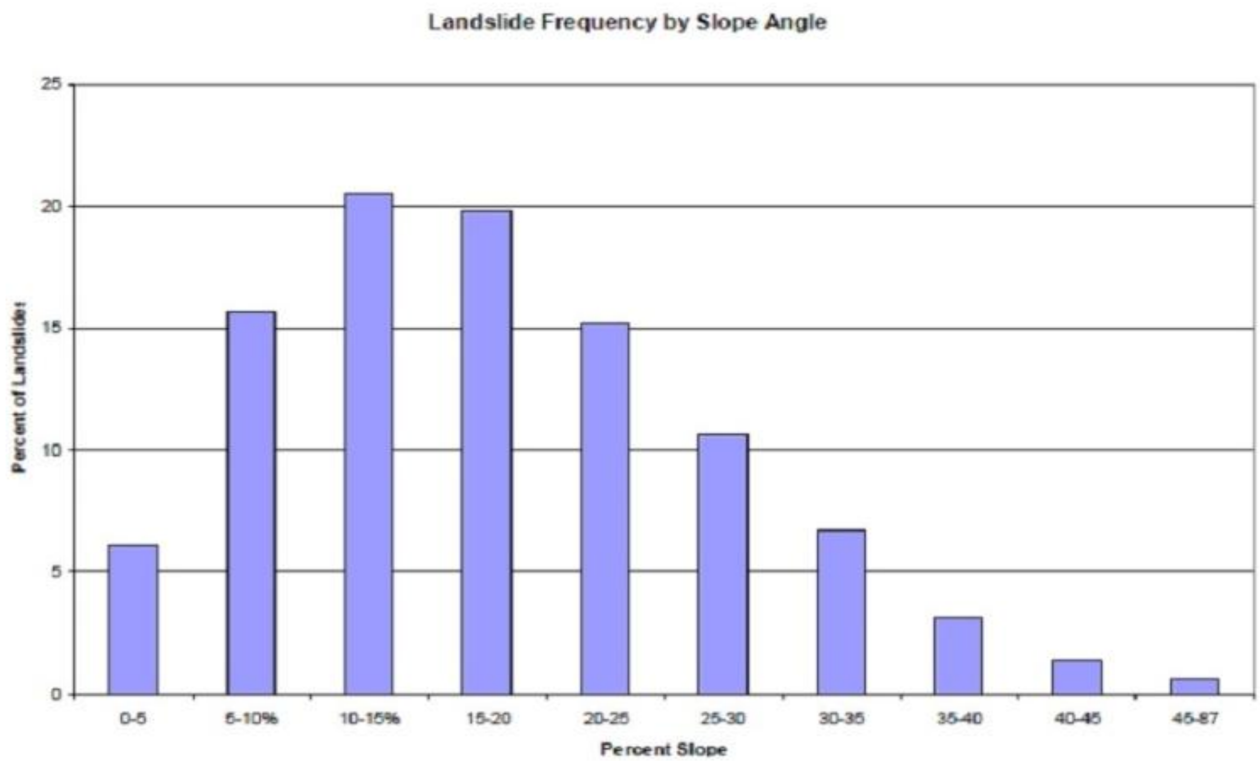


Figure 2-14. Relationship between mapped Quaternary landslides and hill slope gradient in the Carmel Valley.(Smith 2004)

2.7.3 Flooding

Levees have been constructed during the urbanization and development along the river corridor. While the objective of the levees has been to protect developed land from damage during moderate flows, the result has been a false sense of protection from major flood hazards. Consequently, the desire to build directly within the floodplain has been compounded over time. Upstream levees have withheld flows increasing downstream overflows and damage from flooding (Smith et al, 2004).

The 100-year floodplain has a probability of being inundated by flood events ten times in the next 1,000 years while the 500-year flood event is expected twice in the next 1,000 years. However, an interval is not implied by these probabilities. For example, two 100- year floods could occur within the same year (Smith et al, 2004). The mapped areas used to guide development decisions in the Carmel River Valley are only estimations and are likely to change with specific storm events and changes in river morphology. Evidence of the uncertainty of the floodway boundaries was witnessed in recent history. Though the flood of 1998 was a 30-year flood and the 1995 flood was a 65-year flood, the 1998 floods caused significantly more property damage than the previous flood (Smith et al, 2004).

Recent flood events and resident concern have brought about studies and restoration efforts of the floodplain. The Carmel River Lagoon Restoration Project, currently underway, will add significant flood protection to residential neighborhoods north of the lagoon. It also provides a habitat restoration opportunity to an area that was once a significant wetland that was drained and filled for agriculture in the late 1800s. Wetland arms that reflect the original form have been excavated in the Carmel River Lagoon area. Levees have been notched east and west of Highway 1 to relieve floodplain constriction, and plans are underway to expand floodplain potential east of the highway. Figure 2-15A illustrates floodplain functions and delineates the 100-year floodplain.

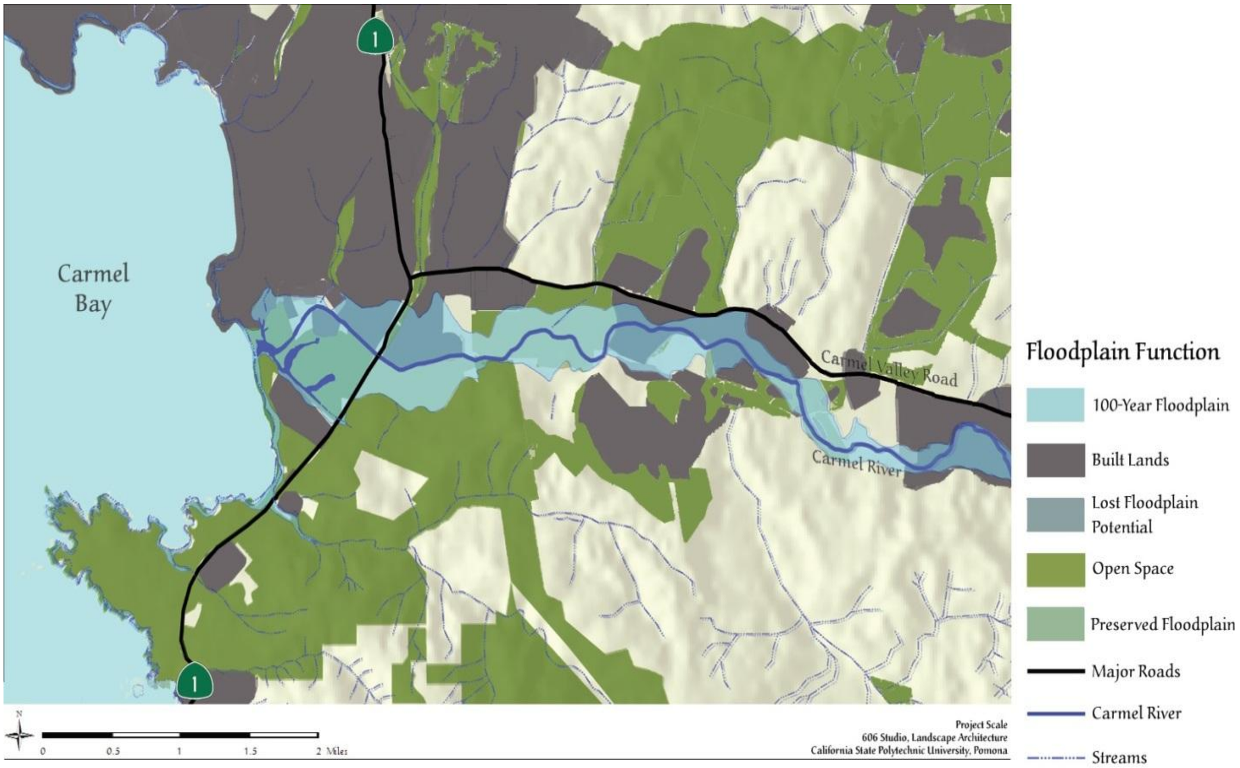


Figure 2-15A. Floodplain functions map (Kasey and Peterson 2005).

Major flood events have occurred in Monterey County during 1911, 1914, 1922, 1926, 1931, 1937, 1938, 1941, 1943, 1945, 1952, 1955, 1956, 1958, 1962, 1966, 1969, 1973, 1978, 1983, 1995, and 1998 (Monterey County Water Resources Agency [MCWRA] 2003). Flooding has occurred along the Carmel River on multiple occasions. Private levees have been constructed along the lower Carmel River as a result, although they are not adequate to hold the 100-year flood (FEMA 1991). Monterey County enforces flood control standards within 100-year flood hazard areas in accord with National Flood Insurance Program (NFIP) requirements. At the USGS gage near Carmel, the 100-year flow has been estimated to be 29,100 cfs. Figures 2-15B and 2-15C delineate the 100-year floodplain and show examples of development in the floodplain.

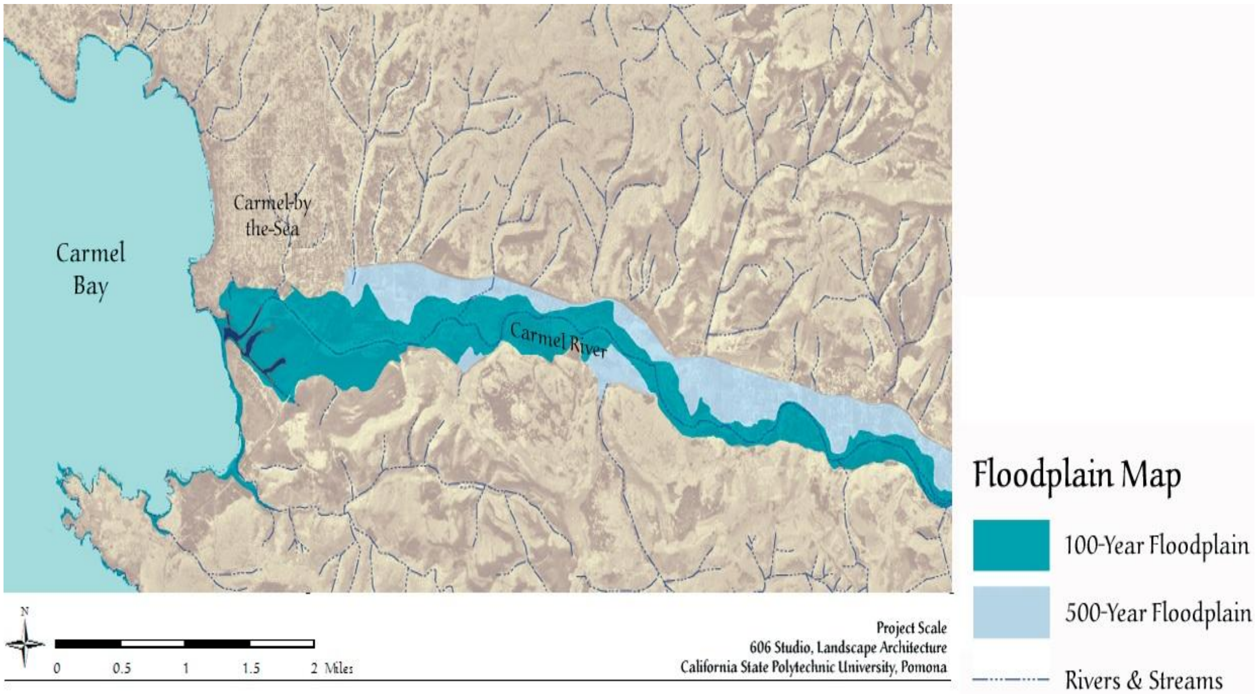


Figure 2-15B. Approximate boundaries of the 100-year floodway (FEMA 1996).

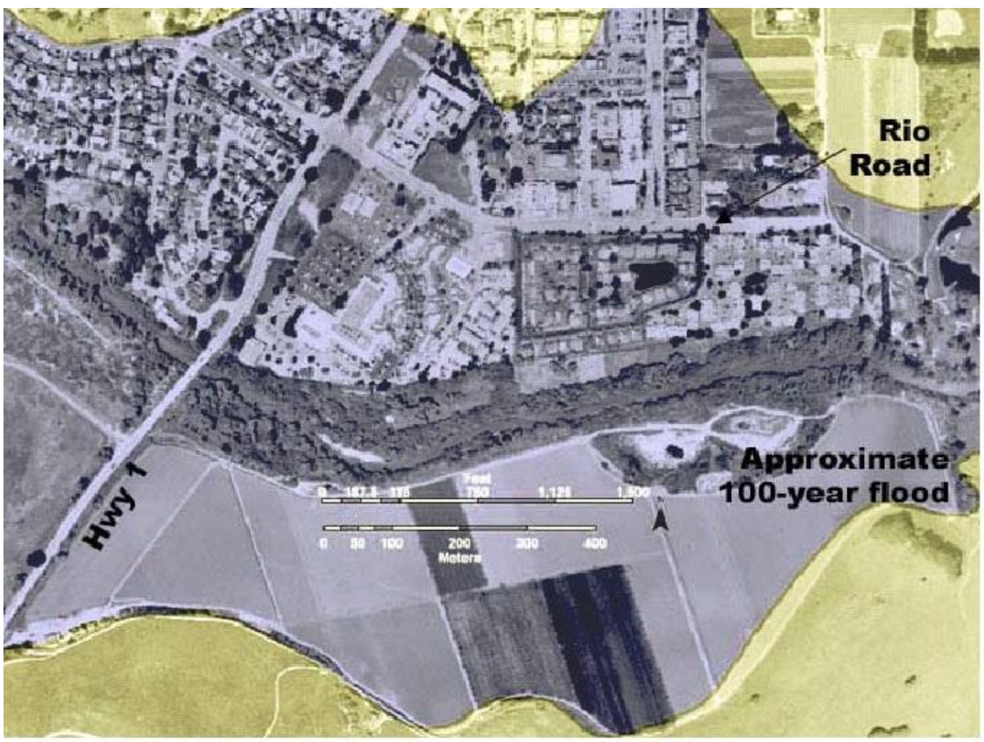


Figure 2-15C. Example of urban development in the lower Carmel River that would be affected by the estimated 100-year flood. Approximate affected area shown in blue (FEMA 1996). Levees exist along both sides of the Carmel River upstream (right) of Highway One. Background photo from MEI (2002) (Smith 2004).

In more recent history, two flooding events occurred along the Carmel River in 1995, one in January and one in March. During the March event, flooding in the Carmel Valley damaged 400 residences and 68 businesses, the Highway 1 Bridge over the Carmel River was closed, and untreated sewage was released into the Carmel River (MCWRA 2003).

The last major flood control channel clearing project using bulldozers occurred in the fall of 1977 in response to a massive die-off of streamside vegetation. This die-off was associated primarily with severe drought and increased groundwater pumping. Many property owners and the Monterey County Flood Control District (since renamed the Monterey County Water Resources Agency) were concerned that the large number dead trees would wash out of the banks and cause debris dams along the river. A flood in 1969 had damaged or washed away several bridges along the river. Photographs from the period depict debris build-ups in several areas, so it is possible that some of the actions in 1977 to clear the river were based on the 1969 experience. Property owners who recalled the clearing said multiple bulldozers were used to remove the dead vegetation in the Schulte reach and near Carmel Valley Ranch. Removal of the vegetation and disturbance of the banks had the disastrous effect of exposing unconsolidated streambank material to high flows between 1978 and 1983. The result was predictable – a severe episode of bank erosion.

Approximately 1,600 parcels have been identified as having residential use and being affected either wholly or in part by the FEMA-defined floodplain (MPWMD 2005). A majority of these are located in the lower six miles, between the lagoon and Schulte Road Bridge. Approximately 420 individual parcels lie adjacent to the mainstem in the lower 18.6 miles of river. In a few reaches, structures virtually overlook the river, or floodplain development has marched to the top of the riverbank, leaving little or no riparian buffer. Building practices and land use changes within the 100-year floodplain were formally regulated by the County of Monterey with the Carmel Valley floodplain ordinance in 1984. About 2.5 miles of this portion of the river is publicly owned. Much of Carmel Valley, including areas adjacent to the river, has developed into premium value real estate, second in cost only to Pebble Beach on the Monterey Peninsula (Monterey Peninsula Water Management District 2004).

Since 1990, MPWMD has conducted vegetation management using hand tools (chainsaw and loppers) as the preferred method of clearing the river channel of vegetation. Most of the large gravel bars deposited in the 1978-1983 episode of erosion have been reconfigured as functional floodplains and revegetated, rather than pushed to the outside of the active channel (Monterey Peninsula Water Management District 2004).

2.7.4 Infrastructure and channel modifications

Infrastructure development and channel modifications in the tributaries and mainstem of the Carmel River include man-made constructs such as dams, roads, and bridges, and facilities related to water extraction. Channel modifications include straightening channels, construction of levees for flood control purposes, and bed and/or bank revetments as protection against bank erosion. These activities increase erosion and the delivery of fine sediment to creek channels, exacerbate low flows in the summer and fall, degrade riparian and aquatic habitat conditions, create barriers to fish migration, decrease water and sediment quality, and introduce non-native invasive species (CDWR 2012).

Since the San Clemente Dam removal in 2015 there will be some additional natural background sediment returning to the system. It will be important to monitor this condition and document how infrastructure and channel geometry react to this change.

2.7.5 Dams

There are three significant dams in the Carmel River watershed: Old Carmel River Dam, San Clemente Dam, and Los Padres Dam. The Old Carmel River, San Clemente and Los Padres Dams were constructed on the mainstem Carmel River in 1880, 1921 and 1949, respectively, for municipal and agricultural water supply (NMFS 2012). The Old Carmel River Dam was constructed in 1880 to deliver water through a 25- mile pipeline to the Del Monte Hotel in Monterey. The dam is sometimes refereed to as the "Chinese Dam" because 700 Chinese workers constructed the dam with granite. The San Clemente Dam and Reservoir, built in 1921 at RM 18.6 (measured from the ocean) is a 106 foot concrete arch dam. It is currently being removed because it has been deemed unsafe by the Department of Saftey of Dams and is nearly full of sediment (2.5 million cubic yards) and no longer has usable storage. The target date for complete removal is fall of 2015. The original storage capacity of San Clemente Reservoir was 1, 425 acre-feet and was reduced to less than 90 % of its original storage capacity by the late 1990s.

The Los Padres Dam and Reservoir at RM 24.8 is a 150-foot embankment dam that was completed in 1949 by California Water and Telephone (California-American Water Company predecessor) to supply water needs of the Monterey Peninsula. Original reservoir capacity was 3,030 acre-feet; current capacity has been reduced to1,775 acre-feet due to siltation; 100% siltation is estimated to occur by year 2100 (Carmel River Advisory Committee 2012). The reservoir normally fills and spills in fall/winter after approximately six inches of rainfall (the only recorded exceptions to this since 1949 were during the 1976-77 drought and one year during the 1987-91 drought); after the reservoir fills, the watershed is considered to be in an "uncontrolled condition" – i.e., the reservoir provides no flood control for downstream properties (MPWMD 201-2014).

Releases from storage are made to the Carmel River mainstem once the level drops below the spillway; rediversion of flow occurs at Cal-Am owned municipal production wells downstream of San Clemente Dam, primarily between River Mile 3 and 8; releases are governed under a quarterly budget process set up by a Memorandum of Agreement between CDFW, Cal-Am, and MPWMD. NOAA Fisheries also participates in water budget decisions (MPWMD 201-2014).

Releases from storage during the dry season generally range from 5 to 15 cfs, depending on inflow conditions and water year type; the effect of the reservoir on water temperature in the river can be variable and result in raising or lowering the water temperature in the river by several degrees; releases during periods of very low storage can be both warmer than incoming river flow and anoxic (low or no dissolved oxygen) (MPWMD 201-2014).

There are three fish ladders below the dam (one fully functional, one partially functional, one abandoned); Cal-Am operates a trap and truck operation to move steelhead upstream of the dam in winter. Juvenile and adult steelhead migrate downstream over the dam's spillway (MPWMD 201-2014). Both San Clemente and Los Padres dams have retained over 2.5 million cubic yards of critical sediment, cobbles and large woody debris (LWD) from the upper half of the watershed, depriving the lower river of bedload and LWD for almost 100 years (MEI 2008a). The dams on the mainstem of the Carmel River have imposed a number of significant impacts, including a disconnected floodplain, reduced flows, disruption of ecological integrity, and a disruption of physical processes and geomorphology.

2.7.4.1 *Disconnected floodplain and reduced flows*

The cumulative effects of channel incision and reduced flow levels in the Carmel River downstream of Los Padres and San Clemente Dams have resulted in a physical separation between the river channel and the seasonal ponds and wetlands in the historic floodplain along the river corridor, and a draining of the connected wetlands into the Carmel River. The loss of connectivity and water exchange between the river, floodplain and wetlands reduces the amount of available habitat for fish, aquatic macroinvertebrates, amphibians, insects, and avifauna (PWA 2007), and affects water quality and infiltration.

2.7.4.2 *Disruption of ecological integrity*

The two dams on the mainstem disrupt processes that are important to the sustenance of many ecosystem functions throughout the watershed. Dam-induced changes in Carmel River hydrology have impacted the transfer and cycling of natural minerals and nutrients downstream. The result has been modification of the bio-chemical cycling and biological uptake of nutrients by the aquatic and terrestrial ecosystem components. Fragmentation of the river has resulted in loss of seasonally important habitats for many aquatic, terrestrial and vegetation species, primarily due to changes in the river and floodplain condition. Such habitat losses impact the ability for many species of fish, amphibians, birds and their food base (insects, plants) to complete their full life cycles (PWA, 2007).

The dams significantly block the movement of the population of steelhead trout (*Oncorhyncus mykiss*) to historic spawning and rearing areas in the upper portions of the watershed. Los Padres Dam constrains upstream steelhead migration, downstream juvenile movement, restricts the natural movement of water and sediment in the Carmel River, modifies the water quality of the Carmel River, and alters the natural geomorphic processes of the watershed.

Hand netting of adults below the dam and transport upstream is the only viable means to move spawning adults above the dam, and downstream migrants must slide down a concrete spillway before dropping into the river. At San Clemente Dam, the fish ladder is outdated and flow across the reservoir sediments is often shallow. Fish mortality occurs as downstream migrants plunge 70 feet over the dam spillway to the pool below. The fish ladder at San Clemente Dam is scheduled to be removed with the dam in 2015. No effort is made to capture and transport downstream migrating young smolts or kelts (post-spawning adults), and no facilities exist to guide the downstream movement of juvenile steelhead to the estuary or rearing habitats located below the dam. Los Padres Dam also constitutes a physical barrier that impairs the migration of steelhead (Smith *et al.* 2004). Currently, fish passage is facilitated by one functional and one semi-functional fish ladder (Carmel River Advisory Committee 2012), and a trap-and-truck operation that transports the fish that are migrating upstream (Monterey Peninsula Water Management District 2004). The Los Padres Dam, however, also provides benefits for the management of the steelhead, because it allows the maintenance of flows during dry periods. A memorandum of agreement between the CDFW, Cal-Am, and the MPWMD governs the releases from storage, and it is estimated that without them, the Carmel River could dry up in the Cachagua area (MPWMD 2010-2014). (Water Management Group 2007).

2.7.4.3 *Disruption of Physical Processes and Geomorphology*

The retention of sediment behind the dams also has detrimental effects on important physical and biological attributes of the river. The reduction of sediment flows downstream contributes to channel narrowing, bed degradation, and increased sinuosity (Kondolf 1982). Additionally, the entrapment of gravel, cobble, and boulders diminishes essential habitat for the threatened steelhead trout (Monterey Peninsula Water Management District 2004). Cal Am, the owner and operator of the Los Padres Dam is currently studying the feasibility of dredging sediment out of the reservoir, although other options, such as removing the dam, have been proposed (Carmel River Advisory Committee 2012). In addition, the coastal marshes and wetlands at the Carmel River Estuary have been reduced in size and ecological viability as the flow of sediment has been modified (PWA, 2007).

The two dams have decreased the amount of spawning gravel reaching the lower river**.** Steelhead trout depend on coarse gravels for spawning. These gravels typically are supplied from headwater source55s, and have been trapped behind the dam. The depletion of gravels from the lower river has reduced the available spawning sites for key fish species (PWA, 2007). In addtion, the dams have increased armoring of the Carmel River bed. In any waterway, channel substrate tends to be moved downstream. Without replenishment of sediment from upstream, all smaller substrate materials become mobilized and transported until the only substrate materials remaining are those that are not capable of movement under normal river flow conditions. The result is an “armoring” of the bed that reduces the habitat availability and results in lower overall fish production (PWA, 2007).

The loss of natural sediment supply has resulted in downcutting and localized narrowing of the channel, and a reduced distribution and ratio of pool and riffle areas The result is a more uniform stream channel and important loss of habitat complexity and diversity (PWA, 2007). Dams can also narrow the active stream vegetation corridor**.** The loss of sedimentation bedforms like bars and flood deposits reduces available substrate for pioneer species such as cottonwoods, willows and other riparian species. When combined with channel incision, the result is a narrowing of the riparian corridor and reduction in the terrestrial riparian habitat complexity and diversity. The result is impaired habitat for many terrestrial and semi-aquatic species and life history stages, a shift from native vegetation species toward exotic invasive plant species, and an overall reduction in the integrity (stability) of the watershed ecosystem (PWA, 2007).

The loss of natural sediment supplies from the headwater areas reduces the availability of spawning gravels below the dams. Hardening of the channel that results from the diminished sediment supply creates lower flushing hydraulic conditions that are less able to maintain spawning gravels. Both effects reduce the actual amount of spawning habitat available for fish reproduction below the dams. Over time, the coarsened and hardened channel bed becomes less mobile during large flows, and the more static and incised river bed loses much of its habitat-forming capacity.

2.7.4.4 *River bank erosion*

The existing dams on the Carmel River currently trap all of the bedload and a portion of the suspended load produced in the upper watershed. The current trap efficiency of Los Padres Dam (LPD) is estimated to be 72 %; the trap efficiency for the smaller San Clemente Dam (SCD) is currently estimated to be over 85 %. After completion of the SCD in 1921, the portion of the Carmel River downstream adjusted to the loss of bedload material by deepening its channel. As the river incised between 1921 and the early 1960s, an extensive riparian forest developed, protecting the banks from erosion, except at bends. By about 1940, the river channel had adjusted to the presence of SCD. A considerable amount of riparian vegetation was lost during the 1976-77 drought, as groundwater pumping during this time lowered the water table in parts of the valley. With the banks unprotected by riparian vegetation, the river adjusted to subsequent flood flows by eroding both the channel bed and banks. As a result of this process, the middle reach of the river between the Garland Ranch Regional Park and Schulte Road changed drastically from a narrow, deep, meandering channel with well-developed riffles and pools to a wide, shallow channel with eroded banks and an unstable bed. Since 1980, the MPWMD has monitored the health and state of the Carmel River riparian corridor closely. A ten-year program was implemented in 1983 to restore stability to portions of the river that had suffered significant erosion and had become seriously degraded in terms of wildlife habitat. Approximately $1.3 million was spent over the ten-year (1983-1993) period for river restoration (CDWR 2012).

2.7.6 Floodplain development

Floodplain development increases runoff associated with impervious areas and increases channel confinement associated with bank hardening and structures built along channel banks, both of which have the potential to cause channel incision and/or widening due to increased flow velocities during high flow events.

Approximately 1,600 parcels have been identified as having residential use and being affected either wholly or in part by the FEMA-defined floodplain (MPWMD 1995). A majority of these are located in the lower six miles, between the lagoon and Schulte Road Bridge. Approximately 420 individual parcels lie adjacent to the mainstem in the lower 18.6 miles of river. In a few reaches, structures virtually overlook the river, or floodplain development has marched to the top of the riverbank, leaving little or no riparian buffer. Building practices and land use changes within the 100-year floodplain were formally regulated by the County of Monterey with the Carmel Valley floodplain ordinance in 1984. About 2.5 miles of this portion of the river is publicly owned. Much of Carmel Valley, including areas adjacent to the river, has developed into premium value real estate.

2.7.7 Roads

Unpaved roads in the Carmel Watershed are a cause of erosion that can lead to impaired streams. In general, unpaved roads generate incremental excess sediment, and many are severe, chronic sediment sources. Besides general erosion from the bare road surface and surface rills, dirt road networks typically produce erosion at stream crossings (especially where an undersized culvert is poorly installed), roadside runoff ditches, cut-slope landslides, fill-slope landslides, and landslides and gullies generated by concentrated runoff (e.g., Weaver and Hagans 1994). A widely successful protocol for reducing the impacts of dirt roads in a watershed is to estimate the volume of sediment that will be eroded from each impaired site in the road system, and then prioritize the sites so that the worst are repaired first. This strategy will result in the most efficient use of resources for the greatest initial erosion reduction. It is typical to find that stream crossings are the leading cause of erosion in a network of roads (Smith *et al.* 2003).

2.7.8 Bridges and creek crossings

There are numerous river crossings (i.e., bridges, fords and culverts) on the Carmel River and its tributaries that may locally influence the dynamics of sediment deposition and erosion and prevent or impede fish migration and movement. Bridges and other crossings frequently cause hydraulic constrictions during high flow, which promote local geomorphic changes including sediment deposition upstream of the structure and erosion of the bed and banks of the creek downstream of the structure as flow accelerates. Likewise, when crossing structures such as fords or driveways are not built to grade with the channel bed, similar impacts are likely. Both causes may result in a significant "step" in the channel bed thereby disrupting geomorphic processes locally and impeding upstream fish passage. Stream crossings and channel conditions in the Carmel River watershed have not been fully assessed to determine the extent to which they may limit fish migration and movement.The concentration of road drainage and crossing related impacts occurs in the upper, rural subwatersheds. The status of these creek crossings in impeding fish passage was recently detailed in the *Assessment of Steelhead Passage Barriers in Portions of Four Tributaries to the Carmel River* (MPWMD 2014).

Nineteen bridges currently span the Carmel River (Figure 2-15D and Table 2-4). Seven are publicly maintained (one by CALTRANS, five by Monterey County Public Works, one by the Monterey Peninsula Regional Parks District). The remainder are privately owned and maintained. All the bridges have supports within the 100-year floodway. Ten bridges have center piers in the active channel. Evidence of several abandoned (washed out) bridges can be seen along streambanks in the alluvial section. Replacement costs are estimated to be between $500,000 for a private golf cart bridge to $5,000,000 for a highway-class bridge (MPWMD 2003).

Figure 2-15D. Bridges on Carmel River (Beck, et al. 2013)

At bridges with supports in the active channel, the minimum open length between abutments and center piers ranges from a low of about 15 feet at the south abutment of Boronda Bridge to as large as 80 feet at the Rancho San Carlos Road Bridge. Cranes or other equipment capable of picking up trees and logs are frequently stationed at five of the 19 bridges during high flows. Equipment operators generally pick up debris caught on the upstream side of piers and abutments and transfer it downstream. Because of the difficulty associated with this (forceful flows, difficult access), and the type of equipment used (small cranes or backhoes), the largest pieces that can be moved are in the 20 to 25-foot range (2-4 tons). Larger pieces require specialized equipment, such as a boom crane and hook assembly. The remaining 14 bridges either don't have center piers and are usually debris-free, or are not accessible to cranes (MPWMD 2003).

The river is subject to wide variations in annual peak flows resulting in significant variations in the flow and size of woody debris, the amount of vegetation encroachment, transport of sediment, and stability of river banks. Instantaneous peak annual flows at Highway 1 have ranged from 0 (multiple years) to an estimated 16,000 cubic feet per second (cfs) in March 10, 1995. The bankfull flow ranges from about 1,500 cfs at San Clemente Dam to 2,200 cfs at Highway 1 (MPWMD 2003).

Table 2-4. List of Bridges on the Carmel River (MPWMD)

Bridge	Owner	River Mile	Year	Comment
Highway 1	CALTRANS	1.09	1995	Four-lane bridge washed out and rebuilt in 1995. Rebuilt bridge has several piers in active channel.
RC No. 5	Rancho Cañada	2.13	1995	Golf cart bridge washed out and rebuilt in 1995. New bridge designed for 50-yr. flood elevation with no center pier.
RC No. 4	Rancho Cañada	2.37	1995	Center pier in narrow portion of river. Abutment damage, 1995. No access for heavy equipment.
RC No. 3	Rancho Cañada	2.55	1995	Center pier in narrow portion of river. Debris build-up, 1995. No access for heavy equipment.
RC No. 2	Rancho Cañada	2.66	1995	Center pier in narrow portion of river. Debris build-up 1995. No access for heavy equipment.
RC No. 1	Rancho Cañada	2.8	1995	Center pier, but river is wide. Debris build-up in 1995. No access for heavy equipment.
Via Mallorca	Hacienda Carmel	3.24	?	Two-lane bridge. Equipment required to be staged on bridge at high flows to remove debris.
San Carlos	Rancho San Carlos	3.86	1995	Center supports and left abutment undermined and repaired. Additional work required after the 1998 flood to shore up left center support previously repaired in 1995 work. Debris removal equipment usually staged at high flows.
Valley Greens	MCPWD	4.82	?	Clear span w/ abutments at edge of active channel.
Quail Lodge	Quail Lodge	5.2	1969	Bridge for golf carts washed out and rebuilt with clear span. No equipment access.
Schulte Rd.	MCPWD	6.7	2013	Five feet of river incision since the late 1940's.
unnamed	Unknown	7.8	1983	Bridge washed out in 1983. Left abutment remained until 1995, when it washed out.
Robinson	MCPWD	8.46	1969	Center pier in narrow portion of river washed out Robinson Cyn. Rd.
Randazzo	private	10.13	1983	Gerry Paddock (partner) reported dropping 10-ton slabs of concrete in the river (and watched them disappear) to protect the bridge. 85-ft. clear span.
Don Juan	MPRPD	10.78	1969	Southern approach into Garland Park washed out in 1969 and was rebuilt. Large (4 ft.) center pier.
unnamed	MPRPD	11.5	?	A center pier, or perhaps a southern abutment, remains in the active channel at Garland Park.
unnamed	private	12	1983	Washed out, not rebuilt, north abutment remains in active channel.
Boronda Rd.	MCPWD	12.69	1983	Monterey County Public Works closed down the bridge in 1995 during high flows to complete emergency repairs to the abutments. Residents stranded on the south side of the river were helicoptered over the river. Two center piers in active channel.
Rosie's or Esquiline	MCPWD	14.45	1995	The south abutment nearly failed during high flows in March 1995. Bridge closed for a few days to complete repairs. Two center piers in the active channel.
Ward	Ward	14.7	1995	Northern approach washed out in 1995 and rebuilt. North abutment damaged in 1998. This bridge does not support heavy equipment access. North abutment in active channel.
Stonepine	Stonepine	15.78	1995	Washed out and rebuilt in 1995. New bridge has wider center span.
Old Carmel Dam	Cal-Am	18.27	?	Right abutment appeared to be threatened by high flows. Collects a significant amount of debris.

2.7.9 Bank revetment

After completion of the San Clemente Dam in 1921, the portion of the Carmel River downstream of the Dam adjusted to the loss of bedload material by deepening its channel. As the river incised between 1921 and the early 1960s, periods of erosion occurred as the river channel tried to adjust to then new lack of bedload. A considerable amount of riparian vegetation was lost during the 1976-77 drought; groundwater pumping during this time lowered the water table in parts of the valley. With the banks unprotected by riparian vegetation, the river adjusted to subsequent flood flows by eroding both the channel bed and banks. This lead to a restoration program implemented in 1983 to restore stability to portions of the river that had suffered significant erosion and had become seriously degraded in terms of wildlife habitat. Approximately $1.3 million was spent over the ten-year period for river restoration. This lead to armoring along the river (Figure 2-16) and still is, used to combat the sediment-starved reaches of the river from eroding banks and widening the river valley. Mussetter Engineering, Inc. (2002) found that up to 40% of the river's banks from the mouth to Rosie's Bridge (RM 14.45) have been artificially hardened to protect infrastructure from erosion (MPWMD 2000-2012). Hardened banks have prevented sufficient compensational erosion from taking place in the lower floodplain, causing the river to downcutand narrow.

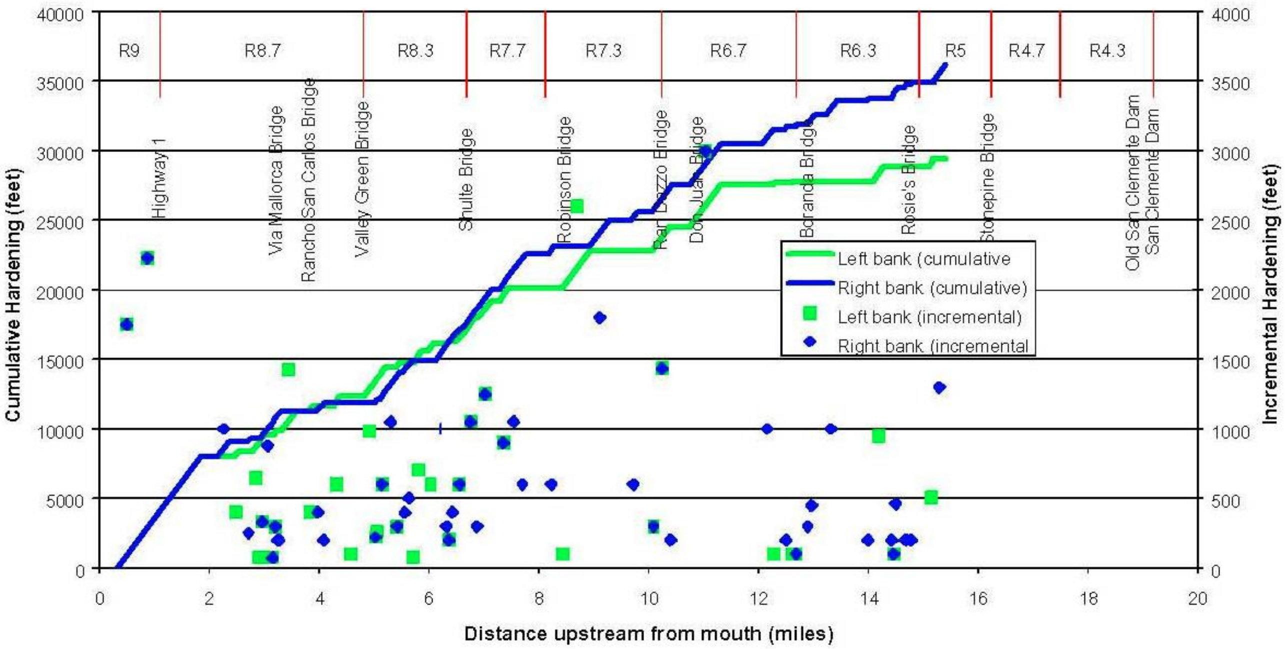


Figure 2-16. Graph of feet of bank hardening as a function of miles from mouth of the Carmel River (MEI, 2002).

2.8 Water Supply

Residents of the Monterey Peninsula rely upon the Carmel River Watershed for their potable water needs since Monterey County does not import any water from the California State Water Project. The rain that falls within the Carmel River watershed recharges the Carmel River alluvial aquifer (Smith et al. 2004). The water from the aquifer serves 75% of the water needs of over 100,000 residents of the Monterey Peninsula (Water Management Group 2007). The other 30% comes from the Seaside Aquifer and a few surrounding wells (MPWMD 2004).

While water resources have limited large-scale growth for many years and local residents have become very conservative in their water consumption rates, the Carmel River alluvial aquifer is over-pumped annually without alternative sources to draw upon (California Public Utilities Commission, 2004). Changes in the river’s flow have caused significant changes in the river’s hydrologic cycle, habitats, and sedimentation processes.

2.8.1Water resources monitoring

Streamflow and precipitation data continue to provide a scientific basis for management of the water resources within the watershed boundaries of the MPWMD. These data continue to be useful in Carmel River Watershed planning studies, reservoir management operations, water supply forecast and budgeting, and defining the baseline hydrologic conditions of the Carmel River Watershed.

There is limited storage of surface water by dams on the Carmel River. Los Padres Reservoir, completed in 1948, holds 1,626 AF of usable storage, based on 2008 survey data. Usable storage in San Clemente Reservoir, completed in 1921, was eliminated with the removal of the San Clemente Dam in 2015 by order of the Department of Water Resources (DWR) due to seismic safety concerns.

Groundwater levels, and consequently groundwater storage conditions, in the Carmel Valley Alluvial Aquifer have maintained a relatively normal pattern in recent years, in contrast to the dramatic storage declines that were observed during the prolonged 1987-1991 drought period. The relatively stable storage in the Carmel Valley Alluvial Aquifer in recent years is attributable to a combination of a period of more favorable hydrologic conditions since 1991 and the adoption of improved water management practices that have tended to preserve higher storage conditions in the aquifer.

In contrast, storage conditions in the coastal portion of the Seaside Groundwater Basin have not been stable in recent years, in particular with respect to the deeper Santa Margarita aquifer, from which over 80 percent of the Cal-Am production in the Seaside Watershed is derived. This downward trend in water levels reflects the changed production operations in the Seaside Watershed stemming primarily from changed practices after SWRCB Order 95-10. The increased annual reliance on production from Cal-Am's major production wells in Seaside, along with significant increases in non-Cal-Am use, have dramatically lowered water levels in this aquifer, and seasonal recoveries have not been sufficient to reverse this trend. To address this storage depletion trend, the MPWMD initiated efforts in the 2000-2001 timeframe to prepare a Seaside Watershed Groundwater Management Plan in compliance with protocols set by the State of California (AB 3030, as amended by SB 1938).

The Carmel River and the Seaside Groundwater Basin are connected through the MPWMD's Aquifer Storage and Recovery Program (ASR). ASR entails diverting excess water flows (typically in Winter/Spring) from the Carmel Valley Alluvial Aquifer through existing Cal-Am facilities and injecting the water into the Seaside Groundwater Basin for later recovery in dry periods. The primary goal of the MPWMD Phase 1 and 2 ASR Projects is better management of existing water resources to help reduce current impacts to the Carmel River, especially during the dry season. The projects are viewed as being complementary to other larger, long-term water augmentation projects that are currently being explored by various entities. These projects, now also known as Water Projects 1 and 2, entail a maximum diversion of 2,426 AFY, and 2,900 AFY respectively from the Carmel River for injection. The combined average yield for both projects is estimated at 2,000 AFY. The operation of the Phase 1 and 2 ASR Projects result in reduced unauthorized pumping of the Carmel River in Summer/Fall and coincidentally increased storage in the Seaside Watershed, which are both considered to be environmentally beneficial.
Groundwater quality conditions in both the Carmel Valley Alluvial Aquifer and Seaside Groundwater Basin have remained acceptable in terms of potential indicators of contamination from shallow sources such as septic systems. There have been no identifiable trends indicative of seawater intrusion into the principal supply sources the coastal areas of these two aquifer systems to date.

2.8.2 Water Supply Management

Groundwater extraction has impacted the health of the Carmel River for decades. After two years of severe drought in 1976 and 1977, MPWMD was formed and charged with the task of managing existing water resources and developing additional supplies. In April 1990, MPWMD prepared a Water Allocation Program Final Environmental Impact Report (EIR). The Final EIR analyzed the effects of California American Water Company (Cal-Am) production, ranging from 16,744 acre-feet per year (AFY) to 20,500 AFY. On November 5, 1990, the MPWMD Board certified the Final Environmental Impact Report, adopted findings, and passed a resolution that set an annual limit of 16,744 AFY as the new water allocation limit for Cal-Am production, and 3,137 AFY for non-Cal-Am production, with a total allocation of 19,881 AFY (Option V) for the Monterey Peninsula Water Resource System (Carmel Valley Alluvial Aquifer and Seaside Groundwater Basin).

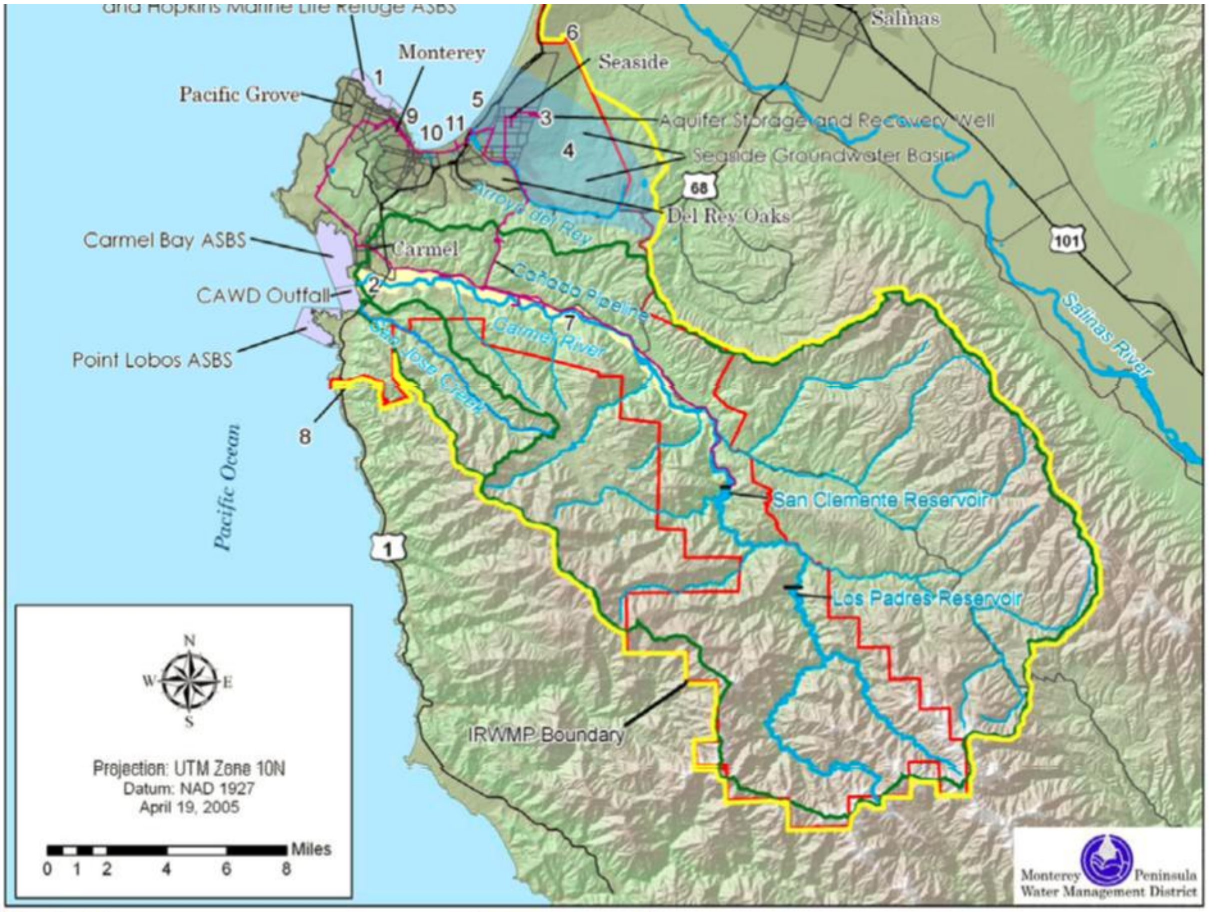
Even though Option V was the least damaging alternative of the five options analyzed in the Water Allocation Program EIR, production at this level still resulted in significant, adverse environmental impacts that must be mitigated. Thus, the findings adopted by the MPWMD Board included a Mitigation Program for Option V and associated mitigation measures. Then in June 1993 with the completion of a new water supply well (Paralta), Ordinance No. 70 was passed, which amended the annual Cal-Am production limit from 16,744 AF to 17,619 AF, and the non-Cal-Am limit from 3,137 AF to 3,054 AF for the Monterey Peninsula Water Resource System. In 1995, the State Water Resources Control Board determined that the California American Water Company (Cal-Am), the private water utility company, was unlawfully pumping 10,730 AF of water from the Carmel River Aquifer. In the same mandate, Cal-Am was ordered to mitigate the impacts on the riparian corridor along the river, including wildlife and aquatic habitats if the MPWMD ceased their Mitigation Program. (*Based on the 2002 Monterey County Floodplain Management Plan, which has since been updated. The direct reference is to Cal-Am's contingent liability in Order 95-10 to carry out the activities of the MPWMD Mitigation Program if MPWMD did not. At the time SWRCB wrote Order 95-10, they were concerned about recently-introduced state legislation to dissolve the District and they wanted the Mitigation Program to continue if MPWMD were to be dissolved. The legislation failed to move out of committee*.)

Regional water supply management

The management of the water resources for the Monterey Peninsula, Carmel Bay, and South Monterey Bay (Monterey Peninsula) Region are addressed by the Integrated Regional Water Management Plan (IRWMP or IRWM Plan). This IRWMP addresses the major challenges and opportunities related to managing water resources within the Monterey Peninsula IRWM region. The Monterey Peninsula IRWM Plan region is approximately 350 square miles and includes the coastal cities of Carmel-by-the-Sea, Del Rey Oaks, Monterey, Pacific Grove, Sand City, and Seaside. Also included are the unincorporated portions of Monterey County in Carmel Valley, Pebble Beach, the Carmel Highlands, the Laguna Seca area, and a portion of the Ord Community (Figure 2.17A). The region includes numerous state and federal marine and coastal protected areas, the Monterey Bay National Marine Sanctuary, and portions of the Ventana Wilderness and Fort Ord National Monument, all of which are extremely valuable for their ecological and socio-economic characteristics.

The IRWM Plan follows the criteria established by the California Department of Water Resources (CDWR) 2012 Proposition 84 and 1E IRWM Guidelines, as amended through December 2013 that establish the general process and criteria that DWR uses to implement each IRWM Grant Program. DWR designed the IRWM planning process to be consistent with the California Water Plan: the overarching document that integrates all regional planning efforts and provides a collaborative planning framework for elected officials, agencies, tribes, water and resource managers, businesses, academia, stakeholders, and the public to develop findings and recommendations and make informed decisions for California's water future.

The Monterey Peninsula Regional Water Management Group (RWMG), the body responsible for the development and implementation of the IRWM Plan, includes seven local agencies and organizations.
Members of the RWMG are required to enter into a memorandum of understanding (MOU) that acknowledges their cooperative efforts to form an institutional structure to develop and implement the IRWM Plan. A clearly defined governance structure and process creates a transparent working relationship with all stakeholders that participate in the creation of the IRWM Plan.



No.	Project	Sponsor
1	Refine ASBS Alternatives	Monterey/PG
2	Lower Carmel River Restoration and Floodplain Enhancement	MCWRA/BSLT/MPWMD
3	Seaside Groundwater Basin Aquifer Storage and Recovery	MPWMD/CAW
4	Seaside Basin Groundwater Replenishment	MRWPCA
5	Seaside 90" Outfall Infiltration Component	City of Seaside
6	CSUMB Stormwater Percolation and Education	CSUMB
7	Carmel River Watershed Volunteer Monitoring Program	CRWC
8	Water Conservation Retrofit Program	MPWMD
9	Sanitary Sewer System Repair and Replacement	Monterey/PG
10	Microbial Source Tracking	Monterey/PG
11	Implementation of Solid Waste Removal Technology	Monterey/PG

Figure 2-17A. Map of Monterey Peninsula Integrated Regional Water Management Planning Region (MPWMD)

2.9 Water extraction

The Carmel River watershed provides the majority of the drinking water for residents of the watershed and surrounding communities. About 75% of water within the MPWMD boundaries is collected, stored, and distributed by the California American Water Company (Cal-Am), which serves 95% of the residents and businesses in the greater Monterey Peninsula. Cal-Am owns and operates a series of production wells along the Carmel River and in the Seaside Groundwater Basin (SGB), and a network of pipelines extending from the San Clemente Reservoir to the Monterey Peninsula and Seaside communities. The majority of wells capable of dewatering reaches of the Carmel River during the low flow season are Cal-Am production wells in lower Carmel Valley producing ~ 7,515 AF in Water Year 2012, but Carmel Valley has approximately 651 private wells, including wells in the alluvial aquifer and upland areas, that produce another ~2,700 AFY, and the cumulative impact of these wells significantly reduces the amount of water available for Carmel River flows. As groundwater levels decline in the dry season it is common for the Carmel River to be dry from Highway One Bridge (RM 1) to Schulte Road (RM 6.7). In dry to critically dry years the river may dry all the way up to Mid-Valley Safeway (RM 8). If adequate winter rains follow, complete recharege of the aquifer generally occurs quite rapidly after the Carmel River reaches the lagoon.

In Water Year 2012, the Carmel River Watershed supplied almost 65% of the area's domestic water supply. The water supply reservoirs on the mainstem of the Carmel River are owned by California American Water (Cal-Am). During the rainy season, river flow is often unregulated by mainstem reservoirs, which have a maximum combined storage capacity of less than 2% of the average annual flow in the watershed. Flow releases in the dry season from the Los Padres Reservoir in Carmel Valley are used conjunctively to meet flow requirements in the Carmel River for steelhead and to augment natural flows along the riparian corridor. To reduce impacts to streamside areas from water extraction, flow diversions for municipal supply generally occur at the farthest downstream production wells and progress upstream in response to demand or maintenace issues. Figure 2-17B illustrates legally available water supply compared to consumer demand in MPWMD territory.

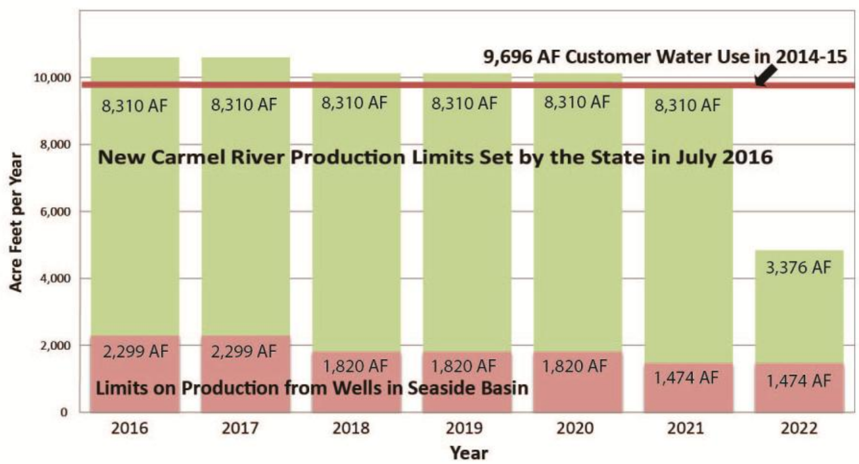


Figure 2-17B. Illustrates legally available water supply compared to consumer demand in MPWMD territory.

2.9.1 State Water Resources Control Board (SWRCB) Order 95-10, Order WR 2009-0060 and Order WR 2016-0016

In response to complaints about the impact of Cal-Am's pumping on Carmel River environmental resources, including Carmel River steelhead, streamside vegetation, and wildlife, the State Water Resources Control Board (SWRCB) imposed Order 95-10 requiring Cal-Am to reduce pumping from the Carmel River Watershed by 75%. In addition, the SWRCB determined that the legal status of the underground water had changed, leaving Cal-Am without a permit to use the water. Believing that an immediate 75% cut would affect public health and safety, the SWRCB imposed an interim 20% cut to 11,285 AF of water that Cal-Am could draw from the Carmel River. Cal-Am's future limit is currently set for 3,376 AF. This is about 25% of Cal-Am's historical pumping (14,106 AF) in the 1980s (MPWMD 2013).

On January 15, 2008, the SWRCB issued a draft Cease and Desist Order (CDO) against Cal-Am. The Draft CDO refers to the 1995 SWRCB Order 95-10, and notes that compliance with Order 95-10 had not been achieved after 12 years. The CDO institutes a series of cutbacks to Cal-Am production from the Carmel River and prohibits new or intensified connections in the Cal-Am main system. MPWMD and several other parties participated in formal hearings before the SWRCB in the summer of 2008. After several draft versions, the final SWRCB determination on the CDO (Order 2009-0060) was issued on October 20, 2009. The CDO reduced the Cal-Am annual upper limit of diversion from the Carmel River previously set by Order 95-10 at 11,285 AF to10,429 AF in Water Year (WY) 2010 with a limit of 3,376 AF in 2017.

Then on July 19, 2016, the SWRCB issued Order WR 2016-0016 amending part of the requirements of Order 2009-0060 to accommodate the anticipated schedule of new water supply projects. This new order set an effective diversion limit from the Carmel River to 8,310 AFY until December 31, 2021 if Cal-Am meets project milestones associated with new water supply projects. If Cal-Am fails to meet specified milestones in the order, the diversion limit can be reduced in 1,000 AF increments. After December 31, 2021, the diversion limit on the Carmel River will be 3,376 AFY.

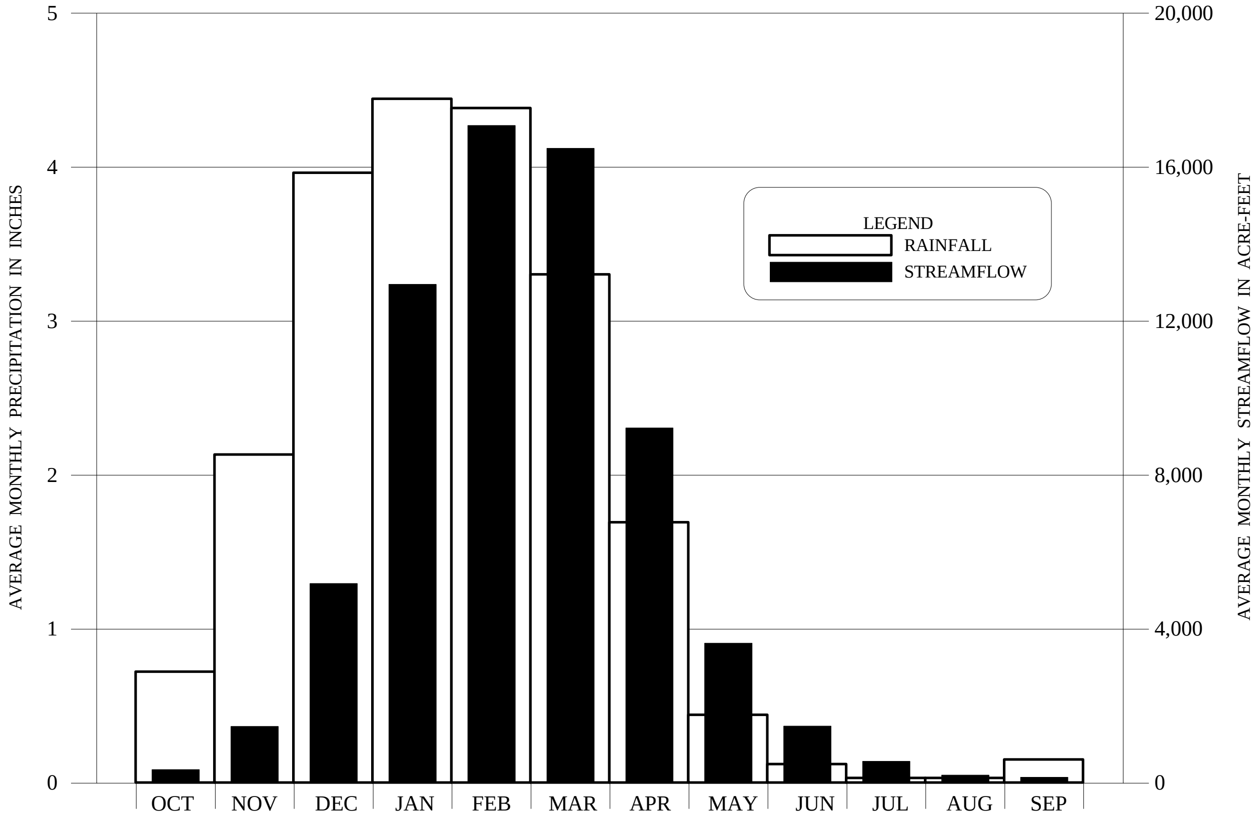
2.10 Surface and ground water hydrology

2.10.1Surface water hydrology

Surface water in the Carmel River has four main sources, direct run-off from rainfall, releases from dams, seeps and springs of groundwater, and return-flow from urban uses including irrigation, septic systems, and waste-water treatment plants. Once water has reached the river channel, it has several potential sinks including groundwater withdrawals in the Carmel Valley, flow to the sea during winter months, evaporation from the stream surface, and transpiration and growth of streamside vegetation. All private or public water diversion, retention, or withdrawals from the watershed tributaries and upland aquifers that include consumptive use have a cumulative impact on the volume of water in the lower valley river/aquifer system (Smith *et al.* 2004). Although most individual claims to water are an insignificant proportion of the watershed hydrologic budget, the collective effect of water use throughout the watershed has resulted in the stream being fully appropriated in summer months (SWRCB, 1995b).

Although the first significant rains of the season typically begin in November, significant changes in streamflow resulting from these rains normally do not occur until December or January. Fall rains replenish soils that have dried out during the summer, and consequently little runoff occurs during this period. During the fall of each year, most of the Carmel River tributaries are dry at their confluence with the river. In addition, the lower reaches of the Carmel River are typically dry at this time. By December or January, winter rains begin to run off saturated soils and watershed streamflow significantly increases. Monthly streamflow is typically the highest during the January through March period, as soils are moisture laden and rainstorms pass through the region on a consistent basis. Figure 2-18 relates rainfall to streamflow and illustrates fall rains (October - December), having a minimal effect on streamflow as rains soak into dry soil. Later in the season (February - May), saturated soil conditions (antecedent moisture) reverse this pattern, as a higher percentage of rain runs off into the river, enhancing streamflow. Water stored in the soil from winter rains also seeps back into the river, contributing to streamflow (James 2009).

A critical role of vegetated, non-compacted soils is the storage, transport, and release of rainfall to channels long after the rains have stopped. That is the only natural mechanism for achieving perennial flow, which the Carmel River may have enjoyed prior to construction of the SCD & LPD (Williams 1984). Well-managed landscapes can augment those natural soil functions even in the face of urban development if the functions are well understood, preserved, and enhanced. The Carmel Valley Master Plan contains numerous references to proper watershed management that includes preserving aquifer recharge areas, native soils, and native vegetation, and further suggests deliberately planning to retain urban storm-water run-off for aquifer recharge (MCRMA, 2013) (Smith, 2004).



Note: Rainfall averages obtained from Table II-1.
Streamflow averages based on unimpaired flows (Table III-2) for the 1902-2008 period simulated by MPWMD.

Figure 2-18. San Clemente Reservoir site average monthly rainfall and streamflow

The MPWMD operates and maintains 14 streamflow gaging stations within the Carmel River Watershed (4 on the mainstem and 10 on the tributaries). In addition, continuous water-level data were collected at both Los Padres and San Clemente Reservoirs, and at the Carmel River Lagoon. MPWMD co-funds two USGS gauging stations on the Carmel River. The MPWMD and USGS continuous recording gauging stations are listed in Table 2-5 and Figure 2-19 (MPWMD 2000- 2013).

Streamflow gaging station O&M at each of the above sites involves obtaining monthly discharge measurements, maintaining recording equipment, obtaining staff gage readings and occasional surveying. Subsequently, river/creek stage and discharge data are processed to produce mean daily streamflow records for the sites. Table 2-6 summarizes the computed annual flows for the MPWMD sites for the WY 1992-2013 periods.

Table 2-5. Gaging stations in the Carmel River Watershed (MPWMD).

Gaging Stations in the Carmel River Watershed				
Location	**Station Name**	**Abbrev.**	**Frequency**	**Operator**
Carmel River	Highway 1	H1	Daily	MPWMD
Carmel River	Near Carmel	NC	Daily	U.S.G.S.
Carmel River	Don Juan Bridge	DJ	Daily	MPWMD
Carmel River	Sleepy Hollow Weir	SH	Daily	MPWMD
Carmel River	Robles del Rio	RR	Daily	U.S.G.S.
Carmel River	Below Los Padres	BL	Daily	MPWMD
Carmel River	Above Los Padres	LP	Monthly	MPWMD
Tributary	Potrero	PO	Daily	MPWMD
Tributary	Robinson Canyon Creek	RC	Daily	MPWMD
Tributary	Garzas Creek	GA	Daily	MPWMD
Tributary	Garzas Canyon	GC	Daily	MPWMD
Tributary	Hitchcock Creek	HI	Daily	MPWMD
Tributary	Tularcitos Creek	TU	Daily	MPWMD
Tributary	San Clemente Creek	CL	Daily	MPWMD
Tributary	Pine Creek	PI	Daily	MPWMD
Tributary	Cachaua Creek	CA	Daily	MPWMD
Tributary	Finch Creek	FC	Daily	MPWMD

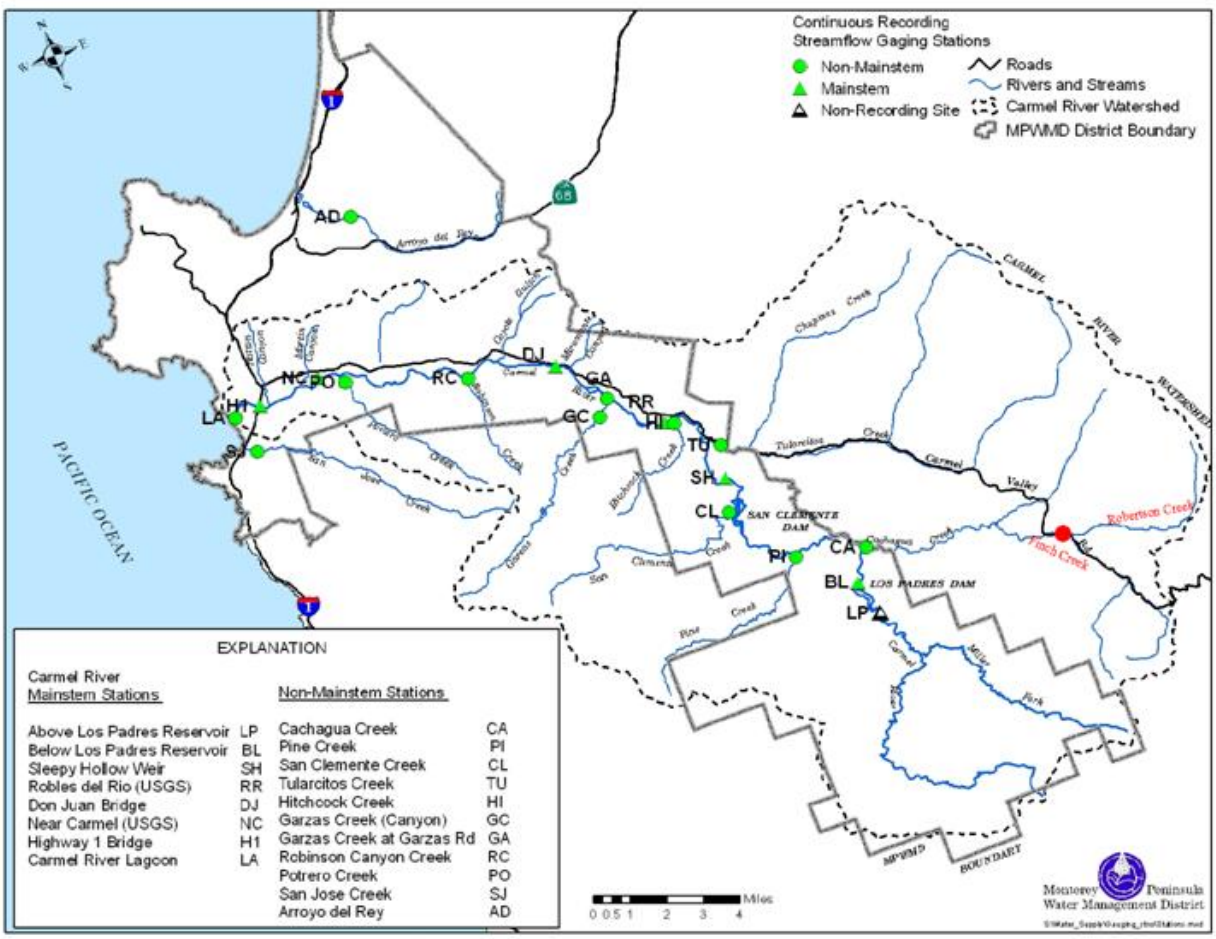


Figure 2-19. Map of Carmel River Watershed gaging stations (MPWMD).

CARMEL RIVER BASIN - ANNUAL STREAMFLOW SUMMARY
WATER YEARS 1992 - 2013
(Values in Acre-Feet)

TRIBUTARY SITES	Drainage Area (Sq.Mi.)	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
CACHAGUA CREEK	46.3	1,780	7,340	560	16,320	3,840	4,990	23,800	2,590	1,730	1,500	245	1,270	1,250	4,340	5,210	261	2,200	*1,020*	*5,030*	*5,320*	*695*	*237*
PINE CREEK	7.8	3,750	9,800	1,230	11,110	6,550	8,300	15,610	4,540	5,300	3,270	2,300	4,250	2,350	8,910	8,020	849	3,840	2,830	6,130	6,960	1,310	1,870
SAN CLEMENTE CREEK	15.6	5,450	17,070	1,820	20,580	9,310	14,100	33,380	7,130	9,830	5,340	3,270	5,850	3,720	16,330	13,720	1,360	5,520	4,270	9,950	12,950	1,960	2,570
TULARCITOS CREEK	56.3	635	3,220	444	5,100	1,650	2,450	22,610	3,810	2,450	1,490	630	552	503	1,000	2,480	503	917	405	1,140	1,430	452	327
HITCHCOCK CREEK	4.6	*	*	52	1,820	451	716	2,970	169	482	214	18	274	234	863	691	2	383	151	549	629	6	57
GARZAS CREEK	13.2	3,700	11,170	746	12,140	4,890	8,570	24,610	5,050	4,980	3,070	1,200	2,760	1,810	8,590	7,420	381	3,010	2,500	5,720	7,620	641	1,320
ROBINSON CANYON CR.	5.4	619	2,360	89	2,230	619	1,430	6,890	545	823	433	82	448	354	1,710	1,010	25	455	451	1,120	1,150	40	153
POTRERO CREEK	5.2	*	*	30	1,790	506	1,210	5,970	855	1,020	310	43	210	164	1,470	1,050	13	308	354	983	1,170	14	50
SAN JOSE CREEK	14.2	*	*	*	*	*	*	*	6,400	6,260	2,890	1,100	1,880	1,480	7,640	6,870	862	1,740	2,330	5,220	5,760	*1,200*	*1,540*
MAINSTEM SITES																							
CR AT ROBLES DEL RIO	193	38,240	109,000	11,800	155,000	75,210	99,340	250,300	54,640	76,750	47,180	31,850	60,560	38,060	114,400	110,100	12,220	49,080	45,930	104,540	110,300	20,750	*31,970*
CR AT DON JUAN BRIDGE	216	*	122,000	12,760	173,600	83,090	111,800	252,200	53,570	73,960	49,360	31,330	60,420	38,330	121,800	118,300	12,150	52,510	*47,410*	*106,300*	*116,500*	*20,820*	*28,340*
CR NEAR CARMEL	246	35,570	123,400	8,200	177,400	74,500	104,100	261,100	55,000	76,190	47,790	28,340	55,400	35,220	119,200	119,200	7,440	43,960	43,960	105,840	115,800	17,120	*24,390*
CR AT HIGHWAY 1 BRIDGE	252	*	123,000	7,410	179,500	83,430	112,000	280,900	50,810	72,660	42,860	24,860	52,000	30,300	115,200	115,000	6,470	42,520	*39,170*	*102,700*	*111,200*	*16,410*	*24,520*

Notes:
1. Carmel River (CR) at Robles del Rio and near Carmel sites are maintained by the USGS.
2. (*) No continuous stage data collected.
3. Streamflow sites listed in downstream order.
4. San Jose Creek is outside the Carmel River Basin, but is shown for comparison.
5. WY 1992-2008 values are FINAL. WY 2009-2013 DRAFT values shown in italic.

Table 2-6. Carmel River Watershed Annual Streamflow Summary Water Years 1992-2013 (MPWMD 2013).

In general, total annual Carmel River streamflow generally gains in a downstream direction in above normal years through extremely wet years due to tributary inflow. In normal through critically dry years, losses in streamflow occur primarily due to Lower Carmel Valley groundwater extraction. Refer to Table 2-7 for the runoff classifications for these years (MPWMD working file Greg James). It is interesting to note that the average annual runoff on the Carmel River at U.S.G.S gage Near Carmel (3.56 River Miles upstream of the Pacific Ocean) was 78,190 acre-feet (AF) for the period of record 1962-2006 (USGS 2006) (Water Management Group 2007).

Table 2-7. Classification of Unimpaired Carmel River Flow at San Clemente Dam Site (MPWMD)

CLASSIFICATION OF UNIMPAIRED CARMEL RIVER FLOWS AT SAN CLEMENTE DAM SITE
(RUNOFF IN ACRE-FEET)

Water Year	Runoff	Classification	Water Year	Runoff	Classification
1902	58,872	Normal	1958	154,843	Extremely Wet
1903	63,516	Normal	1959	29,702	Below Normal
1904	36,704	Below Normal	**1960**	**20,780**	**Dry**
1905	73,489	Above Normal	**1961**	**9,278**	**Critically Dry**
1906	111,242	Wet	1962	50,942	Normal
1907	166,057	Extremely Wet	1963	86,582	Above Normal
1908	46,177	Normal	1964	26,977	Dry
1909	127,394	Wet	1965	49,941	Normal
1910	53,977	Normal	1966	27,892	Dry
1911	143,892	Extremely Wet	1967	114,304	Wet
1912	**24,611**	**Dry**	1968	13,177	Critically Dry
1913	**12,933**	**Critically Dry**	1969	174,213	Extremely Wet
1914	120,075	Wet	1970	53,112	Normal
1915	110,110	Wet	1971	32,707	Below Normal
1916	136,932	Extremely Wet	1972	14,680	Critically Dry
1917	71,580	Above Normal	1973	113,269	Wet
1918	37,917	Below Normal	1974	86,102	Above Normal
1919	42,107	Normal	1975	87,211	Above Normal
1920	35,198	Below Normal	**1976**	**6,358**	**Critically Dry**
1921	49,583	Normal	**1977**	**2,855**	**Critically Dry**
1922	104,977	Wet	1978	151,421	Extremely Wet
1923	71,493	Normal	1979	50,087	Normal
1924	13,304	Critically Dry	1980	143,395	Extremely Wet
1925	34,626	Below Normal	1981	41,445	Below Normal
1926	80,608	Above Normal	1982	130,522	Extremely Wet
1927	92,274	Above Normal	1983	318,987	Extremely Wet
1928	45,261	Normal	1984	69,179	Normal
1929	33,188	Below Normal	1985	26,611	Dry
1930	30,988	Below Normal	1986	125,911	Wet
1931	9,988	Critically Dry	**1987**	**15,551**	**Dry**
1932	79,097	Above Normal	**1988**	**10,083**	**Critically Dry**
1933	14,383	Critically Dry	**1989**	**10,248**	**Critically Dry**
1934	49,058	Normal	**1990**	**8,606**	**Critically Dry**
1935	58,486	Normal	**1991**	**25,965**	**Dry**
1936	70,684	Normal	1992	41,777	Normal
1937	85,456	Above Normal	1993	109,505	Wet
1938	161,366	Extremely Wet	1994	13,313	Critically Dry
1939	18,297	Dry	1995	153,118	Extremely Wet
1940	102,907	Wet	1996	75,412	Above Normal
1941	229,468	Extremely Wet	1997	98,561	Above Normal
1942	126,930	Wet	1998	226,901	Extremely Wet
1943	71,489	Normal	1999	51,222	Normal
1944	48,730	Normal	2000	73,499	Above Normal
1945	51,264	Normal	2001	44,981	Normal
1946	44,886	Normal	2002	30,888	Below Normal
1947	**14,743**	**Dry**	2003	59,434	Normal
1948	**14,703**	**Dry**	2004	36,910	Below Normal
1949	31,955	Below Normal	2005	112,153	Wet
1950	25,543	Dry	2006	107,217	Wet
1951	47,061	Normal	2007	12,542	Critically Dry
1952	128,995	Wet	2008	49,017	Normal
1953	54,446	Normal	2009	47,506	Normal
1954	**29,467**	**Dry**	2010	98,419	Above Normal
1955	**26,496**	**Dry**	2011	101769	Above Normal
1956	128,805	Wet	**2012**	**20,025**	**Dry**
1957	31,002	Below Normal	**2013**	**27,303**	**Dry**

Notes:
1. Year type classifications are based on the Carmel River Basin Runoff Index.
2. Outlined years indicate two or more consecutive dry or critically dry years and are defined as hydrologic droughts.
3. Runoff values for Water Years 1902-2005 were reconstructed by the Monterey Peninsula Water Management District based on records provided by the United States Geological Survey (USGS) and California American Water (Cal-Am). The runoff values for WY 2006 through WY 2013 were computed by the Monterey Peninsula Water Management District based on records provided by Cal-Am.

2.10.1.1 Tributary contribution

Relative tributary contribution varies from year to year, and it is postulated that the primary influences are spatial variations in sub-watershed rainfall and differences in drainage areas between sub-watersheds. Other important factors affecting tributary runoff include: water extraction, urbanization, local terrain and soil type, and vegetative cover. In addition, antecedent moisture conditions (i.e., rainfall received in previous years) affect sub-watershed runoff and base flow in a given year (James 2009).

San Clemente and Pine Creeks drain portions of the southernmost perimeter of the watershed. These areas receive relatively high annual rainfall, averaging more than 40 inches per year. Accordingly, these tributaries are high contributors of flow to the Carmel River. As indicated in Table 2-8, San Clemente Creek consistently contributed the highest volume of tributary inflow to the Carmel River over the period. Pine Creek, despite its small drainage area, ranked second or third except during the extremely wet years of 1995 and 1998. Garzas Creek headwaters also drain an area of high rainfall, and its flow contribution consistently ranks second or third. However, it is notable that during the 2004 – 2008 reporting period Pine and Garzas Creeks ranked second and third respectively, in all five water years. Cachagua and Tularcitos Creeks, the two largest sub-watersheds, located in the northeastern portion of the watershed, lie in a “rain-shadow”. Accordingly, they are moderate flow contributors in dry to average years. In extremely wet years such as 1995 and 1998, these large watersheds become saturated and their relative contributions increase significantly. The relatively small tributary drainages including Hitchcock, Robinson and Potrero Creeks, each drain approximately five square miles and are not located in a high rainfall region. Therefore, these tributaries are the lowest flow contributors of the eight gaged major tributaries **(**Table 2-8**)** (James 2009).

Table 2-8 expresses tributary contribution as a percentage of the total annual flow measured at the Carmel River at Highway 1 Bridge (HWY 1) site. The HWY 1 site essentially represents the total catchment of the Carmel River Watershed, with a drainage area of 252 square miles, as compared to 255 square miles at the lagoon. Table 2-8 shows how the various tributaries ranked in flow contribution over the past 16 years. In addition, the table shows that tributary runoff accounts for approximately 40 % of the flow at HWY 1. It is important to note that Table 2-8 does not account for gains or losses that occur along the river, particularly groundwater extraction from the Lower Carmel Valley**,** which averaged approximately 9,300 AF annually (Cal-Am groundwater production) over the 1993-2008 periods. Consequently, percentages of tributary flow contribution shown in the table are more exaggerated in dry years such as WY 1994 and 2007. In both of these years, lower Carmel Valley groundwater diversions (by Cal-Am) totaled approximately 10,000 AF, significantly more than the total gaged flow at HWY 1 (7,410 AF and 6,470 AF) in both of these years (James 2009).

Table 2-8. Percentage of Carmel River Tributary Flow Contribution Relative to Total Flow at the Carmel River at Highway 1 Bridge Site (James 2009).

PERCENTAGE OF CARMEL RIVER TRIBUTARY FLOW CONTRIBUTION RELATIVE TO TOTAL FLOW AT THE CARMEL RIVER AT HIGHWAY 1 BRIDGE SITE

TRIBUTARY SITES	Drainage Area (Square Miles)	% of CRB Area	% of Total Tributary Flow Contribution by WY																			
			1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	1993-11
SAN CLEMENTE CREEK	15.6	6	14	25	11	11	13	12	14	14	12	13	11	12	14	12	21	13	11	10	12	12
GARZAS CREEK	13.2	5	9	10	7	6	8	9	10	7	7	5	5	6	7	6	6	7				7
PINE CREEK	7.8	3	8	17	6	8	7	6	9	7	8	9	8	8	8	7	13	9	7	6	6	7
CACHAGUA CREEK	46.3	18	6	8	9	5	4	8	5	2	3	1	2	4	4	5	4	5	3	5	5	6
TULARCITOS CREEK	56.3	22	3	6	3	2	2	8	7	3	3	3	1	2	1	2	8	2				4
ROBINSON CANYON CR.	5.4	2	2	1	1	1	1	2	1	1	1	0	1	1	1	1	0	1				1
POTRERO CREEK	5.2	2	---	0	1	1	1	2	2	1	1	0	0	1	1	1	0	1				1
HITCHCOCK CREEK	4.6	2	---	1	1	1	1	1	0	1	0	0	1	1	1	1	0	1				1
Total	154.4	60		67	40	33	37	48	49	37	36	31	30	34	38	34	52	39				

NOTES:

1. Percent of Carmel River Basin (CRB) figures are based on a total basin area of 252 square miles (Sq. Mi.).
2. Percent of total flow contribution figures are based on the total annual flow at Carmel River at HWY 1 Bridge site.
3. The above table does not account for gains or losses that occur along the river including but not limited to ground and surface water production, interflow, un-gaged drainage, local runoff, evapotranspiration etc.
4. Percentage values for the 1993-2003 period do not incorporate Water Year 1993 at the Hitchcock and Potrero Creek sites.
5. Total percentage values are calculated from actual values and are not derived from addition of individual, rounded percentage values.
6. Percentages of tributary flow contribution in "Critically Dry" years (1994 & 2007) are poorly represented as LCV groundwater production exceeds gaged HWY 1 flows in these years.

The Carmel Valley can be considered to be a “U”-shaped bedrock bathtub with a thick layer of sand in the bottom. The sand at the bottom is the major unconfined aquifer for regional water supplies (e.g., Kapple et al, 1984). The sand and water rest above the low permeability bedrock of the valley. When water flows through the Carmel Valley, it occupies both the surface river channel and a subterranean river flowing within the sand beneath the channel (Kondolf and Curry, 1982; Maloney, 1984). This geometry makes groundwater and surface water the same resource (SWRCB, 1995a); managing one requires managing the other. Currently the surface water resource is impaired because the shallow sub-stream aquifer is over-pumped by approximately 11,000 acre-feet/yr (SWRCB 1995a; Smith *et al.* 2004).

Many of the Carmel watershed streams go dry annually, leaving fish populations at risk. Most of the small headwater streams located high in the watershed do not have enough shallow groundwater to sustain them through the summer. The lower reach of the Carmel River goes dry annually because the surface water percolates downward through the gravel in its bed, replacing the water removed by municipal and private wells that tap the sands and gravels underlying the riverbed. The resulting drop in the water table resulted in impaired riparian vegetation and consequent enormous loss of land to bank erosion in the early 1980’s (Kondolf and Curry 1986). Presently, the riparian zone of the lower Carmel Valley owes its existence to miles of seasonally-deployed irrigation systems that counteract the overdraft of the unconfined aquifer (Smith *et al.* 2004).

Of critical importance to sustainable fisheries is the maintenance of year-round surface water at various reaches in the Carmel River with the appropriate seasonal range of discharge, temperature, and chemistry. The success of anadromous fisheries does not hinge upon the Carmel River being perennial, but there are minimum conditions that must be met to sustain the population. There must be sufficiently large winter flows to present significant opportunities for fish migration to and from the sea, yet the Carmel River did not necessarily flow to the sea during the migratory season in every year. Likewise summer flows must be of sufficient local volume to provide cool, well-oxygenated, protected habitat for fish that will remain in the river during the dry season. These low summer flows must also be able to dilute septic return flow to a level that is not toxic to the fish population. Other benefits of summer surface flow would include a healthy riparian forest (Kondolf and Curry, 1986), reduced stream bank erosion (Kondolf and Curry 1986), and the aesthetic appeal of flowing water (Smith *et al.* 2004).

2.10.1.2 Storm water

Storm water is water that originates during precipitation events and enters the storm water or storm drain system. Storm water that does not soak into the ground becomes surface runoff, which either flows directly into surface waterways or is channeled into storm drains, which eventually discharge to the Carmel River and Carmel Bay. Storm water is of concern for two main issues, the volume and timing of runoff water can lead to flooding, and the potential contaminants that the water is carrying.

Storm water originates from roads and then flows into drainage ditches and road culverts that collect runoff and sediment from road surfaces and adjacent slopes. Ditches and culverts concentrate flow, and carry a high sediment load to creeks and the river. Nearly every culvert visited during a 2004 study of the Carmel Watershed observed that universally-used corrugated culverts concentrate high flows from above into a narrow, high-velocity flow that literally hoses the downstream part of the creek bed, akin to a hydraulic mining operation. It would be difficult to estimate the enormous volume of excess sediment that has been liberated into the Carmel River and National Marine Sanctuary because of the erosion caused by undersized, poorly installed, culverts (Smith *et al.* 2004).

2.10.2 Ground water hydrology

The principal water-bearing geologic formation in the Carmel Valley is the younger alluvium, consisting of poorly consolidated boulders, gravel, sand, and silt deposited by the Carmel River in the last 10,000 years. The thickness of the alluvium increases in a downstream direction from zero above the Carmel Valley Filter Plant to more than 200 feet west of Highway 1 near the river mouth, with a typical thickness of 50 to 100 feet. The Carmel Valley alluvial aquifer (Figure 2-20) is unconfined and is highly permeable, recharging rapidly after extended dry periods. The aquifer is underlain by much less permeable bedrock formations consisting of pre-Tertiary Period igneous and metamorphic rocks, and Tertiary Period sedimentary rocks. Only a few wells on the valley floor have been drilled through the alluvial sediments into underlying bedrock. Because the permeability of these rocks is considerably less than that of the alluvial sediments, groundwater exchange within the alluvium is thought to be limited and, therefore, has not been studied extensively or definitively quantified (CDWR 2012).

It is estimated that about 85% of the water entering the aquifer percolates through the bed of the Carmel River (Kapple et al. 1984). Additional recharge comes from the tributary drainages, direct infiltration of precipitation, inflow from subsurface bedrock formations, and return flow from irrigation and septic systems. Water in the aquifer is primarily lost by groundwater pumping; minor sources of loss include discharge into the river, seepage into the ocean, evapotranspiration by riparian vegetation, and deep percolation into underlying bedrock formations (Jones & Stokes Associates 1998).

Although riparian vegetation was much more abundant before the valley was developed and, consequently, evapotranspiration was greater, the water level in the aquifer in summer and fall was generally high enough to provide base flow to the river and sustain year-round flow. Upstream diversion of water and large-scale groundwater pumping now dry up the river in the Lower Carmel Valley during the summer months (Jones & Stokes Associates 1998). During water year 2012 (October 1, 2011 – September 30, 2012), Cal-Am wells withdrew 7,514 AF from the alluvial aquifer, and non–Cal-Am wells withdrew 2,732 AF from the watershed within the MPWMD boundary, for a total of 10,246 AF (MPWMD well records for reporting year 2012). A portion of the non-Cal-Am pumpage is assumed to return to the aquifer as recharge from irrigation and septic system return flow.

Figure 2-20. Carmel Valley Alluvial Aquifer (MPWMD)

The volume of groundwater storage in the Carmel Valley aquifer is a function of the geometry of the watershed and the porosity of the alluvial sediments. Based on available information from logs of existing wells in the watershed, the total groundwater storage capacity of the aquifer is estimated by MPWMD to be approximately 48,000 AF. Not all of the total storage volume is considered usable; however, as this would result in complete dewatering of the aquifer. This would not be desirable or even possible, given the present configuration of production wells. In addition subsurface outflow to the lagoon and ocean is required to prevent seawater intrusion and minimize impacts on the lagoon and wetland environment. The volume of usable groundwater storage in the aquifer is estimated at 28,500 AF. The total and usable storage capacities in each of the aquifer subunits are summarized in Table 2-9 (Jones & Stokes Associates 1998).

Table 2-9. Usable Storage Capacities for the Carmel River Valley Aquifer (MPWMD)

Total and Usable Storage Capacities for the Carmel Valley Aquifer Subunits						
(values in acre-feet)						
Subunit	**Location**	**Total**	**Non-Usable**	**Usable**		
AQ1	SC Dam to Esquiline Rd Bridge	2029	0	2029		
AQ2	Esquiline Rd Bridge to Narrows	6099	1597	4502		
AQ3	Narrows to Via Mallorca Bridge	19615	2688	16927		
AQ4	Via Mallorca Bridge to lagoon	20475	15475	5000		
Total		**48218**	**19760**	**28458**		

2.10.3Lagoon dynamics

The lagoon area and associated wetlands, which are located immediately south of the city of Carmel-by-the-Sea in Monterey County, cover an area of approximately 100 acres (Figures 2-21 and 2-22). The lagoon is a valuable aesthetic and recreational resource to residents and tourists, and provides rich habitat for juvenile steelhead, birds and other wildlife. Most of the lagoon and wetlands area are within the Carmel River Lagoon and Wetlands Natural Preserve which is part of the Carmel River State Beach (James 2005).

Figure 2-21. Carmel lagoon aerial photograph (Casagrande 2006).

Figure 2-22. Carmel lagoon aerial photograph (Casagrande 2006).

Lagoon morphology (i.e., areal extent, level and form) is strongly influenced by the Carmel River and the Pacific Ocean. In years when fall or winter rains produce sufficient runoff, the Carmel River will advance toward the lagoon and begin to fill it. Prior to 2014, the Monterey County Public Works Department (MCPWD), under contract with the Monterey County Water Resources Agency (MCWRA), typically used bulldozers to artificially breach the sand bar at the lagoon mouth to avoid flooding residences that are located immediately north of the wetlands. Following this initial, artificial breaching, the beach berm generally remains open and the river flows to the ocean through the winter and early spring. During this period, the lagoon closes and opens (either naturally or by artificial breaching) multiple times depending on variable ocean and river conditions. As inflows recede in spring or summer, the river mouth eventually closes for the remainder of the season until the next significant rainy period repeats the process (James 2005).

Two major lagoon excavation projects that increased lagoon volume were completed in 1997 and 2004. The 1997 excavation was a Cal-Trans mitigation bank project that included levee removal along portions of the southern bank of the Carmel River near Highway 1, grading downstream of Highway 1, and excavation of the South Arm of the lagoon. Preliminary earthwork estimates proposed that approximately 25 acre-feet (AF) would be excavated and removed from the South Arm vicinity (Cal-Trans 1996). As-built drawings that quantify the actual excavation volume are unavailable; therefore, it is uncertain how much additional lagoon volume was created. In 2004, California State Parks implemented the Carmel River Lagoon Enhancement Project that involved excavation of new lagoon, marsh and riparian habitats. This project extended the existing South Arm approximately 3,000 feet eastward to Highway 1. As-built drawings indicate that at the five-foot level (National Geodetic Vertical Datum of 1929 or NGVD), lagoon volume was doubled from 30 AF (based on 1994 volume estimate), to 62 AF, with a total volume gain of 89 AF at the 10-foot level (Dettman 2005) and (James 2005).

2.10.3.1 Lagoon phases

The lagoon is characterized by four phases that are described below:

Seawater Inflow Phase

The summer and fall seasons are relatively static periods at the lagoon, with the exception of occasional filling by ocean waves. As river inflow to the lagoon ceases in late spring or summer, the lagoon mouth closes and the water level gradually recedes until its level has equilibrated with the local water table. Although southerly swells during the summer can occasionally overtop the beach berm and flow into the lagoon, it is the fall and winter seasons when significant west and northwest swells generated by storms over the North Pacific Ocean reach the California coast. These swells, when accompanied by spring tides which occur at full and new moon cycles, will begin to fill the lagoon with seawater. The effects of seawater inflow (also referred to as wave in-wash) to the lagoon are most pronounced in the fall because the initial lagoon level is low and the mouth is closed, resulting in a dramatic increase in lagoon level with no outlet for the seawater to escape. Following the event, the increased lagoon level which has been raised above the local water table, slowly recedes as it recharges local alluvium, seeps through the beach, or evapotranspires (James 2005).

Once the initial seasonal lagoon breach has occurred, usually in December or January, periodic high long period swells continue. However, their effect on lagoon levels are much different than in the fall, as the river maintains an outflow channel. In general, depending on river flow, the lagoon level will "spike" at the arrival of high swell and the higher high tide, and then recede. This "spike" as seen in lagoon hydrographs on February 26, 2004, and on March 9, 2005 results from a combination of seawater inflow and a backwater effect on the river and lagoon at the ocean/outflow channel interface (James 2005).

Rainfall and Initial Lagoon Opening Phase

At the lagoon, the late fall/early winter period is characterized by occasional large ocean swells overtopping the beach berm and, in years with normal rainfall and runoff, it is the time of year when Carmel River streamflow reaches the lagoon. In general, a river inflow of 10 cfs or greater will begin to fill the lagoon when it is closed to the ocean. Because the lagoon at the 10-foot level holds only about 300 AF, even a moderate inflow of 150 cfs is sufficient to fill the lagoon in one day. In some years such as December 1995, the river reaches the lagoon as a relatively low flow (25 cfs or less) that slowly fills the lagoon. This "slow filling" scenario provides public officials ample time to monitor and assess lagoon flood risk. In other years such as January 1995, the river reaches the lagoon as a flood flow, and officials must act much more quickly. An example of this would be the January 10, 1995 event, when the lagoon inflow of 25 cfs increased to 10,000 cfs in 12 hours. In anticipation of this flood wave, county officials breached the lagoon the previous day (James 2005).

Once flow in the Carmel River reaches the lagoon, the level begins to rise and artificial breaching of the lagoon becomes necessary to prevent flooding of local roads, private property and homes. Prior to 2014, lagoon breachings were typically performed by the Monterey County Public Works Department, who mobilized for river mouth breachings when the water level in the Carmel River Lagoon reached an elevation of 7.5 feet NGVD (Interim Plan and Criteria for Emergency Breaching of the Carmel River Mouth, dated September 1, 1992, by Monterey County Public Works). Actual excavation of the sand berm begins when the water level in the lagoon reaches an elevation of 8.78 feet. With high initial lagoon inflows (>500 cfs) similar to what occurred in January 2000, breaching normally occurs the same day the flow arrives. With low initial inflows (< 50 cfs), the lagoon is allowed to fill, sometimes for days, before it is breached (e.g., December 1995). Over the past 14 years, the mean and median initial breach levels have been 9.93 and 9.82 feet, respectively. It is interesting to note that the maximum lagoon level on the initial opening date was less than 10 feet for all years during the 1992 – 1998 period (9.06' average), and greater than 10 feet for the 1999 – 2005 period (10.8' average). This apparent change in artificial breaching practice is likely related to the Federal listing of the Carmel River Steelhead as a threatened species in 1997, and the associated, increased involvement of environmental resource agencies (i.e., NOAA Fisheries, CDFG). Inherent to the complexity of lagoon breaching tactics is the fact that each year is different requiring public officials to adapt to variable rainfall, river and ocean conditions, while considering species protection mandates (James 2005).

Open Lagoon Phase

Once the initial opening of the lagoon occurs, the river mouth remains open 85 % of the time (13 years of data). In some years like the extremely wet WY 1995, the lagoon mouth was open nearly 100 % of the time, while during the critically dry year of WY 1994, the lagoon was open only half of the time. Ocean energy and river inflow are the two major factors that determine whether the lagoon will stay open or closed. In general, low wintertime river flows favor frequent periodic closures and subsequent breaches (e.g., November 1998) as wave and tidal action are the dominant forces. Inflows greater than 100 cfs maintain an open lagoon nearly all the time as river flows are sufficient to scour out beach sand. If the lagoon does close, it will fill in a day or two, until it is either breached by County crews, or naturally, as the lagoon level eventually spills over the low point of the beach berm. Recorded data and field observations indicate that lagoon inflow rates greater than 100 cfs will maintain an open lagoon mouth 95 to 100 % of the time. Inflows of 20 cfs maintain an open lagoon about 50 % of the time, and the lagoon mouth normally will close at 10 cfs or less, even under the most benign surf and tidal conditions (James 2005).

Closed Lagoon Phase

With the exception of seawater inflow, the period of time during which the lagoon mouth is closed is relatively uneventful. As river inflow recedes to 10 cfs in the spring or summer, the mouth will close for the remainder of the dry season until the following winter's flow returns. Once the final seasonal closure has occurred at the lagoon, there is a final filling by dwindling surface inflows, followed by a gradual water level decline that reaches a minimum in August or September. The seasonal low during this period averages about 3.0 feet, with 2.5 feet as the lower limit. This minimum level cannot be easily explained by the presence of river flow (as it is with an open lagoon), as the river is dry at this time. It is hypothesized that local water table elevation and associated subsurface inflow are the primary factors limiting further decline (James 2005).

2.11 Water quality

Water quality of the Carmel River is acceptable. It is not listed among the impaired California Rivers by the Environmental Protection Agency's Clean Water Act (303d) listings. Turbidity is generally low except after large winter storms or following wet winters when effects of landslides continue after the rainy season (Smith et al, 2004).

In addition, groundwater quality conditions in the Carmel Valley Alluvial Aquifer have remained acceptable in terms of potential indicators of contamination from shallow sources such as septic systems, and there have been no identifiable trends indicative of seawater intrusion into the principal supply source. Rather, it is the lack of water caused by environmental factors such as drought and large scale groundwater pumping that causes water quantity issues.

Since 1991, surface-water quality data have been collected by MPWMD at three sampling stations along the Carmel River on a semi-monthly basis. The locations of the sampling stations are as follows: (1) below Los Padres Reservoir (BLP) at River Mile (RM) 25.4, (2) below San Clemente Reservoir at the Sleepy Hollow Weir (SHW) at RM 17.1, and (3) at the Carmel River Lagoon (CRL) at RM 0.1. River miles are measured from the mouth of the Carmel River. Monitoring at these specific stations gives MPWMD staff information on the quality of water released from each reservoir and in the surface layer of the lagoon (MPWMD 2000-2013).

Data were collected for the following chemical and physical parameters: temperature (°F), dissolved oxygen (mg/L), carbon dioxide (mg/L), pH, specific conductance (uS/cm), salinity (ppt), and turbidity (NTU). The emphasis for this suite of parameters is on the suitability for rearing juvenile steelhead (MPWMD 2000-2013).

MPWMD staff also monitors river temperatures continuously at six locations within the Carmel River Watershed (Figure 2-23). The objective is to document the temperature regime in different stream reaches and to determine whether water-quality criteria for maximum stream temperatures are exceeded. In addition, these data allow MPWMD staff to monitor changes in the thermal regime of the river over time (MPWMD 2000-2013).

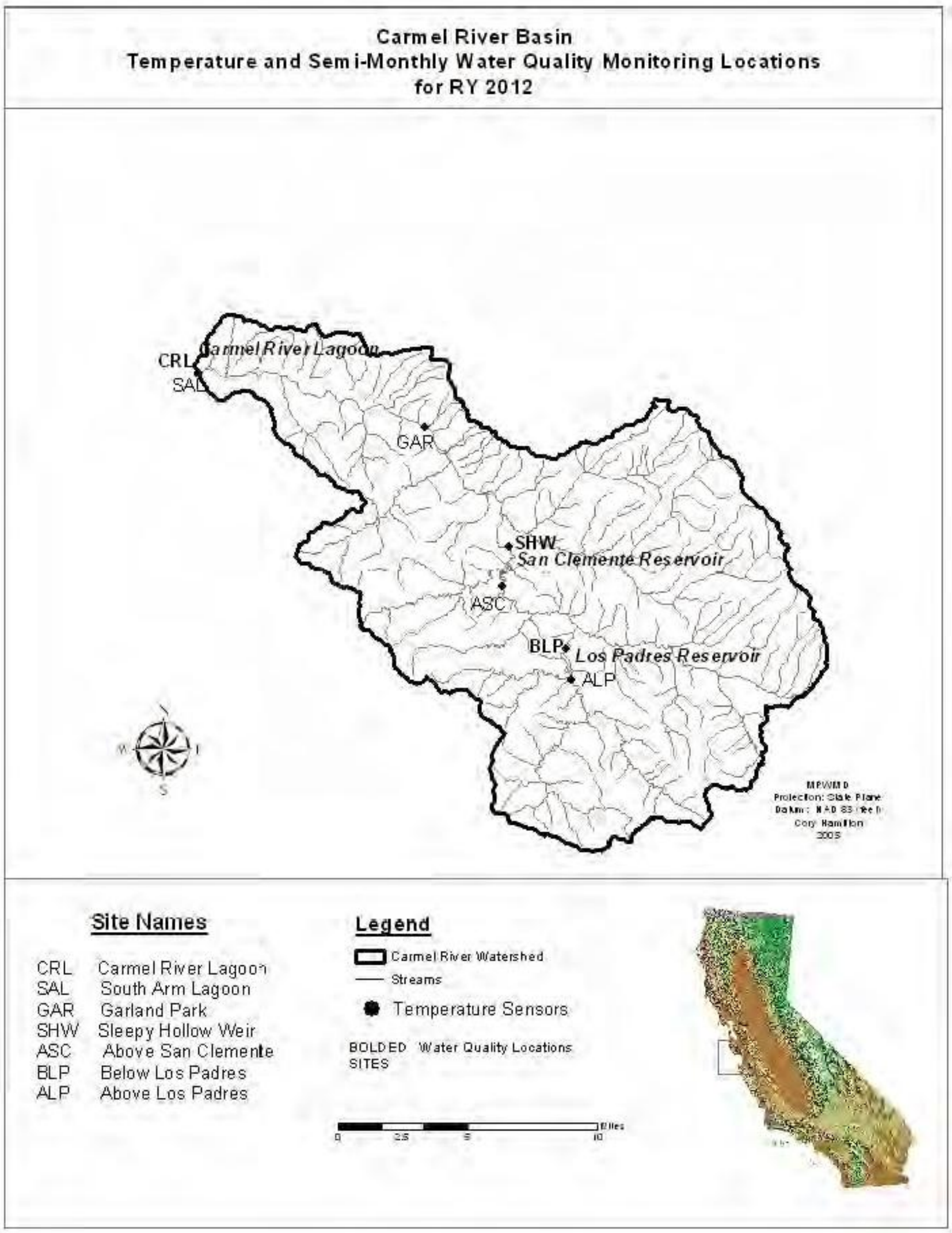


Figure 2-23. Temperature and Semi-Monthly Water Quality Monitoring Locations in the Carmel River Basin During RY 2012 (MPWMD).

2.11.1 Surface water quality condition in the mainstem and lagoon

The following paragraphs describe the results of the MPWMD's semi-monthly data collection and continuous temperature recorders at specific sampling stations in the watershed (MPWMD 2000-2013).

Carmel River Lagoon-- The water-temperature monitoring station for the Carmel River Lagoon is located in the south arm of the lagoon on the Carmel Area Wastewater District (CAW) effluent discharge pipe. This station had operational difficulties associated with it during Reporting Year (RY) 2012. Staff continues to apply adaptive strategies to correct these difficulties. During RY 2012, all data collected at this water-temperature station were unreliable, and therefore have not been reported. Water-quality data collected at the CRL station, which is located on the south side of the main body of the lagoon, were reliable and are listed in Table 2-10. Maximum water temperature during water-quality sampling was 67.6°F, occurring on September 9, 2011. The minimum dissolved-oxygen measurement recorded was 6.2 mg/L, which is within the suitable criteria recommended by the Environmental Protection Agency (EPA) for steelhead (Chapman 1986). The pH measurements ranged from 7.5 to 8.0, which is also within suitable range. Carbon dioxide measurements ranged from 10 to 20 mg/L . However, it is important to note that when sampling lower into the water column at the lagoon, one can find certain parameters (D.O., Temperature, and Conductivity) unfavorable to steelhead during certain times of the year.

Variability in carbon dioxide is usually caused by an increase of marine organic debris entering the lagoon during high surf events. Carbon dioxide is a byproduct of decomposition of this material. Fish located in waters with free carbon dioxide concentrations above 20 mg/L can show signs of distress (Wedemeyer 1996).

The conductivity measurements ranged from 135 to 35,000 uS/cm. The surface salinity ranged from 0.2 to 28.5 ppt. The conductivity and salinity are highly variable at the lagoon due to tidal influences and river inflows. The turbidity measurements ranged from 0.1 to 6.0 NTU. Overall, the biggest threat to steelhead rearing continues to be the high salinity readings that occur in in the lagoon, severely reducing the amount of rearing habitat that is adequate for juvenile steelhead in the late summer and fall months, coupled with the constant sub-optimal water temperatures and dissolved oxygen during this period (MPWMD 2000-2013).

Table 2-10. Water quality data collected by MPWMD during RY 2012 at Carmel River Lagoon's Surface Water Quality Station.

Date	Time 24 Hr	Temperature (F)	Dissolved Oxygen (mg/L)	Carbon Dioxide (mg/L)	pH	Conductivity (uS/cm)	Nacl (ppt)	Turbidity (NTU)	WSE (ft)
7/7/11	1400	58.5	7.8	15	8.0	35000	28.5	0.1	2
8/2/11	0920	63.3	8.6	10	8.0	549	0.3	0.7	6.76
8/24/11	1000	65.8	8.2	10	8.0	558	0.3	0.1	6.06
9/9/11	0945	67.6	8.2	10	8.0	135	0.8	0.6	5.94
9/22/11	0930	62.1	6.2	15	8.0	23860	20.8	6.0	6.98
10/6/11	0930	64.8	11.1	15	7.5	1050	0.6	3.0	7.66
10/20/11	1000	64.8	8.4	15	7.5	1280	0.8	0.3	8.76
11/10/11	0950	52.0	7.5	15	7.5	785	0.5	0.2	9.19
11/17/11	1000	55.0	11.0	10	8.0	738	0.5	0.1	9.8
12/7/11	1020	49.5	9.0	15	7.5	397	0.4	0.3	8.76
12/15/11	1000	47.5	8.4	15	8.0	540	0.4	0.4	9.6
1/4/12	1015	48.7	8.5	15	7.5	789	0.6	0.2	9.9
1/18/12	0930	43.8	8.1	15	7.5	749	0.6	2.6	8.2
2/7/12	1010	51.8	8.1	10	7.5	1268	0.9	0.1	6.68
2/22/12	0951	52.8	8.5	15	8.0	3188	2.3	0.5	5.93
3/6/12	0974	54.0	13.6	20	8.0	4570	3.3	0.8	6.01
3/19/12	0950	49.3	9.2	20	7.5	1964	1.5	4.2	3.4
4/3/12	0950	52.5	9.0	20	8.0	573	0.4	1.8	2.6
4/16/12	1015	54.0	8.9	20	8.0	470	0.3	2.8	2.5
5/9/12	0900	57.2	13.4	20	7.5	1571	0.4	1.0	5.02
5/23/12	0930	66.2	7.6	20	8.0	470	0.3	0.5	6.55
6/5/12	0930	64.4	7.1	20	7.5	433	0.2	0.6	8.16
6/22/12	1048	66.0	8.9	15	7.5	637	0.4	0.6	7.34
Minimum		43.8	6.2	10.0	7.5	135	0.2	0.1	
Maximum		67.6	13.6	20.0	8.0	35000	28.5	6.0	
Average		57.0	8.9	15.4	7.8	3547	2.8	1.2	

Garland Park-- Water temperature for the Garland Park (GAR) station is shown in Figure 2-24. Data for this site during the period of August 11, 2011 to October 26, 2011 were air temperatures and are not included in the summary statistics provided below. The sampling period that is included is July 1, 2011 to August 10, 2011 and October 27, 2011 to June 30, 2012. The maximum annual water temperature was 69.7°F, occurring on July 30, 2011. The overall average water temperature during the reporting year at this station was 54.9°F. Maximum daily average water temperature was 65.1°F, occurring on July 3, 2011. Daily average water temperatures were within adequate range for steelhead rearing during the entire sampling period (MPWMD 2000-2013).

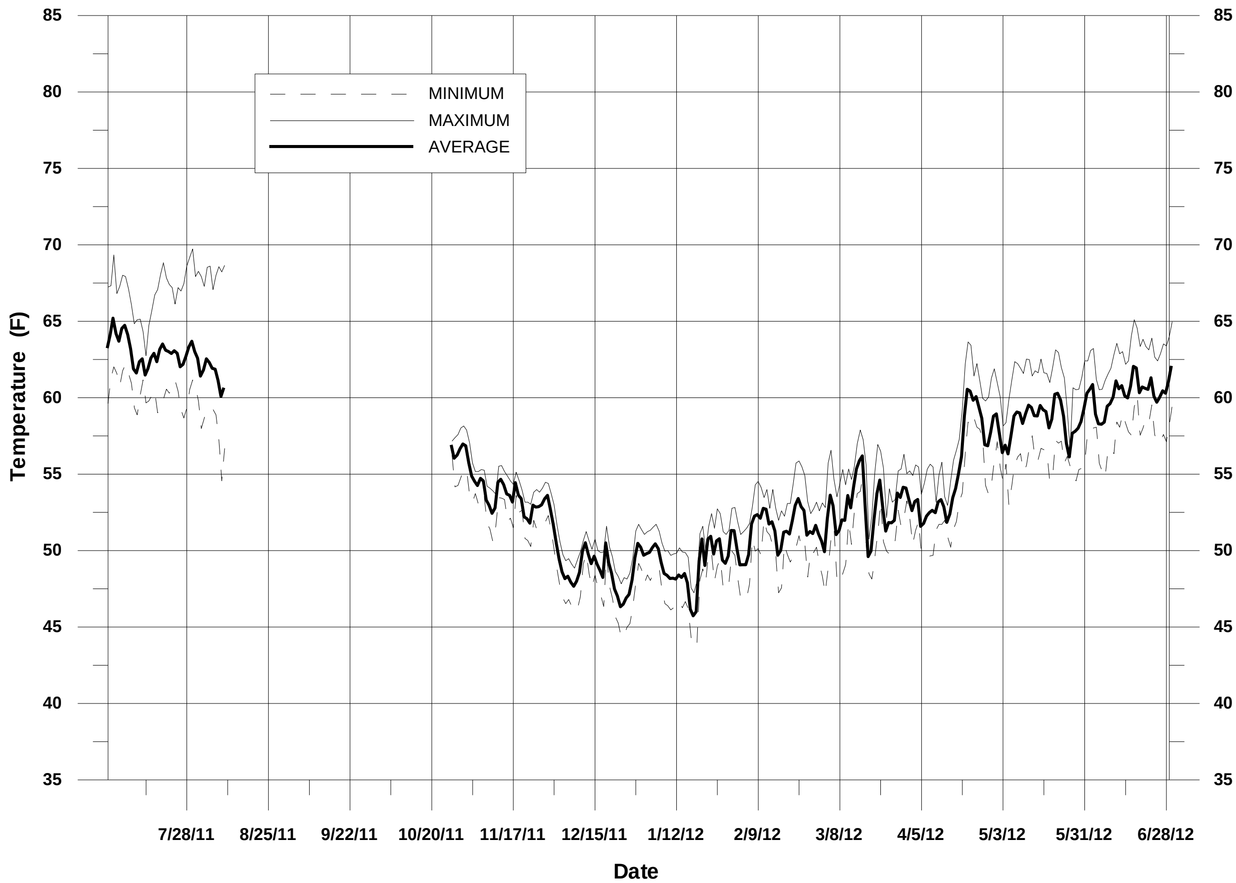


Figure 2-24. Daily temperatures recorded from a continuous temperature data logger at the Garland Park (GAR) station during RY 2012 (MPWMD).

Sleepy Hollow Weir-- The maximum annual water temperature for the Sleepy Hollow Weir (SHW) station was 68.9°F, occurring on July 7, 2011. The overall average water temperature during the reporting year at this station was 55.3°F. The maximum daily average water temperature was 67.3°F, occurring on July 7, 2011. Constant water temperatures over 68°F are considered stressful for steelhead (Brungs and Jones, 1977). Daily average water temperatures were within adequate range for steelhead rearing during the entire sampling period. This Water-quality data collected at this station are listed in Table 2-11. The minimum dissolved-oxygen measurement recorded was 8.4 mg/L, which is within the suitable criteria recommended by the EPA for steelhead (Chapman, 1986). Carbon-dioxide measurements ranged from 5 to 15 mg/L. The pH measurements ranged from 7.5 to 8.5. The turbidity measurements recorded were between 0.1 to 3.2 NTU. Water-quality parameters measured were within the adequate range for steelhead rearing during the sampling period, with the exception of the July water temperatures mentioned above (MPWMD 2000-2013).

Table 2-11. Water quality data collected by MPWMD during RY 2012 at Sleepy Hollow Weir station.

Date	Time 24 hr	Temperature (F)	Dissolved Oxygen (mg/L)	Carbon Dioxide (mg/L)	pH	Conductivity (uS/cm)	Turbidity (NTU)
7/7/2011	1100	66.9	8.6	10	8.0	230	0.05
8/2/2011	1050	63.5	8.6	10	8.5	231	0.75
8/24/2011	1110	63.3	8.7	5	8.5	233	3
9/9/2011	1050	65.1	8.7	5	8.0	236	2.6
9/22/2011	1030	68.0	8.4	10	8.0	240	2.7
10/6/2011	1020	59.5	9.0	10	8.0	251	1.7
10/20/2011	1100	62.1	9.3	15	8.0	239	1.4
11/10/2011	1115	50.5	10.2	5	8.0	214	1.75
11/17/2011	1130	52.5	10.4	10	8.0	222	2.06
12/7/2011	1200	45.9	11.6	10	8.0	204	1.92
12/15/2011	1130	45.3	10.4	10	8.0	211	1.98
1/4/2012	1130	44.4	11.4	10	8.5	209	2.77
1/18/2012	1100	39.7	12.8	10	7.5	195	3.2
2/7/2012	1200	48.7	10.0	15	8.0	180	0.36
2/22/2012	1110	49.1	14.6	5	8.0	178	0.12
3/6/2012	1050	50.0	15.4	5	8.0	N/A	0.25
3/19/2012	1120	48.4	9.4	15	8.0	163	0.88
4/3/2012	1130	51.0	10.6	10	8.0	138	0.15
4/16/2012	1130	52.0	9.5	15	8.0	143	0.71
5/9/2012	1010	58.1	9.0	15	8.0	172	0.45
5/23/2012	1145	60.8	9.6	10	8.0	218	0.43
6/5/2012	1050	64.2	8.8	15	8.0	180	0.35
6/22/2012	1256	64.8	9.6	10	8.0	205	0.6
Minimum		39.7	8.4	5.0	7.5	138	0.1
Maximum		68.0	15.4	15.0	8.5	251	3.2
Average		55.4	10.2	10.2	8.0	204	1.3

Above San Clemente Reservoir-- Water temperature for the Above San Clemente (ASC) station is shown in Figure 2-25. The sampling period for this station was July 11, 2011 to June 30, 2012. The maximum annual water temperature was 67.4°F, occurring on June 17, 2012. The overall average water temperature during the reporting period at this station was 54.7°F. Maximum daily average water temperature at this station was 64.8°F, occurring on September 11, 2011. Daily average water temperatures were within adequate range for steelhead rearing during the entire sampling period (MPWMD 2000-2013).

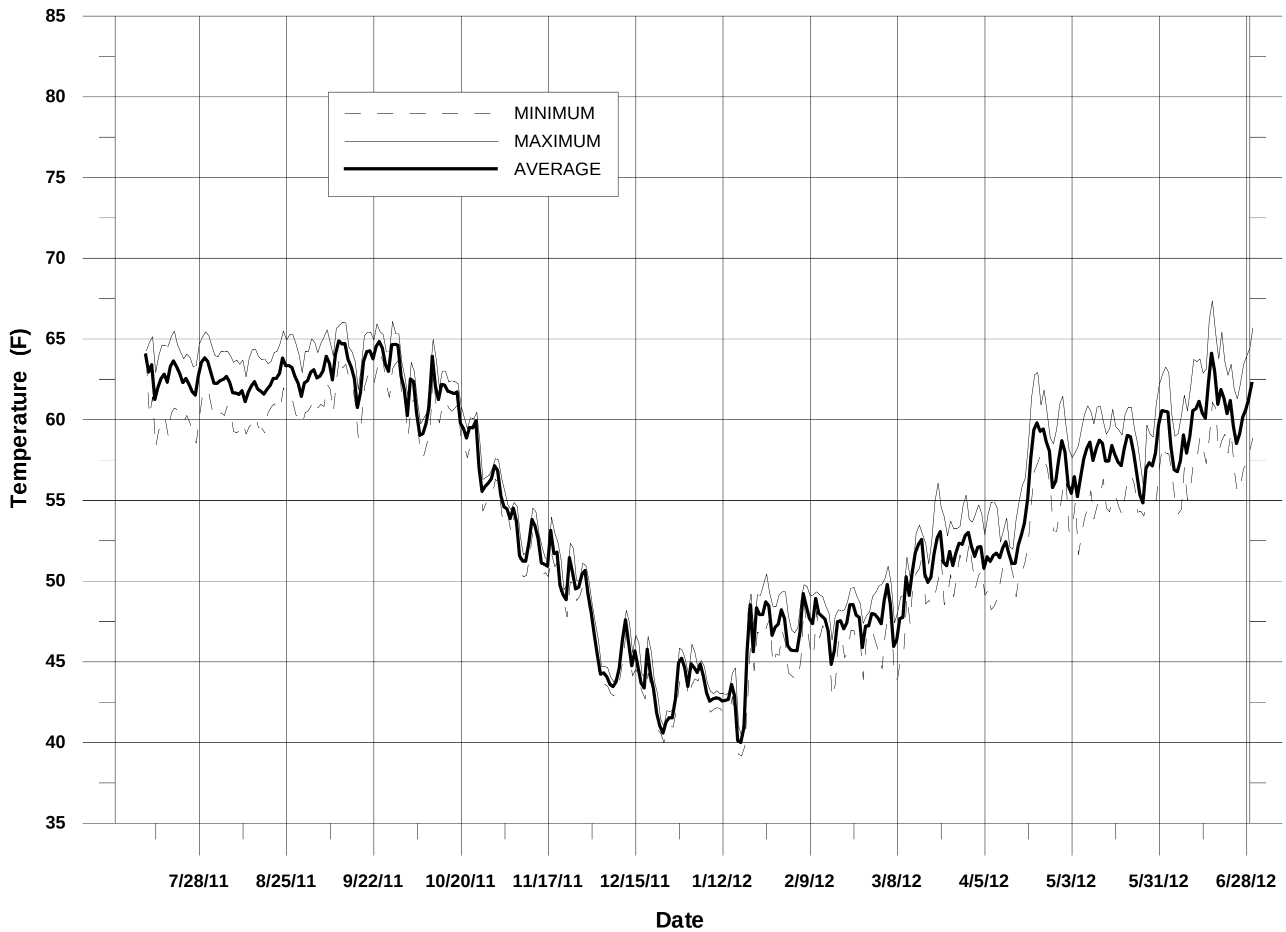


Figure 2-25. Daily temperatures recorded from a continuous temperature data logger at the above San Clemente (ASC) station during RY 2012

Below Los Padres Reservoir-- The sampling period for this station was July 1, 2011 to June 30, 2012. The maximum annual instantaneous water temperature observed was 68.4°F, occurring on July 6, 2011. The overall average water temperature observed at this station during the sampling period was 55.5°F. The maximum daily average water temperature at this station was 67.2°F on September 28, 2011.

Daily average water temperatures were within adequate range for steelhead rearing during the entire sampling period. Water quality data collected at this station are listed in Table 2-12. Water quality at this station is highly influenced by reservoir water quality and release location. The minimum dissolved oxygen measurement recorded was 6.7 mg/L, which is within the suitable criteria recommended by the EPA for steelhead (Chapman 1986). Carbon dioxide measurements ranged from 5 to 20 mg/L. The pH and conductivity measurements ranged between 7.5 to 8.0 and 122 to 245 uS/cm, respectively. Turbidity measured at this station ranged from 0.2 to 4.8 NTU. Water-quality parameters measured were within the adequate range for steelhead rearing during the reporting year (MPWMD 2000-2013).

Table 2-12. Water quality data collected by MPWMD during RY 2012 at Below Los Padres station.

Date	Time 24 hr	Temperature (F)	Dissolved Oxygen (mg/L)	Carbon Dioxide (mg/L)	pH	Conductivity (uS/cm)	Turbidity (NTU)
7/7/2011	0930	68.2	8.4	5	7.5	211	0.15
8/2/2011	1400	65.8	7.7	10	8.0	201	1.2
8/24/2011	1300	66.0	7.6	10	7.5	206	0.96
9/9/2011	1300	61.9	7.3	10	7.5	232	2.9
9/22/2011	1250	62.2	6.8	10	8.0	242	1.1
10/6/2011	1210	59.9	7.9	15	7.5	239	1.7
10/20/2011	1330	59.0	6.7	20	7.5	245	1.6
11/10/2011	1300	56.8	8.4	15	7.5	225	3.18
11/17/2011	1315	50.5	9.0	15	7.5	220	3.1
12/7/2011	1310	43.9	9.3	20	8.0	N/A	2.2
12/15/2011	1330	47.7	9.5	15	7.5	192	1.85
1/4/2012	1350	45.7	9.7	15	7.5	186	1.17
1/18/2012	1230	44.6	10.4	15	7.5	173	1.65
2/7/2012	1330	47.8	9.7	15	7.5	155	1.2
2/22/2012	1330	48.3	9.7	10	7.5	N/A	1.25
3/6/2012	1300	48.4	10.3	20	7.5	N/A	1.25
3/19/2012	1300	51.8	9.5	10	7.5	147	N/A
4/3/2012	1300	52.0	11.4	10	7.5	122	0.22
4/16/2012	1300	52.0	9.2	15	7.5	125	0.4
5/9/2012	1230	59.2	9.2	15	7.5	147	0.35
5/23/2012	1045	58.1	9.3	15	8.0	149	0.95
6/5/2012	1300	59.5	9.1	20	7.5	159	1.65
6/22/2012	1430	59.2	8.9	10	7.5	170	4.8
Minimum		43.9	6.7	5.0	7.5	122	0.2
Maximum		68.2	11.4	20.0	8.0	245	4.8
Average		55.2	8.9	13.7	7.6	187	1.6

Above Los Padres Reservoir-- Water temperature for the Above Los Padres (ALP) station is shown in Figure 2-26. The maximum annual water temperature was 65°F, occurring on June 17, 2012. Average water temperature during the reporting period was 52°F. Maximum daily average water temperature at this station was 64°F, occurring on July 7, 2011. Daily average water temperatures were within the adequate range for steelhead rearing during the entire reporting year (MPWMD 2000-2013).

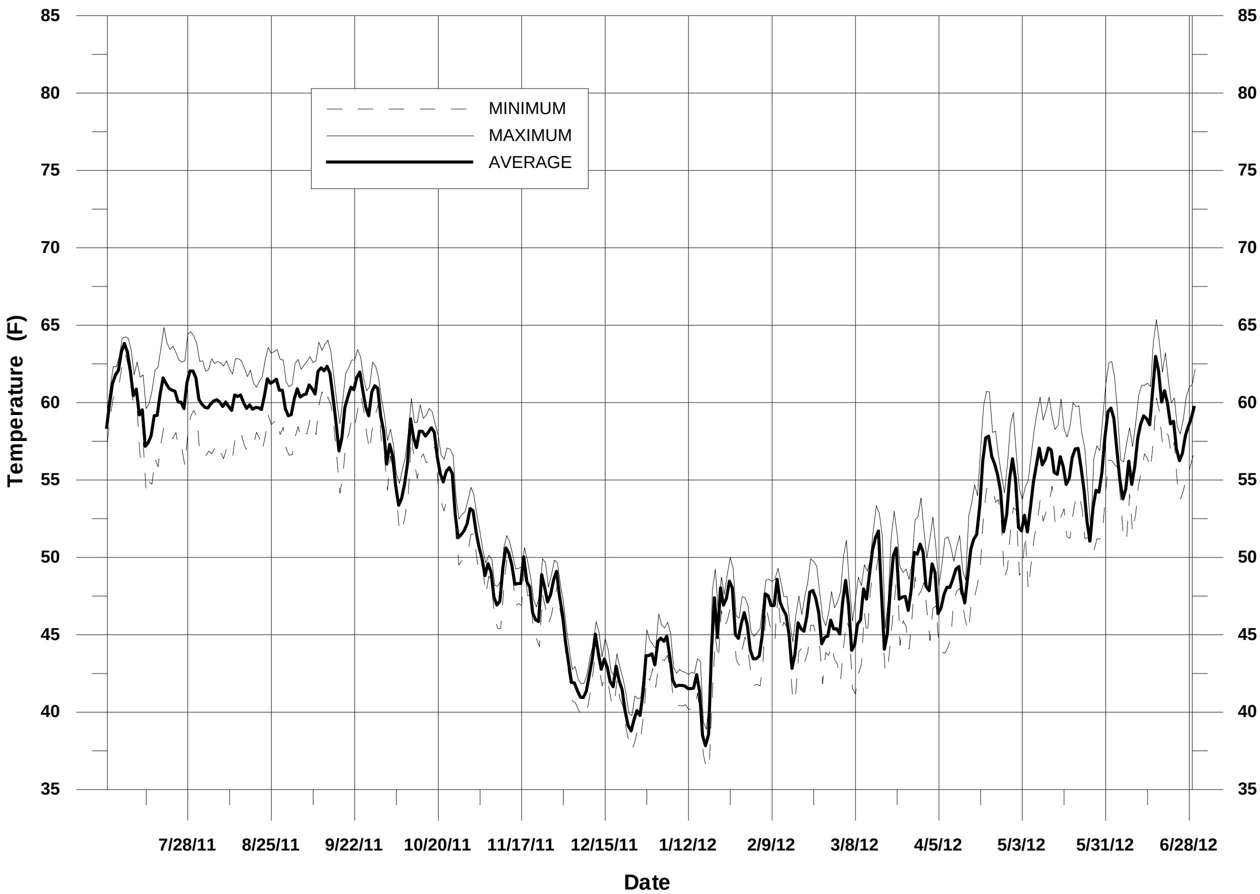


Figure 2-26. Daily temperatures recorded from a continuous temperature data logger at the Above Los Padres station during RY 2012

Water-quality conditions at all stations in the mainstem Carmel River for RY 2012 were within adequate ranges for steelhead rearing. Even though Water Year 2012 was characterized as a "dry" hydrologic year, water temperatures were relatively cooler, and no sample sites observed average daily water temperatures above 68oF. Water-quality conditions in the Carmel River Lagoon during the late summer and fall months (July through October) are commonly within stressful ranges and likely decrease growth and survival rates of rearing steelhead. This is mainly caused by a lack of river inflow and variability in tidal influences. These factors can dramatically change the water-quality dynamics in the lagoon depending on their outcomes. During the RY 2012, salinity readings for this period are commonly stratified and increase with depth. The deepest parts of the lagoon ranged up to 20 parts per thousand and above, reducing rearing habitat that is available to juvenile steelhead. Lagoon water temperature frequently was observed within sub-optimal ranges during the course of this period. For more information and figures for multiple years see MPWMD Mitigation Reports at:
http://www.mpwmd.dst.ca.us/programs/mitigation_program/annual_report/annual_reportrev1.htm
(MPWMD 2000-2013). In addition, summaries of surface water quality parameters have been made in the 2004 Watershed Assessment. This report can be viewed at:
http://www.mpwmd.dst.ca.us/programs/river/watershed_assessment/5_6/5_6_1/5_6_1_text.pdf

2.11.2 Groundwater quality condition in the watershed and aquifer

The quality of groundwater in the Carmel Valley aquifer generally reflects that of the river in terms of the relative concentrations of the major inorganic constituents, but groundwater in the aquifer is somewhat more mineralized. The dissolved mineral content of the groundwater generally increases from upstream to downstream locations in the aquifer. As shown in Table C-10, the average total dissolved solids (TDS) concentration increases from less than 300 milligrams per liter (mg/l) in Aquifer Subunit 1 to more than 600 mg/l in Aquifer Subunit 4. This is because of the longer groundwater residence time, which allows for greater chemical dissolution of the aquifer sediments in contact with the groundwater, and the variable composition of the aquifer sediments. In general, groundwater from the Carmel Valley aquifer varies from calcium-bicarbonate to calcium-sulfate in chemical type in the downgradient flow direction. Groundwater pumped from the aquifer above the Narrows (with the exception of the Russell wells) requires no special treatment prior to municipal use. Groundwater pumped from the aquifer downgradient from the Narrows requires treatment to comply with national secondary drinking water standards, specifically those for iron and manganese (California Department of Water Resources 2012).

There has been some concern about the potential for degradation of the groundwater in the Carmel Valley aquifer (particularly from nitrates) from overlying septic systems that exist on the valley floor. This concern prompted MPWMD to establish a groundwater quality monitoring program in 1981. This program was designed to track water quality trends in the shallow zones of the alluvial aquifer to serve as an early warning of possible contamination that could affect the deeper water supply wells in the valley (California Department of Water Resources 2012).

The results from this ongoing monitoring program indicate that, typically, there is a seasonal fluctuation of water quality in the shallow zones of the aquifer, presumably related to flushing of the overlying unsaturated soils subsequent to winter storm periods. However, all analyses from the alluvial aquifer through 1997 indicate that water quality is well within established water quality standards with no clearly discernible long-term trend of deteriorating water quality. This conclusion was confirmed when MPWMD commissioned a groundwater quality evaluation in 1991 to address concerns about the threat of increased nitrate levels in the upper valley (i.e., above the Narrows) during the 1987–1991 drought period (K^2 Environmental Planning and Engineering Consultants 1992). A groundwater pollution study in the Carmel Valley Village area conducted for the Monterey County Health Department in 1986 (EMCON Associates 1986) also indicated similar results (California Department of Water Resources 2012).

In early 1989, MPWMD installed a series of monitoring wells near the coast as part of a hydrogeologic investigation of the coastal portion of the Carmel Valley aquifer (Staal, Gardner & Dunne Inc. 1989). These monitoring wells have been integrated into MPWMD's monitoring network and are being used to collect baseline water quality data from the coastal area of the aquifer. Water quality results from these wells indicate that a mixing zone of fresh water and seawater exists at the mouth of the valley near the Carmel River State Beach, but no seawater intrusion into the freshwater aquifer system is indicated. The potential for seawater intrusion into inland areas may be limited by the presence of granitic rocks at the mouth of the valley, which appear to constrict the opening of the alluvial aquifer at the seashore to a narrow gap, approximately 500 feet wide by 100 feet deep. Because the aquifer's ability to flush seawater back out, once it has intruded it is uncertain, sustained pumping in the coastal area would not be prudent (California Department of Water Resources 2012).

2.11.3 Benthic macroinvertebrates (BMI)

Benthic macroinvertebrates (BMI) are the community of insects living in the river bottom, and are an important food source for fish, reptiles and birds, and an indicator of water quality. BMI's are especially vital for steelhead survival. The MPWMD initiated a ten-year monitoring program in the fall of 2000 to evaluate the water quality and physical habitat conditions of the Carmel River and to establish baseline information that would be used in conjunction with other water quality programs to assess potential effects of future land and water use activities.

Carmel River BMI monitoring conducted over a 10-year program period (2000-2010) by the MPWMD indicated strong and consistent effects of the dam/reservoir systems on downstream BMI assemblage quality. Biotic integrity values improved with increasing distance downstream of the reservoirs. The ten-year study yielded a total of 133 samples from which 46,378 BMIs were processed. After site compositing and standardization of subsample size, 66 composite samples were generated comprising 111 total taxa, 42 EPT taxa, 13 mayfly taxa, six stonefly taxa, 23 caddisfly taxa, and 14 beetle taxa (Table 2-13) (MPWMD 2010).

Table 2-13. BMI monitoring study results (MPWMD).

Metric*	**Totals**	**Median**	**Minimum**	**Maximum**
Taxa Richness	111	21	13	41
EPT Taxa	42	7	4	22
Ephemeroptera (mayfly) Taxa	13	2	1	9
Plecoptera (stonefly) Taxa	6	0	0	6
Trichoptera (caddisfly) Taxa	23	5	2	12
Coleoptera (beetle) Taxa	14	1	0	5
Tolerance Value	5.1	5.4	2	6.3
Shannon Diversity	2.7	2	1.1	2.9

Project Statistics (n=66 samples)

Results of the study indicated that urbanization effects on Carmel River BMI assemblage quality were of less magnitude than expected. While periodic accumulations of both natural and anthropogenic organic material have been documented at the lowest elevation Carmel River monitoring site, the level of organic material did not preclude the presence of sensitive BMI taxa, nor did it compromise abundance. Conversely, the lowest elevation monitoring site had the highest BMI abundance and biovolume of all sites probably because of seasonal accumulations of organic matter. Reservoir systems sequester organic matter, which may be one factor compromising BMI assemblage quality at sites immediately downstream of the reservoirs. But reservoir systems can also augment downstream BMI food supplies with plankton as appeared to be the case downstream of Los Padres Reservoir where BMI abundance and biovolume were higher than the upstream reference site.

There were downward trends in BMI assemblage quality over the 10-year monitoring period at two successive sites downstream of San Clemente Reservoir, possibly in response to annual drawdowns of the reservoir. There were no upward or downward trends in BMI assemblage quality at the other sites throughout the monitoring period. However, there was a large magnitude decline in BMI assemblage quality at the reference site in 2007 during a critically dry water year. Full recovery occurred the following years despite the Basin Complex Fire in the Los Padres Wilderness, which occurred in the summer of 2008. While there were seasonal influences on BMI taxonomic composition, index of biotic integrity values were minimally affected by season.

Instream and riparian habitat quality at the monitoring sites were generally good as determined by qualitative assessments outlined in the monitoring procedure. Instantaneous water quality constituents (temperature, pH, dissolved oxygen and specific conductance) measured during the monitoring period fell within ranges typical for the region. A literature review of historical information regarding BMI assemblages in the Carmel River and tributaries were conducted (MPWMD 2010).

2.11.3.1 Limiting factors for Benthic Macroinvertibrates

Published literature sources list multiple effects of dam/reservoir systems on downstream benthic fauna, which include altering fluvial processes, allochthonous material transport, flow, water temperature and food supplies. While inconclusive, several factors assessed during the Carmel River Bioassessment Program likely contributed to lowered macroinvertebrate assemblage quality downstream of the reservoirs. These factors included elevated water temperature downstream of the reservoirs when compared to the upstream reference site and slightly higher average substrate size at sites immediately downstream of the reservoirs. Annual hydrographic data indicated a mostly seasonal pattern of flow through the sites, indicating that the dams do not appreciably alter seasonal flow patterns.
Factors contributing to streams with productive and diverse benthic fauna include mixtures of loosely consolidated substrate, a natural hydrograph, allochthonous (organic material of terrestrial origin) inputs with retention and good water quality (Allan and Castillo 2007). These conditions become altered in urban areas where upstream impervious landscape surfaces alter natural percolation and interfere with the production, transport and retention of allochthonous material (Williams and Feltmate 1992, Schueler 1995, and Karr and Chu 1999). While bank sloughing is a natural phenomenon of stream systems, urban streams are characterized as having higher peak discharges, which contribute to increases in bank instability, increasing channel cross-sectional area and sediment discharge (Trimble 1997). Excessive sediment input occludes interstitial space and thereby decreases the variation of area within the substrate for colonization of benthic fauna (Allan and Castillo 2007). Benthic fauna of urban streams may also be affected by constituents from storm water runoff such as petroleum hydrocarbons, fine sediment, organic enrichment, pesticides, fertilizers and detergents (Schueler 1987).

In addition to urbanization of watersheds, reservoir characteristics (operations management, depth of release point, level of primary production and effects on fluvial processes) influence BMI assemblages downstream by affecting flow and temperature regimes, food resources and substrate composition (Allan and Castillo 2007; Camargo and Voelz 1998; Mount 1995; Petts 1984; Ward and Stanford 1979). BMI assemblages often recover with distance downstream of reservoir systems with sufficient inputs from unregulated tributaries (Rehn et al. 2007; Stanford and Ward 2001; Camargo and Voelz 1998; Armitage 1989).

MPWMD implemented gravel augmentation downstream of the dams between 1993 and 2015, where approximately 4,900 tons of 1.5-4 inch gravel was placed below the two dams for salmonid spawning habitat enhancement (B. Chaney, MPWMD staff, personal communication). Without the gravel enhancement, substrate index values would have been higher at sites downstream of the dams, which would likely have contributed to even lower IBI values if gravel augmentation had not occurred.

Urbanization effects on Carmel River macroinvertebrate assemblage quality were of less magnitude when compared to reservoir effects. While periodic accumulations of both natural and anthropogenic organic material have been documented at the lowest elevation Carmel River monitoring site, the level of organic material did not preclude the presence of sensitive macroinvertebrate taxa, nor did it compromise abundance. Conversely, the lowest elevation monitoring site had the highest macroinvertebrate abundance and biovolume of all sites probably because of seasonal accumulations of organic matter. Reservoir systems sequester allochthonous organic matter, which may be one factor compromising macroinvertebrate assemblage quality at sites immediately downstream of the reservoirs. But reservoir systems can also augment downstream macroinvertebrate food supplies with plankton as appeared to be the case downstream of Los Padres Reservoir where macroinvertebrate abundance and biovolume were higher than the upstream reference site (MPWMD 2010).

2.12 Vegetation

The flora of Monterey County is one of the largest and most diverse in the state, owing to the county's size, location, climate, topography, and complex geology (Mathews, 2006). Likewise, the Carmel River watershed supports a diverse assemblage and mosaic of plant species. At Garland Ranch, a 3,464 acre regional Park in Carmel Valley, over 350 species of flowering plants have been identified (Mitchell and Yeager, 2011). The wide range of topography, rainfall patterns, soils, geologic processes, episodic wild fires and landslides, and proximity to marine air have created ideal conditions for endemism and localized genotypic variations in plant and animal species.

The watershed's dominant vegetation types include grasslands, scrub/shrub dominated habitats, and mixed oak woodland (Figure 2-27). Coastal plant communities include live oak woodlands, grasslands, coastal scrub, freshwater and saline wetlands, Monterey pine forest, and marshes. Interior plant communities include redwoods, chaparral, oak savannah woodlands, and annual and perennial grasslands. The riparian zone is composed of a mixed riparian forest composed of various trees like willows, alders, cottonwoods and sycamores, as well as diverse shrubs and herbaceous species like cattails, sedges, and grasses. Riparian habitats sustain a rich diversity and abundance of plant and animal life, as they provide critical shelter, foraging, nesting and rearing habitat.

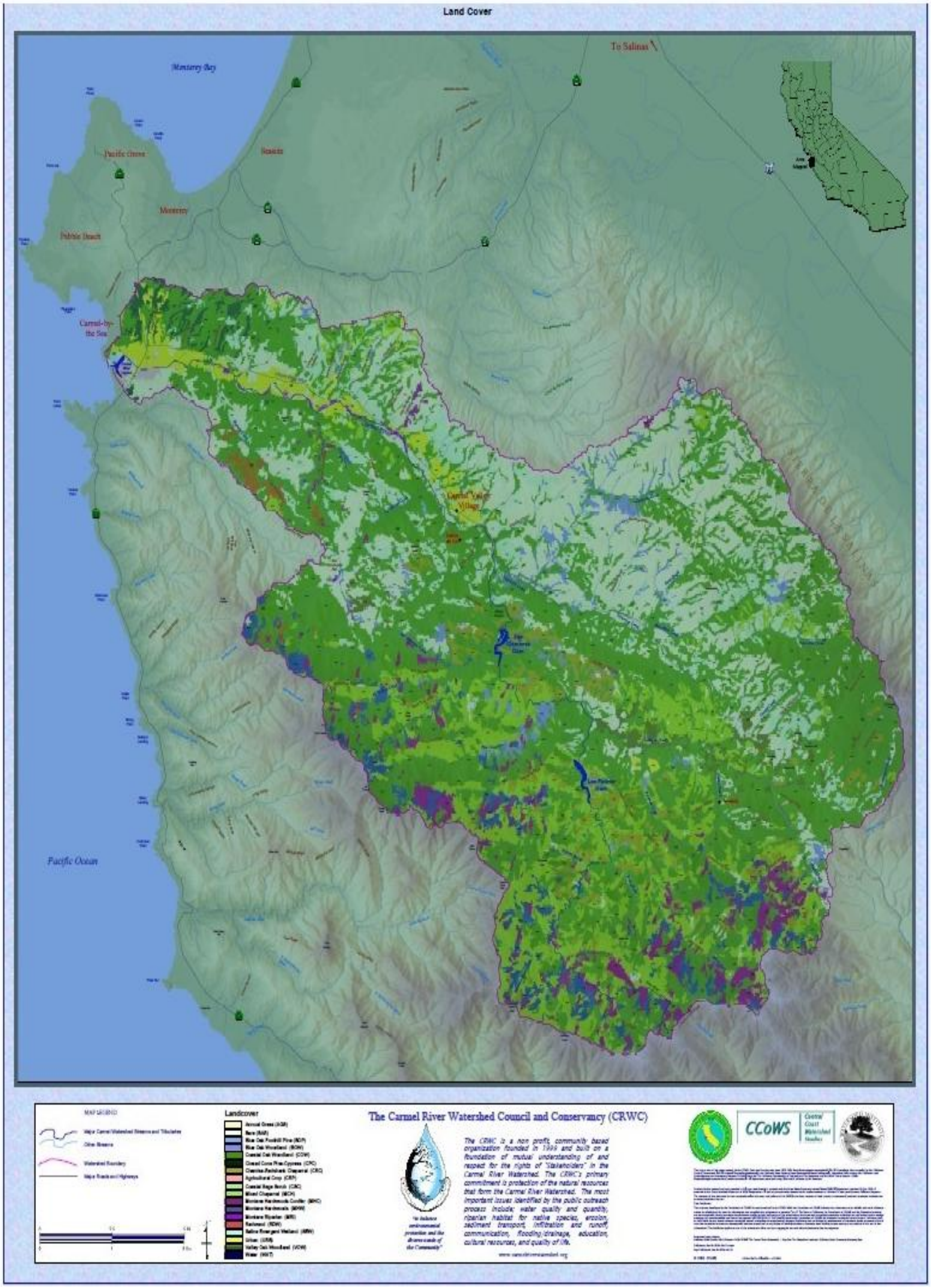


Figure 2-27. Vegetation cover map for the Carmel River Watershed (Smith 2004).

2.12.1 Special-status plant species

Protecting and improving the habitat of threatened and special-status plant species in the watershed is an important aspect of watershed planning. The Carmel River watershed includes a diverse assemblage and mosaic of plant species (Figure 2-28). Changes in land use and the introduction of non-native animals and plants are the largest threats to native plant species and vegetation types.

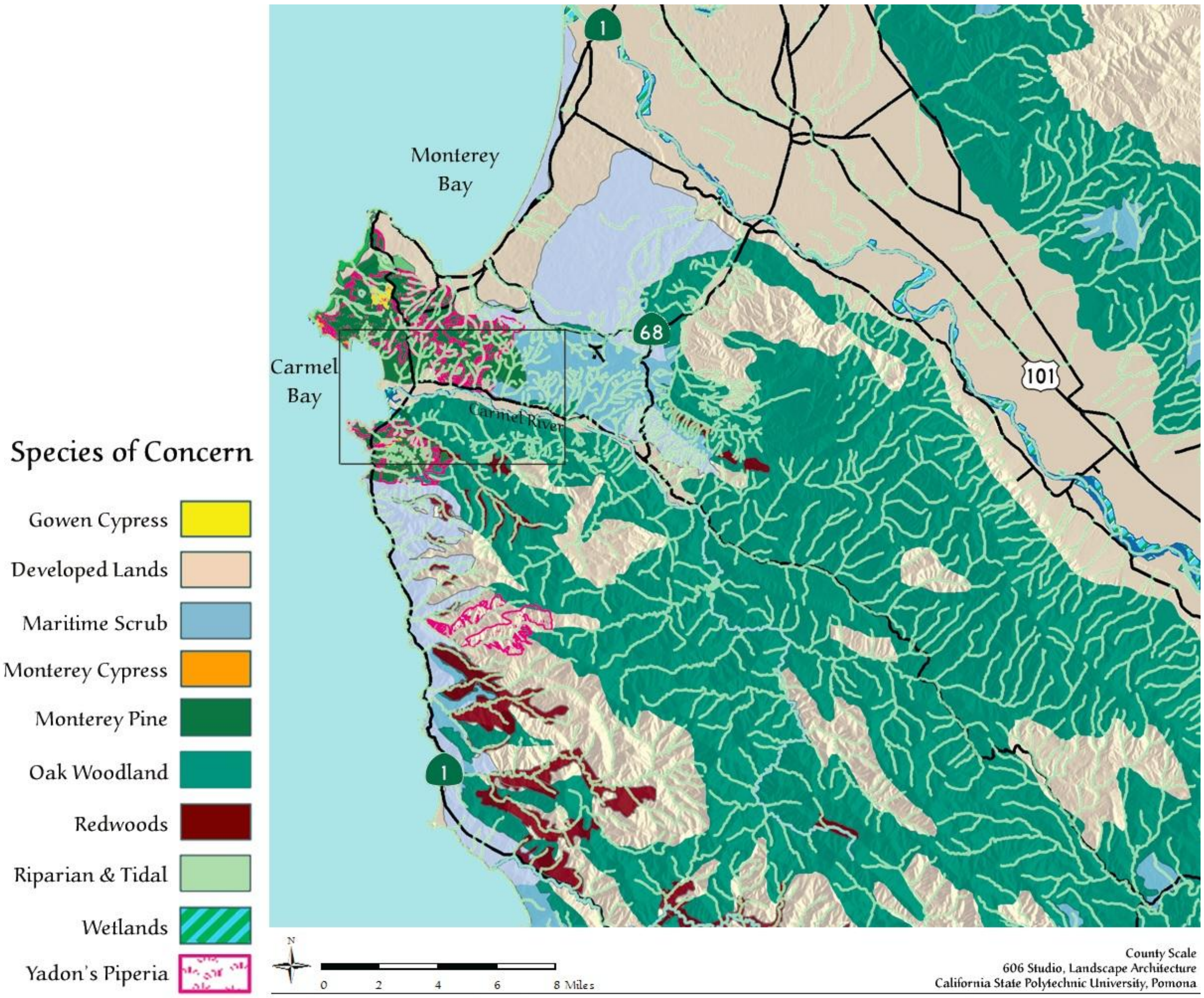


Figure 2-28. Species (vegetation) of concern map (Kasey and Peterson 2005).

Information on special-status plant species was compiled through a review of the California Natural Diversity Database (CNDDB)(California Department of Fish and Wildlife 2014) for the Carmel River watershed, the California Native Plant Society's (CNPS) Inventory of Rare and Endangered Vascular Plants of California (Skinner and Pavlik 1994), the California Department of Fish and Wildlife's (CDFW) State and Federally Listed Endangered and Threatened Plants and Animals of California (CDFW 2014), and the USFWS list of special-status animals (USFWS 2014).Vegetation types and distribution.

Table 2-14. Plant species that occur in the Carmel River Watershed and are considered to be "special", "threatened" or "endangered" by the State of California or the federal government:				
SCIENTIFIC NAME	**COMMON NAME**	**FED LIST**	**CAL LIST**	**CDFW STATUS**
Nasturtium gambelii	Gambel's water cress			CNPS species of concern
Arenaria paludicola	marsh sandwort			CNPS species of concern
Eriastrum virgatum	virgate eriastrum			CNPS species of concern
Clarkia lewisii	Lewis's clarkia			CNPS species of concern
Piperia yadonii	Yadon's rein orchid	Endangered		
Trifolium polyodon	Pacific Grove clover		Rare	
Sidalcea hickmanii ssp. parishii	Parish's checkerbloom		Rare	

2.12.2 Riparian habitat - mainstem and tributaries

Riparian habitats are critical to watershed health because they are ecologically specialized habitats of limited distribution, have high value for wildlife, and have declined greatly in California due to large-scale disturbances such as urbanization, stream channelization, and agricultural conversion (Warner and Hendrix 1984). The riparian corridor of the middle and lower Carmel River, between the Pacific Ocean at River mile (RM) 0.0 and San Clemente Dam at RM 18.6, begins at the Carmel River lagoon and ends in a relatively inaccessible and valuable aquatic habitat area immediately downstream of the San Clemente Dam (Carmel River watershed map, Figure 1-1). In this portion of the river, patches of mature riparian forest reflect the width of appropriate floodplain habitat and the periodicity of flood events. Dominant plant species included arroyo willow (*Salix lasiolepis*), red willow (*Salix laevigata*), black alder (*Alnus rhombifolia*), black cottonwood (*Populus trichocarpa*), California sycamore (*Platanus racemosa*), boxelder (*Acer negundo*), black twinberry (*Lonicera involucrata*), poison oak (*Toxicodendron diversilobum*), and California blackberry (*Rubus ursinus*). The riparian corridor in the upper watershed above San Clemente Dam (RM 18.6 to RM 36) is relatively intact and pristine. Above the Los Padres Dam (RM 21), the riparian habitat is undisturbed, as much of it is located in the Los Padres National Forest and Ventana Wilderness. Big-leaved maple (*Acer macrophyllum*), Hind's willow and Sitka willow (*Salix exigua* var. *hindsiana* and *S. sitchensis*) become common in the riparian corridor upstream of San Clemente Dam.

The Carmel River's riparian habitat continues to show many signs of recovery and stabilization despite a combination of natural and man-made events in the 1970s, 1980s and 1990s that resulted in increased groundwater extraction and degraded riparian habitat. In many reaches of the river, fine material (silt and sand) that entered the main stem during periods of instability has been washed out of the system leaving behind a more complex channel with improved steelhead spawning substrate, diverse habitat, and a richer riparian community. Areas with perennial or near perennial flow (upstream of Schulte Bridge) or a high groundwater table, such as downstream of Highway 1, have experienced vigorous natural recruitment along streambanks and in the channel bottom, which has helped to stabilize streambanks and diversify aquatic habitat.

In these areas, natural recruitment in the channel bottom has led to vegetation encroachment that, in some areas, may constrict high flows and induce bank erosion by deflecting flow. In contrast to areas with perennial flow, the recovery of streamside areas in the lower mainstem has been consistently impacted by groundwater extraction. In this reach, only irrigated areas are able to sustain a diversity of plant species. Plant stress in the late summer and fall is evident in non-irrigated portions of the riparian zone. In these areas, streambanks exhibit unstable characteristics during high flows, such as sudden bank collapse, because of the lack of healthy vegetation that would ordinarily provide stability.

Restoration project areas sponsored by MPWMD since 1984 continue to mature and exhibit more features of relatively undisturbed reaches, such as plant diversity and vigor, complex floodplain topography, and a variety of in-channel features such as large wood, extensive vegetative cover, pools, riffles, and cut banks. Areas that were repaired after the 1995 and 1998 floods are still developing these natural features. In part, the location and geometry of the projects constrain the rate of progress toward a fully restored stream channel (i.e., several are located in highly developed, narrow sections of the river impacted by groundwater extraction). Also, many of these projects relied heavily on the use of bank hardening (e.g., riprap) to stabilize banks, which can discourage plant vigor and diversity.

2.12.2.1Proper functioning condition

The proper functioning condition (PFC) method for assessing the condition of riparian-wetland areas was used to assess 37 sites along the mainstem from the Carmel River Lagoon to the headwaters (Figure 2-20). These assessments, which were conducted during Fall 2003 and Spring 2004, confirm that many reaches were functioning properly between the Narrows at approximately RM 10 and the headwaters at RM 36 at that time. However, several reaches downstream of the Narrows were determined to be “functional at .risk,” meaning that without actions to mitigate for the effects of water diversions, these reaches were at risk of becoming non- functional. Figure 2-29 shows the ratings and locations of these assessments and others performed by the Carmel River Watershed Conservancy in the tributaries of the Carmel River.

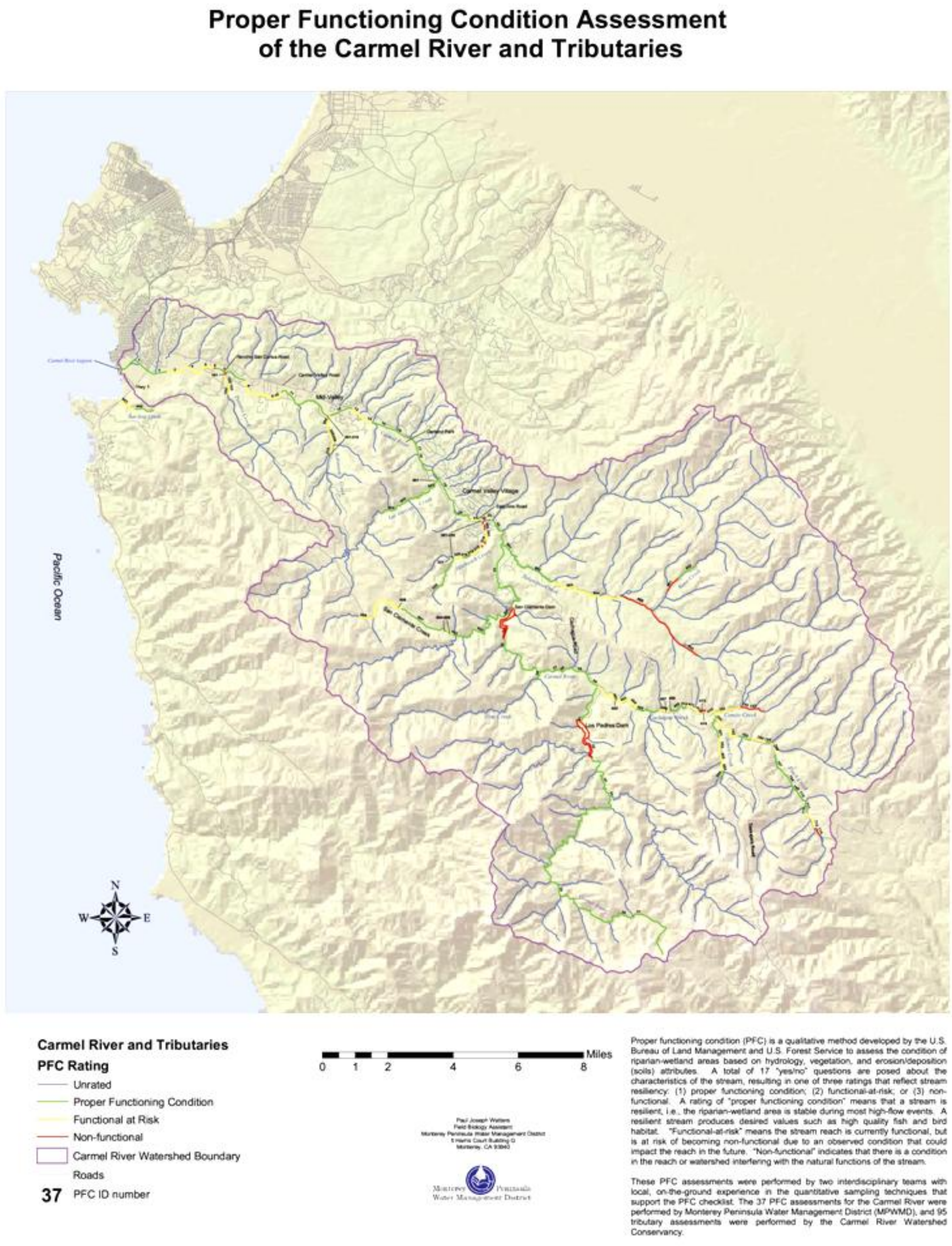


Figure 2-29. Assessment of Riparian Functions and Conditions (Monterey Peninsula Water Management District 2004).

Since the mid-1980's, points of water diversion during summer and fall have gradually been shifted downstream into the lower river and groundwater extraction from reaches downstream of the river has increased. This increased summer and fall surface flow in the 8.6-mile reach between the Narrows and San Clemente Dam, resulting in an increase in aquatic habitat quality, quantity, and diversity upstream of the Narrows. But increased groundwater extraction downstream of the Narrows may have increased vegetation stress in the lower river, resulting in the loss of streamside vegetation and an increase in bank instability. (MPWMD 2004)

Between 1986 and 2001, riparian wooded areas within the streamside corridor downstream of San Clemente Dam increased from an estimated 299 acres (McNeish 1986) to an estimated 438 acres (Christensen 2003). This increase is due to natural recovery after an episode of bank erosion between 1978 and 1986 combined with increased surface flows and restoration work by a variety of groups including private property owners and public agencies.

The riparian corridor between Highway 1 and Schulte Road Bridge remains fragmented and is very thin in some areas (as little as one or two trees wide along the streambank) due to urbanization. In these locations, wildlife mobility is limited by the poor quality and quantity of the riparian corridor. Some streamside areas in the alluvial portion of the river, between the ocean and Carmel Valley Village, continue to come under development pressure as real estate values in Carmel Valley escalate and property owners carve out niches for additional urban living space or seek to stop the natural meanderings of the river. Examples of poor landowner practices include thinning and removing streamside vegetation for view corridors, placing structures adjacent to the stream, and constructing illegal bank protection works (MPWMD 2004).

2.12.3 Lagoon and Wetlands

The lagoon area and associated wetlands, which are located immediately south of the city of Carmel-by-the-Sea in Monterey County, cover an area of approximately 100 acres. The seasonal lagoon at the mouth of the Carmel River supports both riparian vegetation and wetland species. The lagoon and much of the surrounding lands are part of Carmel River State Beach managed by the California Department of Parks and Recreation (State Parks).

The entire lagoon area consists of a diverse assemblage of both seasonal and perennial wetland habitat types that serve as critical wildlife habitat for a wide range of species including several federally listed species. The acquisition and modification of former agricultural lands (the Odello West Property) in the south east corner of the lagoon area has resulted in a significant increase in the total acreage of wetlands, which in turn, has improved habitat quality for many species (Larson et al. 2005). Figure 2-30 shows the distribution of vegetation wetland types throughout the lagoon. Figure 2-31 shows a mosaic of habitat types surrounding the Carmel River, with riparian scrub-shrub in the upper right (Casagrande 2006).

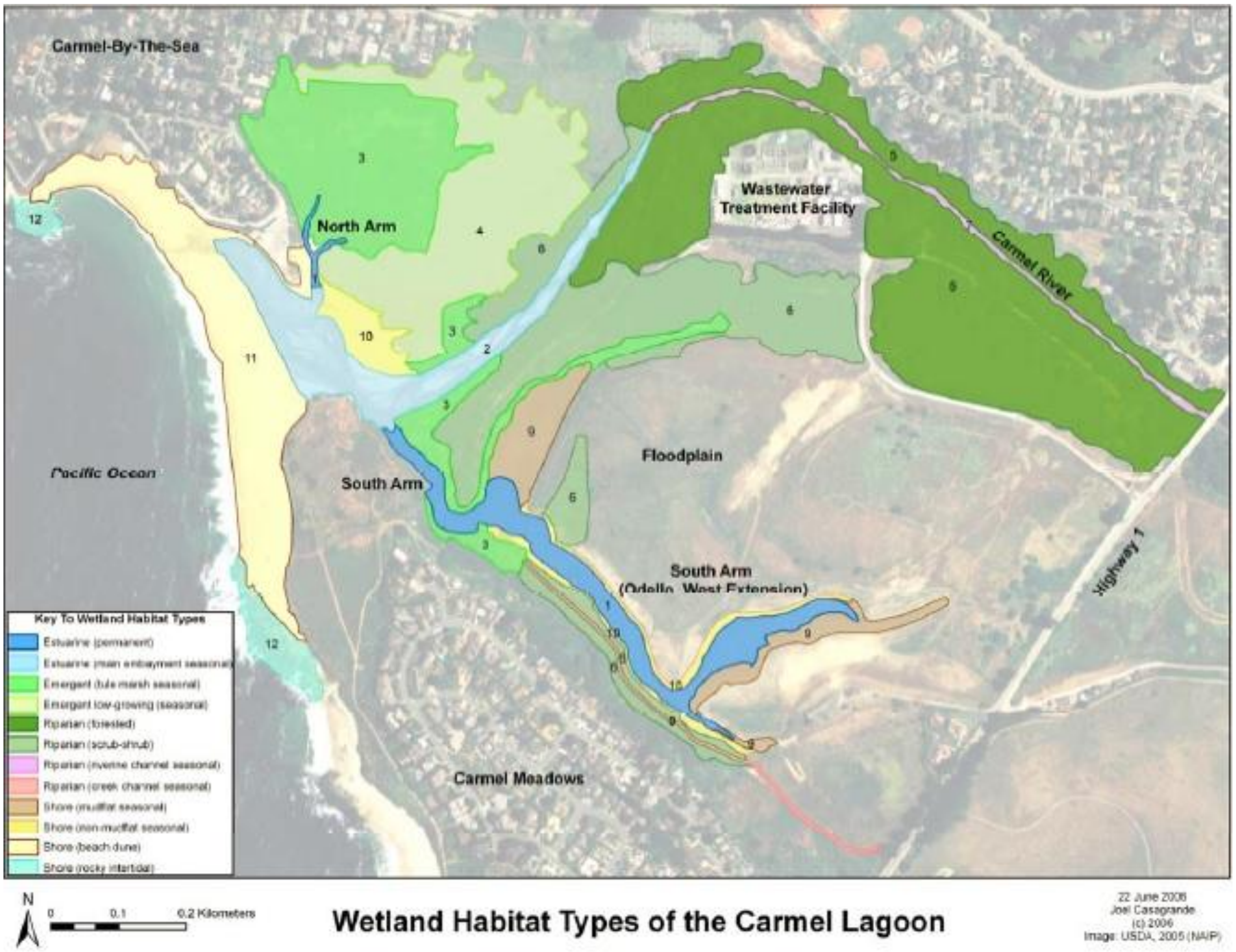


Figure 2-30. Wetland habitat types of the Carmel River Lagoon and surrounding areas (Casagrande 2006)

Figure 2-31. Photo of habitat types surrounding the Carmel River (Casagrande 2006)

1. Estuarine (permanent)

Areas of the lagoon that are permanently flooded include the South Arm (Figure 2-23) and a small portion of the North Arm. Water depths in the permanent section vary throughout. The north arm is generally less than 3 feet in depth while the South Arm contains deeper waters of up to 10+ feet. Substrate conditions in both the South and North Arms vary, but consist primarily of fine sediments (i.e. silt and clay), detritus and smaller amounts of sand. Beds of submerged pondweed (*Potamogeton* spp.) are extensive throughout the South Arm and new Odello Extension. When water quality conditions are suitable in both arms, macroinvertebrate communities are abundant; a significant food resource for rearing juvenile steelhead (Oncorhynchus mykiss). Western pond turtles (Clemmys marmorata) and California red-legged frogs (Rana aurora draytonii) inhabit the South Arm.

2. Emergent (tule marsh; semi-permanent) Wetlands

Emergent vegetation is abundant throughout the lagoon area and in this classification it is divided into two sub-types, tule marsh and low-growing. Tule marsh is found throughout much of the northern area of the lagoon adjacent to Carmel-By-The-Sea and along the edges of both the South Arm and Carmel River portion of the main embayment (Figure 2-32). Recently, newly created shore habitats (10) in the Odello West Extension have been planted with tules and other native vegetation. Tule (*Schoenoplectus* spp.*),* or bullrush, is the dominant species found in this habitat type. In Carmel Lagoon, tule marsh areas are flooded to some extent for significant portions of the year; usually when the sand bar is closed and stream flow entering the lagoon is present. During summer, smaller areas of tule marsh in the North Arm remain flooded. Tule marshes are valuable habitats for a variety of species including the California red-legged frog and a host of wetland related bird species, such as the redwinged blackbird (*Agelaius phoeniceus*). Flooded tule marshes also maintain abundant macroinvertebrate populations, which in turn, present significant feeding areas for rearing steelhead and threespine stickleback.

Figure 2-32. Aerial photo of lagoon (Casagrande 2006).

3. Emergent (low-growing; seasonal) Wetlands

The low-growing emergent community, a patchwork of wetland hydrophytes, is also found in the northern part of the lagoon area. Much of this area is flooded less frequently than the adjacent tule marsh habitats. Dominant species in this habitat include Pacific silverweed (*Potentilla anserina* ssp. *pacifica*), salt grass (*Distichlis spicata*), spike rush (*Eleocharis* sp.), sedges (*Carex* sp.) and coastal gum plant (*Grindelia stricta*). These species are salt tolerant and adapted to being inundated for periods of time. The low growing emergent community provides both nesting and foraging habitat for a variety of species, especially water fowl (Casagrande 2006).

4. Riparian (forested) Wetlands

The upstream portions of the lagoon area, specifically along the Carmel River, support a narrow, although dense riparian forest. Forested habitat borders the banks of the river and areas adjacent to the wastewater treatment plant. In general, riparian forest habitat is dominated by riparian tree species, with multiple canopy layers, and where a majority of the trees are greater than 20 ft. in height. Trees immediately adjacent to the river flood annually, while those located higher on the streambanks are inundated much less frequently. Riparian forest habitat near the lagoon is dominated by willows (*Salix* spp.) and black cottonwood (*Populus trichocarpa*), with California blackberry (*Rubus ursinus*), snowberry (*Symphoricarpos mollis*) and creek dogwood (*Cornus sericea* ssp. *occidentalis*) common in the understory. Red alder (*Alnus rubra*) and a few notable wax myrtle trees (*Myrica californica*) also occur near the wastewater treatment plant.

Riparian forested wetlands serve as important nesting habitat for various bird species, many of which are riparian obligates. In addition, the forested areas provide shelter, migration, and foraging habitat for mammals such as mule deer and amphibian species such as the California red-legged and Pacific chorus frogs *(Pseudacris regilla*). Root wads, overhanging branches, and accumulated woody debris create escape cover and refuge along the river's edge for juvenile steelhead.

5. Riparian (scrub-shrub) Wetlands

Riparian scrub-shrub wetland habitat consists of a mixture of willows (*Salix* spp.*),* shrubs, and vines including California blackberry (*Rubus ursinus*), often in the form of dense thickets less than 20 feet in height. Scrub-shrub habitat can be found immediately adjacent to the lower reaches of the Carmel River near the main embayment confluence, or in areas slightly higher in elevation throughout the South Arm area.

6. Riparian (riverine channel; seasonal) Wetlands

The Carmel River stream bed is also delineated as a wetland type by the U.S. Army Corps of Engineers. The "dividing line" of where the main embayment begins and the river channel ends is poorly defined because it changes annually with lagoon volume. In summer, once the stream flow ceases and the sand bar forms, water in the main embayment often backs up nearly to the treatment plant. This general area is used to separate the two habitat types.

The riverine channel habitat includes only the active stream bed and is defined here as the areas below bank full not vegetated with perennial species. The lower Carmel River near the lagoon is not perennial. Stream flows usually cease by early summer (e.g. June or July). Substrate in the channel consists of gravels, coarse sand, and smaller amounts of cobble and fine sediments. Vegetation is limited primarily to successional willow saplings and various exotic weeds that are scoured out each winter. As stream flow declines in early to mid-summer, isolated pools and the shallow areas of the declining river contain invertebrates and provide seasonal foraging areas for species of shore birds. These same pools sometimes contain stranded juvenile steelhead and threespine stickleback (*Gasterosteus aculeatus*) that may fall prey to predators such as the great blue heron (*Ardea herodias*), raccoon (*Procyon lotor*), or reptile species such as the Western terrestrial garter snake (*Thamnophis elegans*).

7. Riparian Wetlands (creek channel; seasonal)

A small seasonal creek channel flows parallel to the main arm of the newly created Odello Extension. This small channel, once used as an agricultural drain, is a small source of fresh water to the lagoon during the winter and spring. For most of its length, the creek is bordered by willow scrub-shrub and emergent tule marsh habitats. The creek channel provides seasonal habitat for California red-legged frogs and various other bird and mammal species.

8. Shore (mudflat; seasonal)

Another type of shore habitats included in this classification is "non-mudflat," which is dominated by coarser, sandy substrate. This habitat, while not extensive, is found in the main lagoon area nd along the margins of the new Odello Extension (Fig. 2-32). These areas are typically flooded when the sand bar is closed. Recently, native vegetation, including tules and willow saplings, have been planted by California State parks along the shores of the new Odello Extension. These areas will soon develop intoeither tule marsh or willow scrub-shrub habitat. Current habitat benefits include foraging and resting habitat for water fowl, shore birds, and wading birds such as great egrets (*Ardea alba*).

9. Shore (beach dunes and sea bluffs)

Dune shore habitat consists of the broad beach dunes at the mouth of the Carmel River (Fig. 2-23). The dune habitat present at the lagoon is part of a larger beach that extends south towards Monastery State Beach and north where it abruptly ends at the bedrock headland just north of the lagoon parking lot. The environment here is harsh. Constantly shifting sand and strong breezes laden with salt make it hard for plants to survive. The shoreline and foredunes may be inundated with salt water during winter storms or extremely high tides. Plants in this community are referred to as pioneer dune community because of their ability to colonize and stabilize the sand carried ashore by wave action. Beach dune plants include species of sand verbena (*Abronia* spp.), sea rocket (*Cakile maritima*), and the introduced ice plant species (*Carpobrotus* spp.*)*

2.12.4 Coastal Scrub

This habitat type is found on coastal slopes with predictable marine fog influence. The dominant plant species include California sage (*Artemisia californica*), coyote brush (*Baccharis pilularis*), bush monkey flower (*Diplacus aurantiacus*), black sage (*Salvia mellifera*), goldenbush (*Hazardia squarrosa*) and redberry (*Rhamnus crocea*). On the western portion of the project site where the canyons are more mesic, the scrub vegetation is very dense and tall and consists of poison oak (*Toxicodendron diversilobum*) and coffeeberry *(Frangula californica*). Blue blossom (*Ceanothus thyrsiflorus*), cream spray (*Holodiscus discolor*) and California blackberry (*Rubus ursinus*) are also present.

2.12.5 Scrub/Shrub/Chaparral

Coastal scrub and coast mixed shrub occur in the coastal area of the watershed, while Chaparral is supported in more inland locations. Chaparral communities generally grow in dense thickets and are widespread on inland slopes and ridges, and are dominated by drought-tolerant long-lived shrubs, including sage *(Salvia spp.)*, chamise (*Adenestoma faciculatum*) and California lilac (*Ceanothus thrysiflorus*). Above 1000 feet mixed hardwood forest usually dominates the upper slopes or—less often—annual grassland or mixed oak forest. These communities are adapted to winter rains, hot, dry summers, and occasional disturbance by fire, which facilitates seed germination and regeneration of some dominant species (Borchert et al. 1988). A wide variety of wildlife use chaparral habitat. Wildlife that commonly may be found in this habitat type includes common kingsnake (*Lampropeltis getula*), California quail (*Callipepla californica*), Bewick’s wren (*Thryomanes bewickii*), Anna’s hummingbird (*Calypte anna*), greater roadrunner (*Geococcyx californianus*), black-tailed jackrabbit (*Lepus californicus*), and coyote (*Canis latrans*).

2.12.6 Monterey Pine/Coast Live Oak Forest

Monterey pine forest is dominated by Monterey pine (*Pinus radiata*) with continuous or intermittent canopies reaching over 90 feet in height. Coast live oak (*Quercus agrifolia*) is usually the next most abundant species. This community typically occurs on well-drained sandy soils within the limits of the summer marine fog zone up to 300 m in elevation. This community intergrades with other coastal closed-cone coniferous types (Holland 1986), such as upland redwood forest or Monterey cypress forest. Three natural areas of Monterey pine occur in the state, at Año Nuevo in San Mateo and Santa Cruz counties, Cambria in San Luis Obispo County and the Monterey Peninsula. The Monterey pine and coast live oak vary in relative abundance and cover, with the oaks dominant along the southern lower slopes and the pines dominant on the higher ridges to the north (Denise Duffy and Associates 1998). The pine/oak forest understory is generally open and consists of grasses such as leafy bentgrass (*Agrostis diegoensis*) and western wildrye (*Elymus glaucus*), as well as scattered shrubs, including poison oak (*Toxicodendron diversilobum*), bush monkey flower (*Diplacus aurantiacus*), goldenbush (*Hazardia squarrosa*), and redberry (*Rhamnus crocea*).

2.12.7 Coniferous forest (redwood forest and closed-cone conifer forest)

The majority of the coniferous forest in the watershed is Monterey pine (*Pinus radiata*) and redwood (*Sequoia sempevirens)* forest, with Ponderosa pine (*Pinus ponderosa*) occurring at the highest elevations of the Santa Lucia Mountains. In natural stands, Monterey pines form a closed canopy forest with coast live oaks and various shrubs and herbs in the understory.

Coast redwoods occur only in the coastal Santa Lucia Mountain Range drainages, and are mainly located along creeks and tributaries of the Carmel River. Redwood forests are associated with a matrix of mixed hardwood forest composed of species such as tanoak (*Lithocarpus densiflorus*), madrone (*Arbutus menziesii*), canyon oak (*Quercus chrysolepis*), and California bay (*Umbellularia californica*) (Borchert et al.1988).

2.12.8 Oak Woodlands

This plant community occurs in a number of locations throughout the watershed, and is typically common on floodplains and higher ground. It is dominated by a mix of oak species that include coast live oak (*Quercus agrifloia*), blue oak (*Quercus douglasii*), canyon oak (*Quercus chrysolepis*), valley oak (*Quercus lobata*), and California black oak (*Quercus kelloggii*). Other oak species may be present. Tree species associated with oak species include tanoak (*Lithocarpus densiflorus*), madrone (*Arbutus menziesii*), California bay (*Umbellularia californica*), and California buckeye (*Aesculus californica*). Understory species include shrubs such as poison oak (*Toxidendron diversilobum*), toyon (*Heteromeles arbutifolia*), and a mix of low-growing shrubs along the edges of the woodland. Common grass species and herbs found beneath the oak woodland canopy include purple needlegrass (*Stipa pulchra*), small-flowered needlegrass (*Stipa lepida*), ripgut brome (*Bromus diandrus*), soft chess (*Bromus hordeacous*), and Italian ryegrass (*Lolium multiflorum*).

The three most common oak communities in the watershed include:

1. **Coast Live Oak (*Quercus agrifolia*) Woodlands**

Coast live oaks tend to live in places with moderate climates, and they thrive in the cool, foggy coastal areas. In moist areas, species associated with coast live oak are California bay, tanoak, and canyon live oak. In dryer areas, species associated with coast live oak are valley oak, and blue oak.

2. **Blue Oak (*Quercus douglasii*) Woodlands**

Blue oaks are often the dominant tree in the xeric, inland woodlands where they occur, and can be the only tree in large areas of these woodlands. California buckeye, valley oak, interior live oak, coast live oak, canyon live oak, and California black oak may also be present. These woodlands are generally associated with steep, hot, dry, often west-facing or south-facing hillsides. Its understory consists of dominant non-native annual grassland with patches of native grasses.

3. **Valley Oak (*Quercus lobata*) Woodlands**

Valley oaks remain in small pockets of relatively undisturbed valley floors and occasionally high on ridges above the valleys. In California, valley oak woodlands have clearly been reduced more than any other oak woodland (Pavlik et al. 1991). Exemplary stands still remain in the Carmel Valley watershed.
Regeneration of the population of oak trees in California woodlands often appears inadequate. In a 3-year survey of a the 2,000 ac. Hastings Reserve in the upper Carmel Valley, ungrazed and with minimal human disturbance since 1937, only a handful of naturally occurring pole-sized saplings of Valley oak were found (Hastings Natural History Reservation).

Oak woodlands provide habitat for a variety of wildlife species. At least 60 species of mammals are reported to use oaks in some way. As many as 110 species of birds have been observed during the breeding season in California habitats where oaks form an important part of the canopy or subcanopy. Quail, turkeys, squirrels, and deer may be so dependent on acorns in fall and early winter that a poor acorn year can result in substantial declines in their populations (Mayer & Laudenslayer 1988). Wildlife species characteristic of oak habitats are numerous and diverse..

2.12.9 Annual and perennial grasslands

Grasslands in the watershed support a high diversity of native perennial grasses and forbs, many of which are endangered, threatened, or rare. All grasslands in the watershed are comprised of both native perennial grasses and nonnative annual grasses.

Nonnative Annual Grasslands
Nonnative annual grasslands are generally found in open areas throughout the watershed. This vegetation type is dominated by non-native annual grasses and weedy annual and perennial forbs, primarily of Mediterranean origin have replaced native perennial grasslands as a result of human disturbance. Scattered native wildflower species representing remnants of the original vegetation may also be common in managed livestock pastures and fields. Non-native grasslands are annual grasslands that support introduced species such as wild oat (*Avena spp*.), soft chess (*Bromus hordeacous*), ripgut brome (*Bromus diandrus*), red brome (*Bromus rubens*), soft chess (*B.* hordeaceus), Mediterranean barley (*Hordeum hystrix*), and Italian ryegrass (*Lolium multiflorum*).

Native Grasslands
Native grasslands are perennial grasslands that support a wide diversity of native grasses that may include purple needlegrass (*Stipa pulchra*), smallflowered needlegrass (*Stipa lepida*), pine bluegrass (*Poa secunda*), hairgrass (*Deschampsia elongata*), and California oatgrass (*Danthonia californica*). The native flowering herbs identified include: Johnny jump-up (*Viola pedunculata*), suncups (*Taraxia ovata*), shooting star (*Dodecatheon clevelandii*), checkerbloom (*Sidalcea malvaeflora*), blue-eyed grass (*Sisyrinchium bellum*), buttercup (*Ranunculus californicus*), owl's clover (*Castilleja spp.)*, clover (*Trifolium spp*.), California poppy (*Eschscholzia californica*), Mariposa lily (*Calochortus luteus*), sky lupine (*Lupinus nanus*), tidy tips (*Layia platyglossa*), California buttercup (*Ranunculus californicus*), and blue dicks (*Dichelostemma capitatum*).

Common wildlife species typical of this habitat include western fence lizard, western rattlesnake, turkey vulture (*Cathartes aura*), American kestrel (*Falco sparverius*), California ground squirrel, Botta's pocket gopher (*Thomomys bottae*), western harvest mouse (*Reithrodontomys megalotis*), California vole (*Microtus californicus*), black-tailed jackrabbit, and coyote.

(Hastings Natural History Reservation 2014, Nedeff, pers. comm. 2016)

2.13 Fish & wildlife

The Carmel River watershed evolved as a highly dynamic system, experiencing large seasonal variability in flow levels with subsequent variation in sediment transport from the upper watershed to the estuary and ocean. This dynamic system is composed of a connected complex of terrestrial, riparian, freshwater aquatic, and coastal estuarine habitats that support many important wildlife species, including migratory and resident birds, at-risk species such as Pacific lamprey, western pond turtle, California tiger salamander (CTS), SCCCS and CRLF (Water Management Group 2007). SCCCS, CTS and CRLF are currently listed as threatened at both the federal and state levels. The decline of these key species is indicative of the overall decline in ecosystem viability and the fragmentation of the environment in the lower 27 miles of the river that requires intensive management efforts (Figure 1-2; map of river miles) (MPWMD 2013).

Despite declines in steelhead (SCCCS) abundance, in general, the Carmel River environment is in better condition today than it was in 1991, when the MPWMD began its Mitigation Program. This improvement is evidenced by biological/hydrologic indicators such as consistent steelhead adult spawner counts of several hundred fish in recent years as compared to zero to five fish per year; improved densities of juvenile steelhead in quantities that reflect a healthy seeded stream; consistently balanced bird diversity in MPWMD restoration project areas compared to control areas; fewer miles of dry river in summer and fall than in the past; and higher water tables in the Carmel Valley alluvial aquifer at the end of each water year (MPWMD 2013).

The comprehensive MPWMD Mitigation Program is an important factor responsible for this improvement. Direct actions such as fish rescues and rearing, and riparian habitat restoration literally enable species to survive and reproduce. Indirect action such as conservation programs, water augmentation, ordinances/regulations and cooperative development of Cal-Am operation strategies result in less environmental impact from human water needs than would occur otherwise. The MPWMD's comprehensive monitoring program provides a solid scientific data baseline, and enables better understanding of the relationships between weather, hydrology, human activities and the environment.

There are other important factors responsible for this improved situation. For example, between Water Years (WY) 1991 and 2012, the Carmel River received normal or better runoff in 16 out of 21 years. Actions by federal resource agencies under the Endangered Species Act (ESA) or the SWRCB under its Order WR 95-10 and follow-up orders have provided strong incentive for Cal-Am and other local water producers to examine and amend water production practices to the degree feasible, and for the community to reduce water use. Except for one year in 1997, the community has complied with the production limits imposed on Cal-Am by the SWRCB since Order 95-10 became effective in July 1995 (MPWMD 2013).

Despite these improvements, challenges still remain due to human influence on the river. The steelhead and California red-legged frog remain listed as threatened species under the Endangered Species Act. Many others are considered species of concern by the State of California. At least several miles of the river still dry up each year, harming habitat upon which wildlife depends. The presence of the Los Padres dam, and the recently-removed San Clemente Dam, flood plain development, and water diversions to meet community and local user needs continue to alter the natural dynamics of the river (MPWMD 2013).

2.13.1 Aquatic species

The Carmel River currently supports native populations of the following aquatic species (excluding benthic macroinvertebrates):

- Pacific lamprey (Lampetra tridentata)
- River lamprey (*Lampetra ayresi*: observed by one MPWMD biologist but no voucher specimen collected for verification)
- Sacramento hitch (*Lavinia exilicauda:* introduced from elsewhere in California)
- Sacramento blackfish (*Orthodon microlepidotus :* introduced from elsewhere in California)
- Steelhead (Oncorhynchus mykiss)
- Threespine stickleback (*Gasterosteus aculeatus*)
- Prickly sculpin (*Cottus asper*)
- Coast range sculpin (*Cottus aleuticus*)

The following species can be found in the Carmel River lagoon (MPWMD 1994):

- Starry flounder (Platichthys stellatus)
- Shiner perch (Cymatogaster aggregata)
- Pacific staghorn sculpin (*Lepotocottus armatus*)

Of the fish species present in the river, steelhead are considered the most important management species. Most fisheries work in the river has been undertaken to add to knowledge of steelhead, their habitats and their use of that habitat. The Carmel River historically supported what the CDFG described in a 1983 report as the state's largest self-sustaining steelhead run (and the second largest fishery for this species) south of San Francisco Bay (Snider 1983).

Limiting factors include habitat loss and degradation, water quality, water quantity, and the introduction of nonnative species. Nonnative introduced fishes found occasionally but infrequently in the Carmel River include: goldfish (*Carassius auratus*), carp (*Cyprinus carpio*), black bullhead (*Ictalurus melas*), brown trout (*Salmo trutta*), mosquitofish (*Gambusia affinis*), green sunfish (*Lepomis cyanellus*), and bluegill (*L. macrochirus*) (MPWMD 1994). Brown trout are common and well established above Los Padres Dam, but uncommon below it (K. Urquhart, pers. comm.).

2.13.2 Terrestrial species

There are approximately 50 terrestrial species residing in the Carmel Region, including several special-status species. Appendix 4 includes a list of mammals, amphibians and reptiles that inhabit the Carmel River watershed. Wildlife populations in the Carmel River region will benefit from the preservation of sensitive habitats and key connection points for wildlife movement. The *Vision Plan for the Carmel River Parkway* that was developed for Big Sur Land Trust in 2005 included a preliminary analysis of lower Carmel River watershed wildlife corridors (Kasey and Peterson 2005).

2.14 Special-status species

Special-status species include plant and wildlife species listed by the U.S. Fish and Wildlife Service (USFWS) as Threatened or Endangered under provisions of the Federal ESA of 1973 United States Code (16 USC 1531 et. seq., as amended) as well as Proposed and Candidate species for listing by the (USFWS). Special-status species also include wildlife species listed as threatened or endangered by the CDFW under provisions of the 1984 California Endangered Species Act (CESA) (California Department of Fish and Wildlife 2014). Wildlife species listed by CDFW as species of special concern (CDFG 2005b) are also considered special-status species (CDWR 2012).

Seven plant species that occur in the Carmel River watershed are considered to be “special”, “threatened” or “endangered” by the State of California or the federal government.

Three fish and wildlife species in the watershed are federally-listed as threatened: the South-Central California steelhead (SCCCS), *Oncorhynchus mykiss*, and the California red legged-frog (CRLF), *Rana aurora draytonii*, and the California tiger salamander (CTS), *Ambystoma californiense*. The steelhead population of the California Central Coast was first listed as threatened in August of 1997, and its protection is under the jurisdiction of the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS) The California red-legged frog was first listed as threatened in 1996, and its protection is under the jurisdiction of the USFWS (NOAA 2012). The California tiger salamander Central California DPS was listed as threatened by USFWS in 2004.

A complete list of special status wildlife species documented as occurring in the watershed as identified by CDFW, NMFS, USFWS, the California Natural Diversity Database (CNDDB) and the California Native Plant Society (CNPS) are listed in Table 2-15. Special-status wildlife species known or with potential to occur in the watershed study area are discussed in this section, including a discussion of the quality of habitat and likelihood of occurrence for those species with potential to occur.

Table 2-15. Special status species of the Carmel River watershed includes species found in the Carmel River Watershed that are considered to be "special" by the California Natural Diversity Database, or "threatened" or "endangered" by the State of California or the federal government (Water Management Group 2007; California Department of Fish and Wildlife 2014).

SCIENTIFIC NAME	COMMON NAME	FED LIST	CAL LIST	DFW STATUS
Invertebrates:				
Caecidotea tomalensis	Tomales asellid	None	None	
Syncaris pacifica	California freshwater shrimp	Endangered	Endangered	
Fish:				
Eucyclogobius newberryi	tidewater goby	Endangered	None	
Gasterosteus aculeatus williamsoni	unarmored threespine stickleback	Endangered	Endangered	
Oncorhynchus mykiss irideus	steelhead	Threatened	None	
Amphibians:				
Ambystoma californiense	California tiger salamander	Threatened	Threatened	Watchlist
Ambystoma macrodactylum croceum	Santa Cruz long-toed salamander	Endangered	Endangered	Fully-protected
Bufo microscaphus californicus	arroyo southwestern toad	Endangered	None	SSC
Rana boylii	foothill yellow-legged frog	None	None	SSC
Rana draytonii	California red-legged frog	Threatened	None	SSC
Rana muscosa	mountain yellow-legged frog	Endangered	Endangered	Watchlist
Spea hammondii	western spadefoot toad	Under review	None	SSC
Taricha torosa	Coast Range newt	None	None	SSC
Reptiles:				
Anniella pulchra nigra	black legless lizard	None	None	SSC
Emys marmorata	western pond turtle	None	None	SSC
Phrynosoma blainvillii	coast horned lizard	None	None	SSC
Thamnophis hammondii	two-striped garter snake	None	None	SSC
Mammals:				
Lasiurus blossevillii	western red bat	None	None	SSC
Neotoma macrotis luciana	Monterey dusky-footed woodrat	None	None	SSC
Taxidea taxus	American badger	None	None	SSC
Birds:				
Agelaius tricolor	tricolored blackbird	None	None	SSC
Charadrius alexandrinus nivosus	western snowy plover	Threatened	None	
Empidonax traillii brewsteri	little willow flycatcher	None	Endangered	
Empidonax traillii extimus	Southwestern willow flycatcher	Endangered	Endangered	
Geothlypis trichas sinuosa	saltmarsh common yellowthroat	None	None	
Pelecanus occidentalis	brown pelican	Delisted	Delisted	
Vireo bellii pusillus	least Bell's vireo	Endangered	Endangered	
Butterflies:				
Euphydryas editha bayensis	bay checkerspot butterfly	Threatened	None	
Euphilotes enoptes smithi	Smith's blue butterfly	Endangered	None	

2.14.1 South-central coast steelhead, *Oncorhynchus mykiss irideus* (SCCCS)

Monitoring and protecting steelhead trout and their habitat is an important component of the management of the Carmel River Watershed, and it influences how the river, the lagoon, and adjacent areas are managed. Because the steelhead lifecycle requires migration between the ocean and the river, maintaining adequate amounts of water in the river, removing barriers to migration, improving water quality, and maintaining the river-ocean connectivity are all critical aspects of steelhead management in the watershed.

Concern over the ongoing decline in steelhead numbers has led regulatory agencies to institute protective measures directed at providing suitable spawning grounds and maintaining rearing habitat for juvenile steelhead. The CDFW is concerned that the steelhead population in the Carmel River is threatened with becoming a remnant run due to the development of water resources, drought, land use, and environmental problems (CDFG 1986, Snider 1983). CDFW's policy and goal for managing the steelhead resource is to "maintain it as a self-sustaining resource and to restore it as much as possible to its historic level of productivity" (McEwan and Jackson 1996; CDWR 2012).

Steelhead (*Oncorhynchus mykiss irideus*) found in the Carmel River watershed belong to the South-Central California coast Distinct Population Segment (SCCCS DPS), which includes most streams in Monterey, San Benito, Santa Clara, Santa Cruz, and San Luis Obispo counties**.** Recovery of the threatened SCCCS DPS will require recovery of a minimum number of viable populations within each of four Biogeographic Population Groups (BPGs) within the SCCCS Recovery Planning Area. Recovery of these individual populations is necessary to conserve the natural diversity (genetic, phenotypic, and behavioral), spatial distribution, and abundance of the species, and thus the long-term viability of the SCCCS DPS (Figure 2-33).

This steelhead DPS is listed as threatened under the federal Endangered Species Act (NMFS 2011), and is a CDFW species of special concern and NMFS final rule under the federal Endangered Species Act (August, 1997) identified 15 population units of steelhead, called Evolutionarily Significant Units (ESUs). The Carmel River is within the South-Central California Coast (SCCC) ESU, which is designated as threatened. The designated Critical Habitat for steelhead in the Carmel River (2005) includes all accessible reaches of the river including areas upstream of the Los Padres Dam (CDWR 2012).

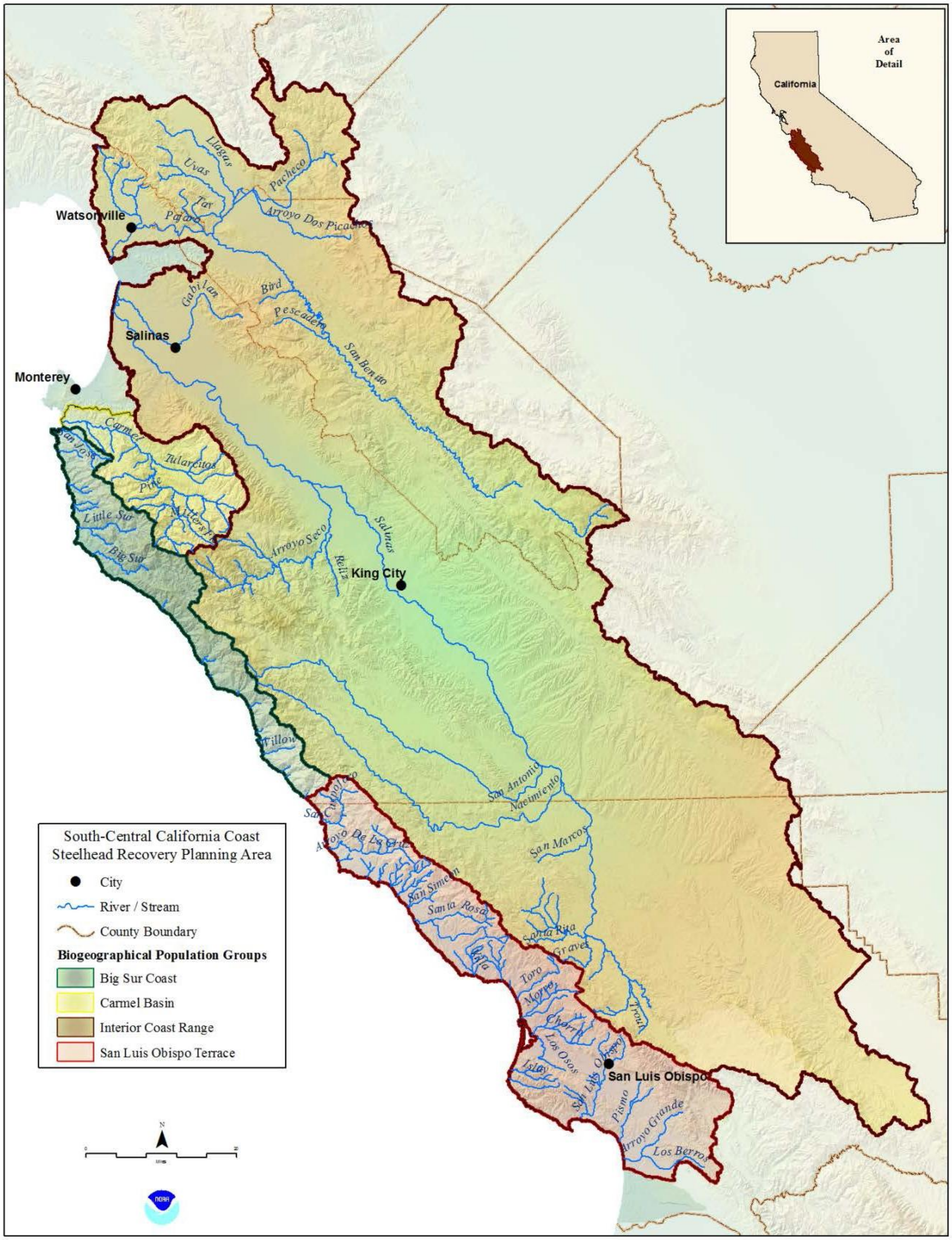


Figure 2-33. Biogeographic Population Groups (BPGs) in the South-Central California Coast Steelhead Recovery Planning Area (after Boughton et al. 2007b) (National Marine Fisheries Service 2013).

The Carmel River supports the largest run of about 27 anadromous streams within the SCCC DPS. Many of the streams in the SCCC DPS are short and occupy smaller watersheds compared to the Carmel River. The Carmel River is the only river within the DPS that has long-term data on adult returns and juvenile abundance. Run sizes in most of the other creeks in this DPS are undocumented but estimated to be in the low hundreds or less compared to counts at SCD that range from the low to high hundreds

(CDWR 2012). The life history of SCCCS and their population trends in the Carmel River watershed are described below. Factors limiting steelhead in the watershed are discussed in detail in the following *Steelhead Limiting Factors Analysis* section.

Annual monitoring conducted by the MPWMD shows that the Carmel River steelhead population has recovered somewhat from the remnant levels of the last drought (1987 to 1991) and from past water-supply practices (MPWMD 2012). Though overall fish populations have improved since the inception of the Mitigation Program in 1990, MPWMD staff has noticed a period of general decline in the adult run from 2001 to 2012. Between 1992 and 2001, the spawning population recovered from a handful of fish to levels approaching 900 adults per year as counted at San Clemente Dam (SCD). Then the run experienced a six-year downward trend from 804 adults in 2001 to 222 adults in 2007, rebounding somewhat in 2008 to 412 adults. However, in 2009 and 2010, the population underwent a dramatic reduction to 95 and 157 adults respectively. In 2011 and 2012, the population rebounded again with 452 and 470 adults passing over SCD, slightly above the 1994-2012 average of 431 adults (MPWMD 2012).

Previous redd surveys below SCD confirm that the spawning habitat in the lower river has improved considerably over the last 21 years and adults are spawning in the lower river instead of passing the SCD fish counting station. In addition, juvenile steelhead rescued by the MPWMD from the lower river that survive to adulthood are more likely to return to the lower river to spawn, rather than migrate upstream past the SCD. The MPWMD deployed a fish counting station, acquired from CDFW grant funding, during the 2011-2012 migration season in the lower river to help determine whether more adults are in fact spawning in the lower river. At present, the exact reasons for this period of apparent decline in adult returns at SCD are not clear, but are likely the result of a combination of controlling and limiting factors including (MPWMD 2012):

- Improved spawning conditions in the lower Carmel River, encouraging fish to spawn before they reach the counter at the dam;
- Spring flow variability such as low flow conditions that could dewater redds prematurely or high flows that could either deposit sediment over redds or completely wash them out;
- Variable lagoon conditions, caused by artificial manipulation of the sandbar and/or naturally occurring periods of low winter flows;
- Impediments to adult and smolt migration routes, such as seasonal barriers, inadequate passage facilities, and intermittent periods of low flow creating critical riffles below the Narrows during the normal winter-spring migration season;
- Low densities of juvenile fish in 2004, 2007, 2009, 2010 and 2011 affecting subsequent adult populations;
- Variable ocean conditions;
- Ongoing but limited impacts of legal fishing (i.e., approximately 0.5 - 1.5% incidental mortality associated with catch-and-release fishing for adults in the winter season, and fishing for juvenile steelhead from in the upper watershed during the spring/summer trout season may slightly reduce the adult spawning stock or the number of juvenile fish that reach the ocean), as well as illegal poaching activities.

Monitoring of the juvenile steelhead population at eleven sites along the mainstem Carmel River below Los Padres Dam shows that fish density continues to be quite variable both year to year and site to site from below 0.40 fish per foot [fpf] of stream to levels frequently ranging above 1.00 fpf, values that are typical of well-stocked steelhead streams. In the 2011-2012 MPWMD mitigation reporting period, the average population density was well below the long-term average of 0.81 fpf for the Carmel River due primarily to low adult returns in 2009-2010. Recovery and fluctuation of the juvenile steelhead population in the Carmel River Watershed is directly related to the following factors (MPWMD 2012):

- Improvements in streamflow patterns, due to favorable natural fluctuations, exemplified by relatively high base-flow conditions since 1995;

- MPWMD and SWRCB rules to actively manage the rate and distribution of groundwater extractions and direct surface diversions within the watershed, coupled with changes to Cal-Am's operations at San Clemente and Los Padres Dams, providing increased streamflow below San Clemente Dam;
- Restoration and stabilization of the lower Carmel River's stream banks, providing improved riparian habitat (tree cover/shade along the stream and an increase in woody debris) while preventing erosion of silt/sand from filling gravel beds and pools;
- Extensive juvenile steelhead rescues by the MPWMD over the last 23 years, now totaling 366,873 fish through 2011;
- Rearing and releases of rescued fish from the SHSRF of nearly 82,000 juveniles and smolts back into the river and lagoon over the past 16 years, at sizes larger than the river-reared fish, which in theory should enhance their ocean survival;
- Variable lagoon conditions, including highly variable water surface elevation changes caused by mechanical breaching, chronic poor water quality (especially in the fall), and predation by birds and striped bass;
- Barriers or seasonal impediments to juvenile and smolt emigration, such as the lack of juvenile passage facilities at Los Padres Dam (potentially resolved with the installation of a smolt passage facility in 2015) and intermittent periods of low flow below the Narrows during the normal spring emigration season;
- Chronic, and occasionally acute, fall temperature and hydrogen sulfide levels below LPD, (and prior to the 2015 San Clemente Dam Removal, the increase in suspended sediment from the SCD summer draw-down); and the
- Potential for enhanced predation on smolts and YOY migrating through the sediment fields of LPD.

A recent challenge that may remain for some years is the potential effects of the removal of San Clemente Dam required by DWR/DSOD and completed in 2015. The most significant issue is the effect of released sediment from the reservoir on downstream river habitat and the developed floodplain (MPWMD 2012).

2.14.1.1Life history

Spawning and Incubation

Steelhead are anadromous fish; adults living in the ocean migrate to freshwater for spawning (Barnhart, 1986). Key elements of the steelhead life cycle are tied to the amount of water in creeks and rivers that are influenced by the region's wet and dry seasons. In the Carmel River Watershed, adults spawn potentially from December through June, but predominantly January through May (Dettman and Kelley 1986). The embryos incubate three to eight weeks and hatch as alevins in late winter or spring (February through June). The newly hatched alevins reside in the gravel up to two weeks, then emerge as fry and disperse into low velocity areas along stream margins. Figure 2-35 illustrates the South-Central California coast O. mykiss Life Cycle Habitat Linkages (Schwing et al. 2010).

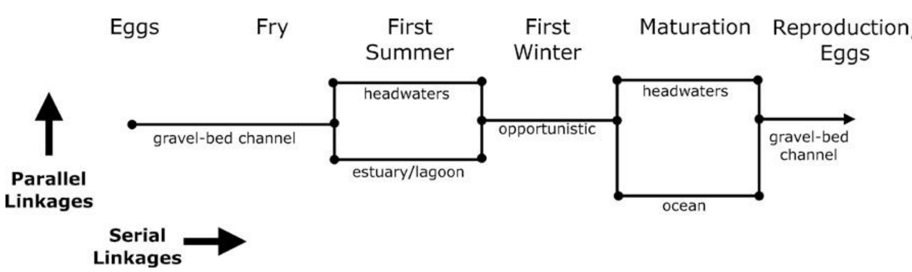


Figure 2-35. South-Central California coast O. mykiss Life Cycle Habitat Linkages (National Marine Fisheries Service 2013).

Steelhead spawning and incubation habitat is typically gravel-cobble substrate at the downstream end of pools or upstream end of riffles. Good quality spawning habitat includes sufficient depth of flow and water velocity over suitable substrate. In most years an estimated 61.5 miles of channel (mainstem and tributaries) provide spawning habitat in the Carmel River system, including approximately 40.5 miles upstream of San Clemente Dam and 21.0 miles downstream. A map of spawning habitat distribution in selected reaches of the Carmel River watershed is presented in figure 2-36. According to Dettman (1990) slightly more than half of the potential spawning habitat occurs upstream of San Clemente Dam (Monterey Peninsula Water Management District 2004). However the latter assessment was made at a time when the lower 9 miles of the river were deemed to be only a migratory zone with no spawning or rearing value. That is no longer the case, and MPWMD is in the process of re-habitat typing the whole main-stem Carmel River to the Level IV criteria in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 2010)

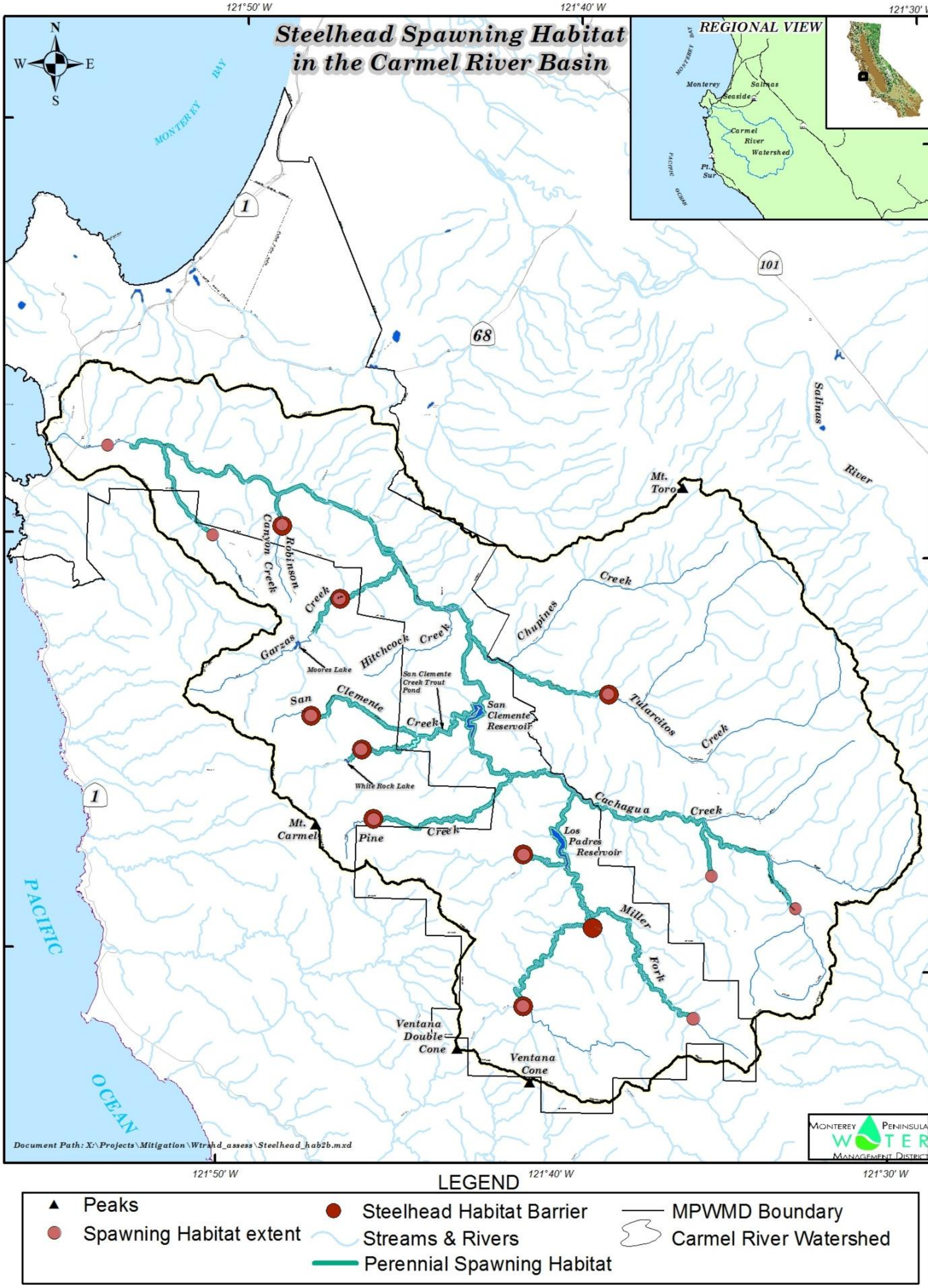


Figure 2-36. Steelhead spawning habitat in the Carmel River Basin. Source: Monterey Peninsula Water Management District 2004,figure 5.5.1.1-A

Extent of Spawning Habitat in the Carmel River Watershed – Barriers keep adult steelhead from migrating upstream and ultimately limit the amount of spawning habitat utilized annually in the Carmel River Watershed. Table 2-17 lists the known upper barriers to adult steelhead migration.

Table 2-17: Accessible Estimates of the linear extent of stream accessible to adult steelhead in the Carmel River Watershed Source: Monterey Peninsula Water Management District 2004, Table 5.5.1.1-A

PORTION OF BASIN, Stream	Length Accessible (Miles)	Type of Permanent Barrier	Permanent Barrier Field Checked	Type of Temporary Barriers
DOWNSTREAM OF SAN CLEMENTE DAM				
- Carmel River mainstem[1]	16.48	none	yes	shallow riffles, flow barrier at Old Carmel Dam, reservoir drawdown at San Clemente Dam
-- Potrero Cr.	3.00	none	yes	culverts, shallow riffles
-- Robinson Canyon Cr.	1.11	unknown	no	concrete fords, boulder piles
-- Las Gazas Creek	2.00	bedrock chute	yes	bedrock chute, shallow riffles
-- Tularcitos Cr.	4.31	concrete ford	yes	Bedrock chutes, culverts
SAN CLEMENTE RESERVOIR TO LOS PADRES DAM				
- Carmel River mainstem	5.41	none	yes	Shallow riffles,bedrock chutes, concrete fords, & summer dams
-- San Clemente Creek	6.00	recreational dam	yes	recreation dams, boulder piles
--- Black Rock Cr.	2.99	bedrock chute and waterfall	yes	recreation dams, boulder piles, & bedrock chutes
-- Pine Creek	5.50	unknown	no	boulder piles, bedrock chutes
-- Cachagua Creek	4.78	none	yes	shallow riffles, concrete fords
--- Finch Cr.	6.00	none	yes	shallow riffles, boulder piles, concrete fords
--- James Cr.	1.80	none	yes	boulder pile, shallow riffles
UPSTREAM OF LOS PADRES RESERVOIR				
- Carmel River mainstem	6.78	waterfall	yes	shallow riffles, boulder piles
-- Miller Fork	5.87	unknown	no	shallow riffles, bedrock chutes
-- Danish Creek	1.70	bedrock chute & waterfall	yes	bedrock chute
Subtotals:				
- Carmel River mainstem	28.67			
-- Primary Tributaries	34.27			
--- Secondary Tribs.	10.79			
TOTAL IN CARMEL RIVER BASIN:	**73.73**			

[1] Downstream spawning habitat extent = Rancho Canada Golf Course, Br. #5 (RM= 2.1) (2013)

[2] Source: MPWMD Technical Memorandum 89-03: based on field reconnaissance of migration barriers in mainstem Carmel River and San Clemente Creek (Kelley and Dettman, 1986; MPWMD, 1989 & subsequent observations) and on CF&G biologist William Snider's description of spawning habitat (Snider, 1983).

[3]Some data updated in 2014 based on MPWMD field observations in 2012 during barrier assessment grant surveys.

Figure 2-37 shows the location and the extent of major fish passage impediments. In normal and above water years, when no temporary barriers limit upstream migration, adult steelhead spawn in a total of 60.5 miles of stream, including 24.5 miles of the Carmel River mainstem, 30 miles of primary tributaries, and 6 miles of secondary tributaries. In dry and some below normal water years, adults probably do not ascend to the uppermost permanent barriers on the primary and secondary tributaries, but utilize the entire 24.5 of the mainstem. Those unable to migrate past barriers are forced to spawn below smaller falls and chutes or in the mainstem (Monterey Peninsula Water Management District 2004).

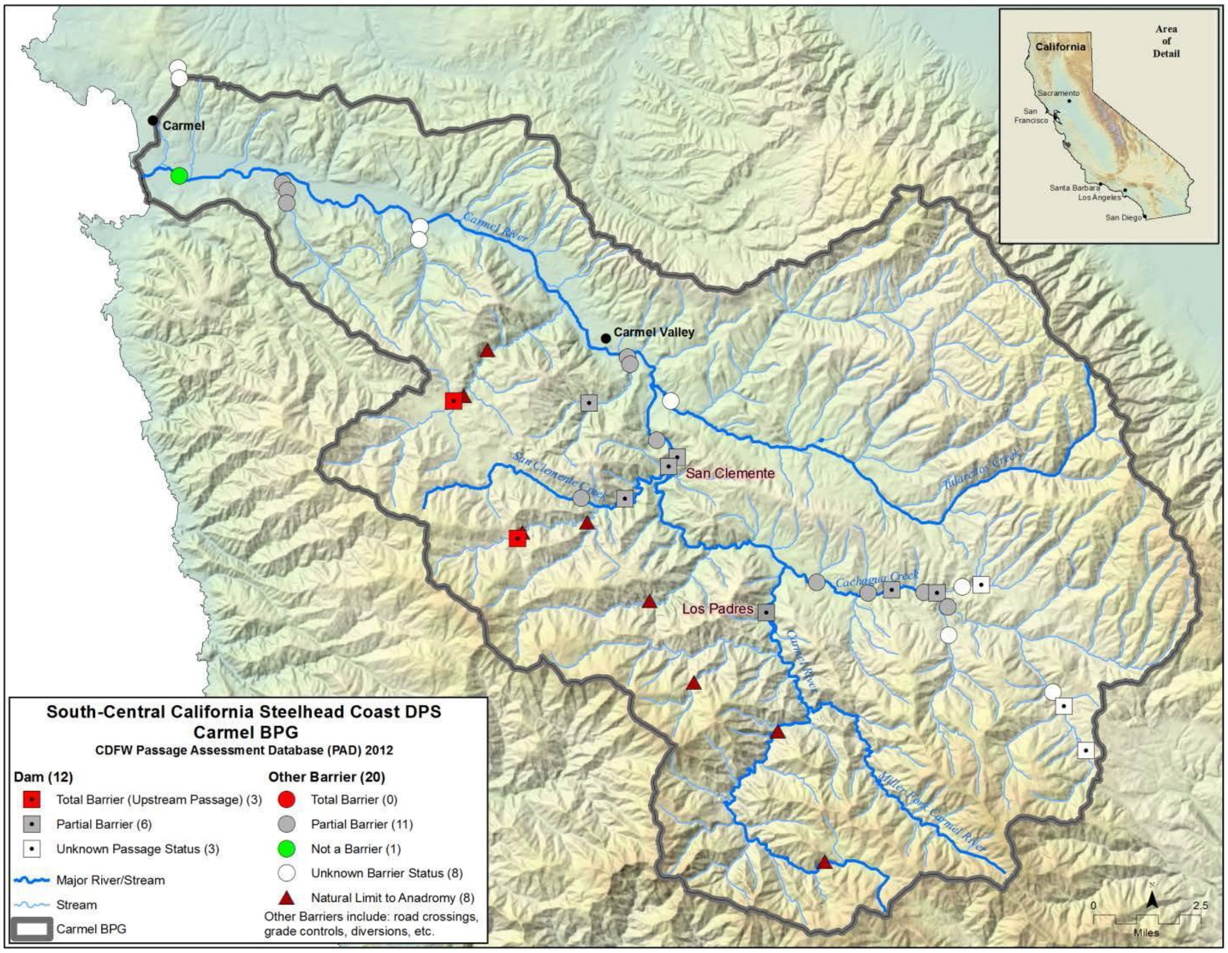


Figure 2-37. Major Fish Passage Impediments, Carmel River Basin BPG (source: National Marine Fisheries Service 2013). Note: the status of fish passage impediments is in flux, with existing ones being removed or modified, while new ones may be installed, or discovered through updated inventories; a current list of fish passage impediments can be found on the California Department of Fish and Wildlife website: http//www.cafishpassageforum.org/

Quantity and Quality of Spawning Habitat in the Mainstem Carmel River – Based on 1989 surveys, the amount of spawning habitat in the mainstem upstream of the Narrows totals ~120,000 square feet, including 50,000 square feet in the reach from the Narrows to San Clemente Dam (41% of total), 11,000 square feet from San Clemente Reservoir to Los Padres Dam (9% of total), and 60,000 square feet upstream of Los Padres Reservoir (50% of total) (Table 2-18). Based on these estimates, the spawning habitat in the mainstem can support approximately 2,400 nests, equivalent to a run of 4,800 adults or about 193 spawners per mile of stream. The large amount of habitat upstream of Los Padres Dam, but disproportionately low returns of adults to Los Padres Dam, suggests that spawning habitat upstream of Los Padres Dam may not be fully utilized and that spawning may not be the primary limiting factor upstream of Los Padres Dam. However the latter assessment was made a time when the lower 9 miles of the river were deemed to be only a migratory zone with no spawning or rearing value. That is no longer the case, and MPWMD is in the process of re-habitat typing the whole main-stem Carmel River to the Level IV criteria in the California Salmonid Stream Habitat Restoration Manual (CDFW 2010), and is seeking concurrence from NMFS and CDFW for what criteria to use in quantifying the current levels of spawning gravel in the system.

Between 1993 and 2015, MPWMD has placed approximately 4,900 tons of gravel below the dams, with the most significant amounts being 800 tons in 1993, 750 tons in 1996, 800 tons in 2003, and 1500 tons in 2014. The 2014 deposit was funded by a California Department of Fish and Wildlife grant for Steelhead Spawning Gravel Enhancement below Los Padres Dam. That year, the District placed 1,500 tons of clean gravel at three sites within ¼-mile of the dam. By the spring of 2016, much of that rock had dispersed into spawning glides up to one-mile downstream, improving spawning habitat below the dam (Chaney, pers. comm. 2016).

Table 2-18: Summary of steelhead spawning habitat measured in 26 reaches of the Carmel River Basin upstream of the Narrows and estimates of spawning habitat in the Carmel River and selected tributaries upstream of the Narrows (Dettman and Kelley (1986) & MPWMD Technical Memorandum 89-03).

	Length of Reach	Portion of Reach Surveyed	Spawning Habitat Measured in Portion of Stream Surveyed	Estimate of Total Spawning Habitat in Reach	Potential Number of Steelhead Nests	Spawner Index
REACH	(ft)	(ft)	(sqft)	(sqft)	(nos.)	(nos./mi)
Narrows to Sleepy Hollow	57,750	57,750	45,445	45,445	909	166
Sleepy Hollow to San Clemente Dam	7,000	5,350	1,864	2,439	49	74
subtotal	64,750			47,884	958	156
San Clemente Res. to Pine Creek	10,600	8,122	3,369	4,397	88	88
Pine Creek to Syndicate Camp	5,350	5,478	2,482	2,482	50	98
Syndicate Camp to Cachagua Creek	6,300	3,594	1,797	3,150	63	106
Cachagua Creek to Los Padres Dam	6,300	6,503	722	722	14	24
subtotal	28,550			10,751	215	80
Danish Creek to Bluff Camp	7,200	5,171	7,480	10,415	208	306
Bluff Camp to Bruce Fork	5,900	1,785	1,573	5,199	104	186
Bruce Fk to trib. above Sulphur Sprgs.	3,850	1,828	2,987	6,291	126	345
Trib. above Sulphur Spr to trib below Buckskin Camp	5,650	2,733	2,254	4,660	93	174
Trib. below Buckskin Camp to rightbank trib. above Buckskin	4,350	1,811	6,826	16,396	328	796
Rightbank trib above Buckskin Camp to trib below Benchmark 1743	4,750	3,234	10,557	15,506	310	689
Tributary below Benchmark 1743 to Barrier above Ventana Mesa Creek	4,200	489	119	1,022	20	51
subtotal	35,900			59,489	1,190	350
Total Mainstem Carmel River	129,200	103,848	87,475	118,124	2,362	193
(miles)	24.47	19.67				

Spawning Habitat between San Clemente Reservoir and Los Padres Dam and below San Clemente Dam - The amount and quality of spawning habitat in these reaches is limited by the inadequate supply of gravel from the upper Watershed, caused by entrapment of bedload in Los Padres and San Clemente Reservoirs. No natural gravel recruitment has occurred in the reach immediately below San Clemente Dam since 1920. Similarly, no recruitment from upstream of Los Padres Reservoir has occurred since 1948, when Los Padres Dam was constructed. The historical loss of spawning gravel is indexed by the trend in Figure 2-38, illustrating that habitat between the dams and immediately below San Clemente Dam contains only one-quarter as much habitat per mile, as compared to upstream of Los Padres Reservoir. Habitat is most limited in the reach between Cachagua Creek and Los Padres Dam where in 1990 there was only enough area to support 14 nests, or about 24 spawners per mile (Table 2-19). To address this situation, the MPWMD has partially restored spawning habitats in the reach between the dams and immediately below San Clemente Dam with two grants from the California Department of Fish and Wildlife and another from the federal government. As a result, the quality of spawning habitat has been improved at key locations and the increased amount has partially offset historical loses (Monterey Peninsula Water Management District 2004).

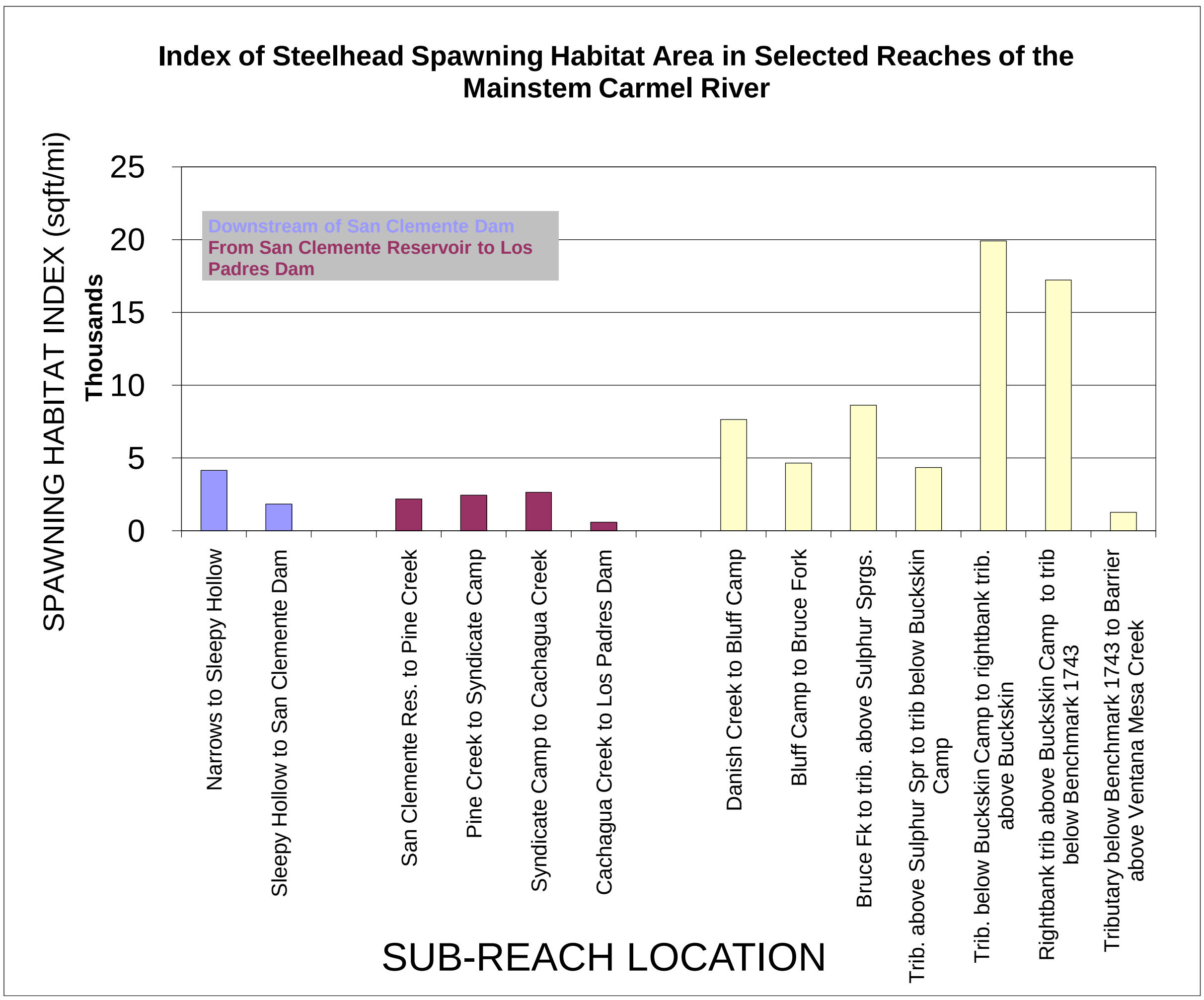


Figure 2-38: Index of Steelhead Spawning Habitat Area in Selected Reaches of the Mainstem Carmel River (Monterey Peninsula Water Management District 2004).

Table 2-19 Summary of steelhead spawning habitat measured in 26 reaches of the Carmel River Basin upstream of the Narrows and estimates of spawning habitat in the Carmel River and selected tributaries upstream of the Narrows (Dettman and Kelley (1986) & MPWMD Technical Memorandum 89-03).

		Length of Reach	Portion of Reach Surveyed	Spawning Habitat Measured in Portion of Stream Surveyed	Estimate of Total Spawning Habitat in Reach	Potential Number of Steelhead Nests	Spawner Index
STREAM	REACH	(ft)	(ft)	(sqft)	(sqft)	(nos.)	(nos./mi)
MILLER FORK	Confluence with Carmel River to meadow ~ 1 mile upstream	5,150	1,117	137	632	13	26
	Meadow to Clover Basin Camp	5,750	1,908	1,659	5,000	100	184
	Clover Basin Camp to Miller Canyon	2,850	1,503	698	1,324	26	98
	Miller Canyon Camp to probable migration barrier	17,300	1,201	50	720	14	9
	Subtotal Miller Fork Basin	31,050	5,729	2,544	7,675	154	52
	(miles)	5.88	1.09				
DANISH CREEK	Confluence with Carmel River to migration barrier	9,000	2,442	1,386	5,108	102	120
	(miles)	1.70	0.46				
CACHAGUA CREEK	From Carmel River to Conejo Creek	24,500	14,011	841	1,471	29	13
	Conejo Creek to Finch Creek	750	680	56	62	1	17
-Finch Creek	From James Creek to Big Creek	10,900	2,405	543	2,461	49	48
-James Creek	From Finch Creek to Lambert Ranch	5,600	451	34	422	8	16
	Subtotal Cachagua Creek Basin	41,750	17,547	1,474	4,416	88	22
	(miles)	7.91	3.32				
SAN CLEMENTE CREEK	San Clemente Reservoir to Trout Pond Dam	9,000	?	?	3,906	78	92
	Trout Pond Reservoir to Black Rock Creek	3,450	2,315	1,005	1,498	30	92
	Confluence with Blk Rk Crk to end of permanent flow	9,750	669	161	2,346	47	51
-Black Rock Creek	Confluence with S Clemente Crk to confluence of No and So Forks	3,450	1,460	410	969	19	59
--No.Fork Black Rock Cr	Confluence with So Fork to permanent barrier at White Rock Dam	12,350	1,494	184	1,522	30	26
	Subtotal San Clemente Creek Basin	38,000			10,241	205	57
	(miles)	7.20					

Spawning Habitat in Selected Tributaries

As part of studies evaluating impacts of water supply alternatives on steelhead populations, the MPWMD assessed the quantity of spawning habitat in three primary tributaries to the mainstem, including Danish Creek, Cachagua Creek and San Clemente Creek. Following is a brief account of spawning habitats in each of these tributaries.

Danish Creek – This watershed contains about 5,100 square feet of available spawning habitat and could support about 100 steelhead nests (Table 2-19). The extent of habitat is limited by a bedrock chute and waterfall 1.7 miles upstream from the confluence with the Carmel River. Substantial habitats are probably available upstream of this barrier, but no surveys have been done to quantify the amount.

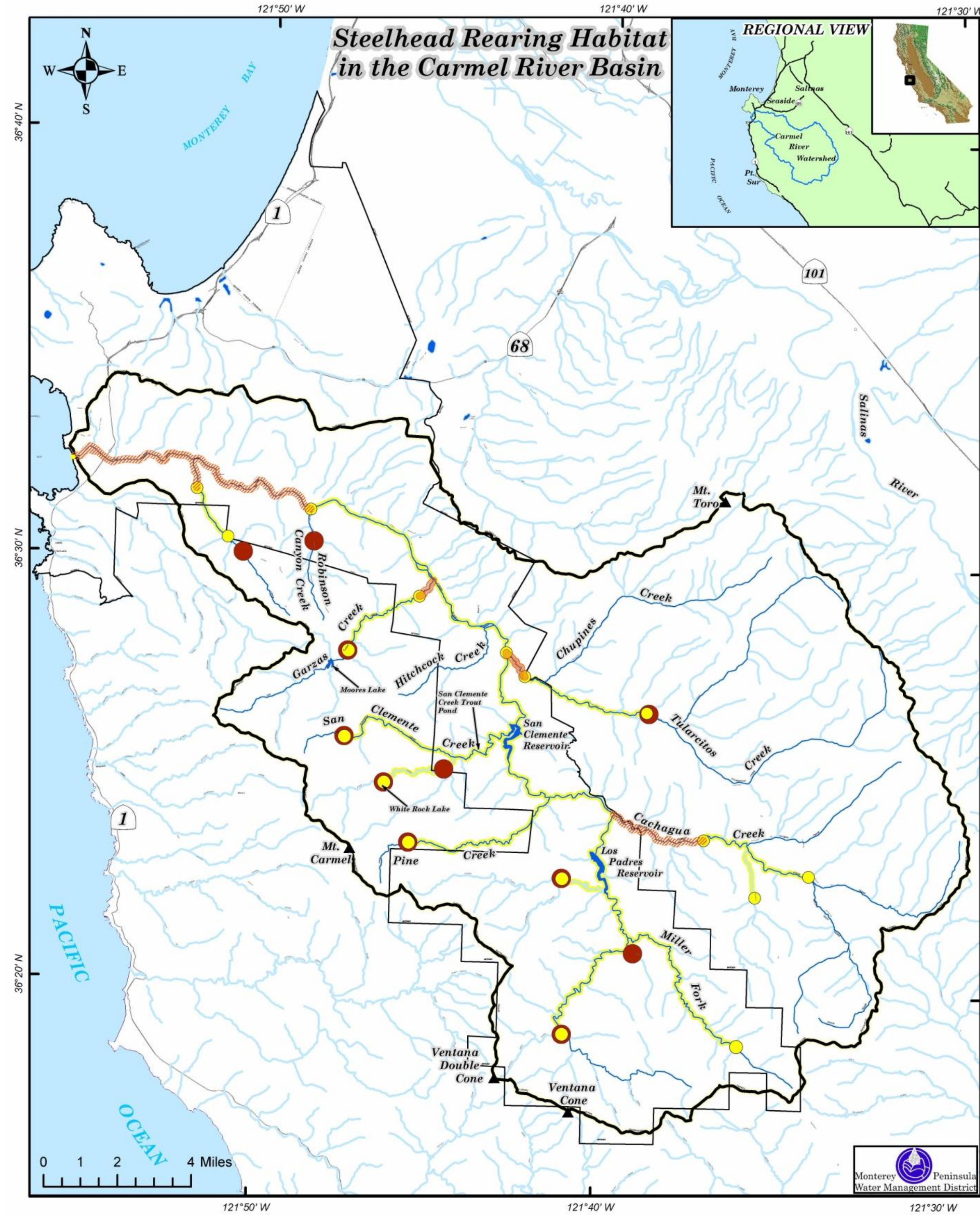
Cachagua Creek – Spawning habitat in Cachagua Creek and its tributaries, Finch and James Creeks, totals 4,416 square feet, or enough for 88 nests (Table 2-19). Although over 8 miles of stream is available to steelhead in Cachagua Creek Watershed, the narrow stream widths and low flow limits the amount of spawning habitat and yields a spawners index of only 22 fish per mile. Although the value of spawning habitat in Cachagua Watershed is marginal, the stream performs the important function of replenishing spawning sized gravels to the mainstem Carmel River below Los Padres Dam.

San Clemente Creek – Spawning habitat in the San Clemente Watershed totals 10,250 square feet, equivalent to 205 nest sites (Table 2-19). Despite narrower stream widths and lower flows, San Clemente Creek supports about the same number of nest sites as the mainstem Carmel between San Clemente Reservoir and Los Padres Dam (Monterey Peninsula Water Management District 2004).

Rearing

Rearing habitat supports the growth and development of juvenile steelhead from fry to Age 2+ juvenile. Steelhead fry grow rapidly through the spring and early summer. Most juvenile steelhead in the Carmel River remain in freshwater for two years before migrating to sea as 8 to 10-inch sized fish. A few individuals may have a freshwater residency of three or four years, as indicated by observations of larger juvenile steelhead in the lower Carmel (Dettman and Kelley 1986) and in nearby Waddell Creek (Shapovalov and Taft 1954). Some steelhead may never go to sea and will mature and spawn in freshwater.

Summer rearing habitat for juveniles is believed to be the most critical limiting factor for juvenile steelhead production in the Carmel River Watershed. Almost three-quarters of the potential summer rearing habitat occurs upstream of the former SCD, and varies depending upon the type of water year. Each dry season, depending on the amount of winter rainfall and pumping volume from the Carmel Valley Aquifer, the river downstream of Robles del Rio can dry back from one mile upstream of the mouth up to 5 to 8 miles, causing a loss of rearing habitat. During times when the river begins drying back, juvenile steelhead are rescued from the drying mainstem reaches and some tributaries by the MPWMD and in selected tributaries by volunteers from the Carmel River Steelhead Association. Fish rescued by MPWMD are taken to the Sleepy Hollow Steelhead Rearing Facility (SHSRF) or released into permanently flowing sections of the Carmel River. CRSA usually re-releases all its rescued fish upstream in the same tributary. During most water years (aside from critically dry and dry years) approximately 49 miles of channel support habitat for juvenile rearing, including 36 miles upstream of the SCD and 13 or more miles downstream (Jones and Stokes, 1998). The extent of rearing habitat is shown in Figure 2-39.



LEGEND

▲ Peaks	Steelhead Habitat Barrier	MPWMD Boundary
Rearing Habitat extent	Streams & Rivers	Carmel River Watershed
	Perennial Rearing Habitat	Seasonal Rearing Habitat

Figure 2-39. Extent of steelhead rearing habitat in Carmel River Watershed (Monterey Peninsula Water Management District 2004).

Juvenile Rearing Habitat in selected portions the Carmel River Watershed –In most years, 49 miles of rearing habitat are available with ~20 miles in the mainstem, 24 miles in primary tributaries, and 5 miles in second tributaries. Juvenile rearing habitat in the mainstem can be divided into three reaches based on the physical character of the channel and summer flow regimes:

Upper Mainstem_– Most rearing habitat upstream of Los Padres Dam is within the Ventana Wilderness area, where river flow is unregulated, roads and trails have not caused erosion, the gradient is steep (~320 feet per mile), and bedrock outcrops control the course of the channel. Typically, deep pools separated by short, shallow glides and long, cobble/boulder riffles and runs predominate throughout the reach.

Middle Mainstem_– The configuration of the reach between the dams is controlled by bedrock outcrops and large boulders. The substrate is a mixture of cobbles and boulders and lacks a natural source of gravel because most of it is trapped behind Los Padres Dam. During summer, water stored in Los Padres Dam is released into the channel and diverted or released at San Clemente Dam. By agreement with CDFW, Cal-Am maintains a minimum flow of 5 cubic feet per second (cfs) below Los Padres Dam during diversion to storage, and as high a flow as feasible during the dry season. Because of variation in natural accretion, the augmented dry-season flows range from 2 cfs in critical years to 15 cfs in wet years.

Lower Mainstem – Below San Clemente Dam, the river is controlled primarily by bedrock outcrops downstream to near Paso Hondo Road (Powell's Hole). Below that point, the interaction of alluvial deposits and storm flows periodically rearrange, scour, and deposit bedload along the river. Beginning in 1984, MPWMD, DFG, and Cal-Am negotiated an agreement to release water during the low-flow season. Under the annual agreements, releases have varied from 2.1 cfs to 10 cfs and have improved aquatic habitat in the reaches downstream of San Clemente Dam, particularly upstream of Robinson Canyon, where the State Water Resources Control Board and NOAA-Fisheries limit Cal-Am pumping from the alluvium (Monterey Peninsula Water Management District 2004). A significant proportion of the fish rearing in the main-stem, can occur in the river downstream of Robinson Canyon in those water years with sufficient flows.

Migration

Migration habitat is the route used by upstream migrating adults and downstream migrating kelts and smolts. Upstream migration can be impaired or blocked at the mouth of the river, at shallow riffles, road crossings, dams or waterfalls. Downstream passage can be impaired by passage down or over spillways. Minimum depth of flow for upstream adult salmonid passage through culverts is one foot and in an open channel is seven-tenths of a foot of water (CDFW 2002, NMFS 2001). The depth of flow criteria for passage for juvenile steelhead is five-tenths of foot of water.

In some years the upstream adult migration begins as early as mid-December. The steelhead migration can extend through April into May or even June in some years. Early migration can occur when storms open the river mouth earlier than usual. Conditions to support migration can become impaired when the river flow through the valley falls below 45 CFS and access to the lagoon is no longer possible when the bar closes which normally happens when flow at the Near Carmel River gage falls below 20 CFS.

2.14.1.2 Current watershed conditions

Watershed conditions for steelhead trout in the Carmel River watershed have been assessed by various agencies and groups since steelhead were listed by the state as a special-status species in the 1990's. Watershed conditions were assessed by MPWMD in 2011-2013 as detailed earlier in Section 2.14.1 and by NMFS in 2013.

The NOAA analysis rated overall habitat conditions for anadromous *O. mykiss* in the Carmel River watershed as “Fair.” Approximately 33 % of the indicators were impaired (fair condition) or severely impaired (poor condition) and these indicators repeatedly focused on lack of surface flows in the mainstem caused by water management activities that include surface water diversions, dams, and excessive pumping of groundwater (Hunt & Associates 2008; Kier Associates and National Marine Fisheries Service 2008a, 2008b; Casagrande 2006; Casagrande and Watson 2006; California Department of Fish and Game 2005; MPWMD and Carmel River Watershed Conservancy 2004; Carmel River Conservancy 2004; Stephenson and Calcarone 1999; Dettman and Kelly 1986, 1987; Kondolf 1986; Snider 1983; California Department of Water Resources 1978.). Surface diversions and excessive groundwater pumping are the primary threats to Carmel River steelhead (McEwan and Jackson 1996). Habitat loss caused by land use changes, and barriers to their migration have also been identified as impairments to steelhead in the watershed (Monterey Peninsula Water Management District 2004). MPWMD, Cal Am, the Carmel River Steelhead Association, and other local NGO’s have been actively restoring critical habitat to mitigate negative impacts of human activities for many decades (National Marine Fisheries Service 2013).

The mainstem contains suitable spawning habitat and functions as the conduit connecting the ocean and estuary to even more extensive spawning habitat in the upper watershed. However, San Clemente and Los Padres Dams (while equipped with fish passage facilities) impede or delay access to spawning and rearing habitat in at least 50 % of the Carmel River watershed. The San Clemente Dam presented a challenge to the emigration of fish from the upper watershed to the ocean. While the dam’s fish ladder facilitated some movement upstream, for downstream migration fish had to swim over the edge of the dam and drop to the plunge pool below. This drop of over 100 feet into the pools may be responsible for the death of some fish during their trip downstream to the ocean. San Clemente Dam was removed in 2015. The Los Padres Dam presents similar challenges for the migrating steelhead, but a new smolt emigration facility was added in 2015 and will be operating during the 2016 smolt emigration season. Despite these obstacles, native non-anadromous *O. mykiss* populations persist in the mainstem and most of the tributaries above these dams (National Marine Fisheries Service 2013).

The Carmel River Estuary & Lagoon also received low ratings by the NMFS assessment. While the existing estuary has undergone substantial restoration and still contains valuable rearing habitat, at least 33% of the original estuary has been eliminated due to encroachment from residential development, transportation corridors (Highway 1), and recreational development (Carmel Beach State Park).
The sandbar-closed lagoon that forms during low flow periods provides essential nursery habitat for juvenile steelhead. The seasonal closure of the lagoon may constrain the temporal emigration period of smolts to the ocean, as well as the delay the return of spawning adults to the river (Bond et al. 2008; Hayes et al. 2008).

Estimates based on the amount of suitable habitat available in the watershed to produce adult steelhead have ranged from 3,500 to 4,200 adults, with habitat similar to conditions in 1975 and 1982. Comparing the number of adults counted at San Clemente and Los Padres Dams with the capacity of the watershed to produce adults indicates that the existing adult steelhead population is about one-third of the potential adult production. Some of the factors that limit the adult population include flow diversions between San Clemente Dam and the Carmel River Lagoon, degraded spawning habitat, fish passage problems at Los Padres Reservoir, sand deposition in the Lagoon, and loss of streamside vegetation (National Marine Fisheries Service 2013).

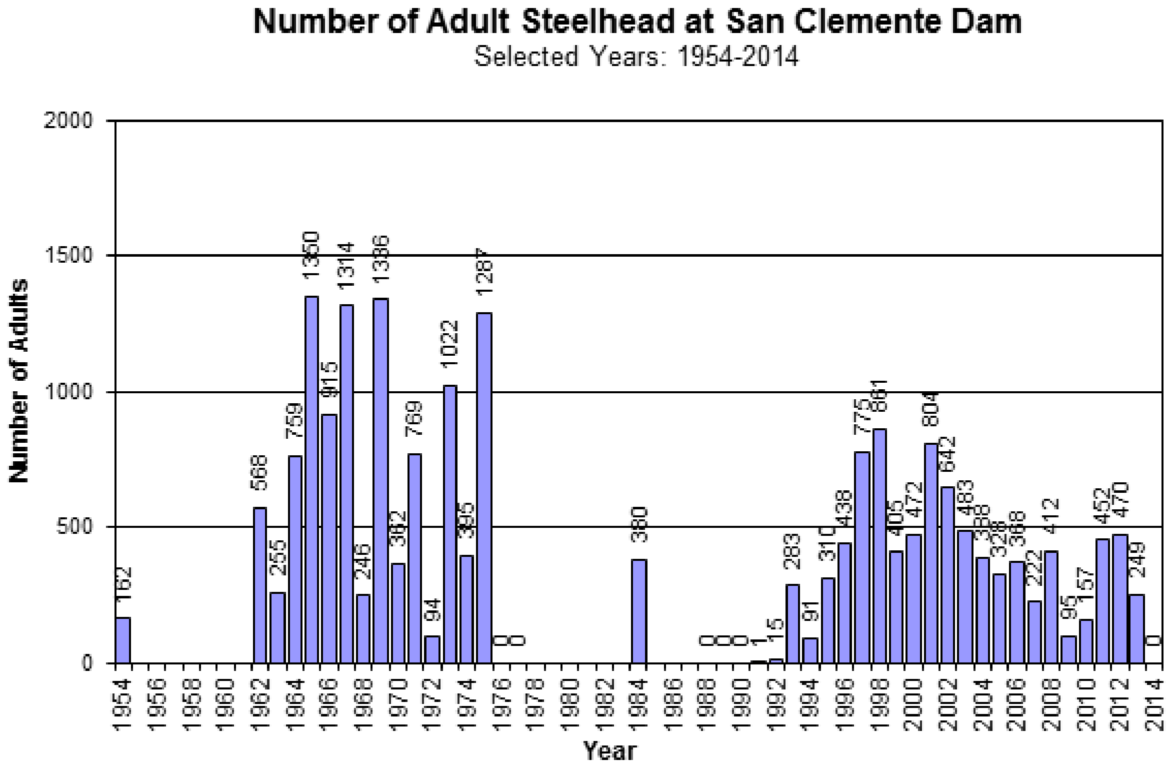
Most of the tributaries and mainstem areas containing spawning habitat have been surveyed, with Chupines and Hitchcock Creeks being notable exceptions. Within surveyed areas, approximately 66.9 miles of stream are accessible to adults in normal and above water years. When no temporary barriers limit upstream migration, adult steelhead spawn in a total of 60.5 miles of stream, including 24.5 miles of the mainstem, 30 miles of primary tributaries, and six miles of secondary tributaries. In the remaining 6.4 miles of accessible stream, spawning is limited by water availability in late spring. In dry and some below normal water years, adults probably do not ascend to the uppermost permanent barriers on the primary and secondary tributaries, but utilize the entire 24.5 miles of the mainstem up to Los Padres Dam. Those unable to migrate past barriers are forced to spawn below smaller falls and chutes or in the mainstem.

It is estimated that the spawning habitat in the mainstem can support approximately 2,400 nests, equivalent to a run of 4,800 adults or about 193 spawners per mile of stream. However, 50% of this habitat is located upstream of Los Padres Dam, where disproportionately low returns of adults to Los Padres Dam indicate that spawning habitat upstream of Los Padres Dam has not been fully utilized for many years and that the amount of spawning habitat upstream of the reservoir is most likely not the primary limiting factor. This condition was first noted by CDFW in the 1950's shortly after completion of the Los Padres Dam. Spawning areas influenced by the armoring effect of the mainstem dams are estimated to have 25% of the habitat per mile found in similar areas upstream of Los Padres Reservoir. Armoring refers to the coarsening of the channel bottom over time as gravel and cobble is stripped out by high flows with no new gravel and cobble able to pass the dams to replace lost materials. This effect is dramatic in the reaches from Los Padres Dam to the confluence with Cachagua Creek and from San Clemente Dam to the confluence with Tularcitos Creek. In these reaches, much of the channel bottom is covered with boulders and sand, with little spawning sized material visible. Armoring lessens in the downstream direction due to inputs of gravel and cobbles from tributaries and mainstem bed and bank erosion.

In most years, 49 to 53 miles of rearing habitat are available in the watershed with approximately one-half in the mainstem and the remainder in primary and secondary tributaries. The length of viable habitat is somewhat dependent on flow levels downstream of San Clemente Dam and on the amount of diversion of subsurface flow (i.e., the volume of water pumped from wells). It is estimated that this rearing habitat can support up to 245,000 young-of-the-year steelhead. Similar to spawning habitat, an estimated 42% of juvenile rearing habitat is located above Los Padres Reservoir, where fish densities appear to be much lower than in other areas of the river (Monterey Peninsula Water Management District 2004).

2.14.1.3 Distribution and status

The Carmel River watershed is the only watershed within the SCCCS Recovery Planning Area which has a relatively long-term (20+ years) time-series for adult steelhead runs; this monitoring is conducted principally at the San Clemente and Los Padres Dams. 4)The mean annual run size past San Clemente Dam for the continuous period of record with full fish counts made by an automated counter from 1994-2015 was 383 steelhead, and on average 27.8% of them would continue on upstream to pass over Los Padres Dam. The estimated average run over SCD prior to 1985, based mostly on statistically invalid partial daily counts as estimates, was approximately 623 fish. (K. Urquhart, pers. comm.) These observed adults, however, do not represent all the steelhead that may have entered the Carmel River system but did not reach the fish ladder or trap and truck facilities, and were therefore not observed; some un-detected adults may have spawned in the mainstem and tributaries below these dams or emigrated back to the ocean without spawning (MPWMD 1991-2014).



Note: Counts are based on Snider (1983), Dettman (1986), CDFG and MPWMD files. The 1962-73 and 1991-93 counts at San Clemente Dam are the sum of daily numbers of fish observed by shutting off the flow in the fish ladder. The 1974,1975,1984, and 1994j to present are complete counts registered on an automatic counter. The 2007 counts are incomplete, low flows caused the district to pull counter on April 2.

Figure 2-41. Steelhead Counts at San Clemente Dam: 1954 - 2014 (MPWMD)

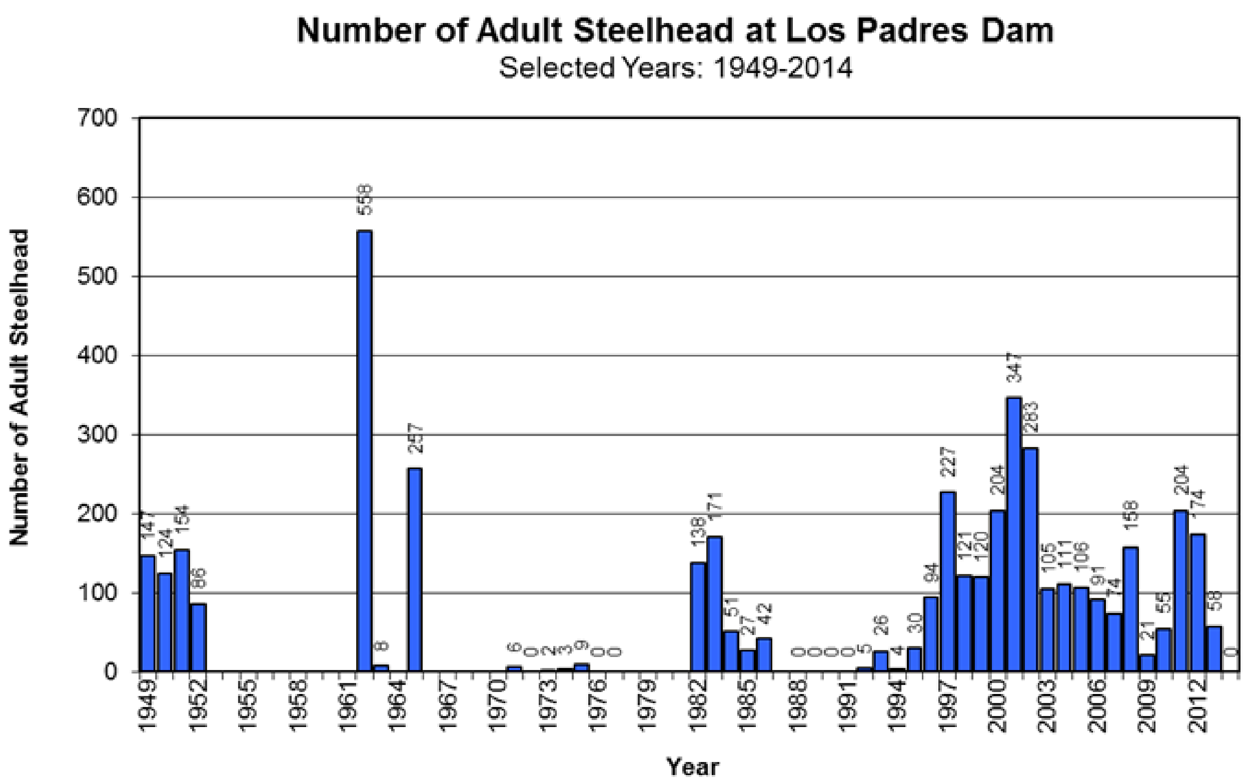


Figure 2-42. Steelhead Counts at Los Padres Dam: 1949 - 2014 (MPWMD).

Data collected from the Carmel River since the 2005 indicates the abundance of anadromous *O. mykiss* spawners in the Carmel River has increased since the 1987-1992 drought, but that the average run-size has decreased since the early 1960s. Continuous data have been collected at San Clemente Dam for the period from 1994 through 2012 and the specific years of 1974, 1975 and 1984 (however these counts are not complete run size estimates because fish spawning below San Clemente Dam are not included). Counts from the start of the 1988-2002 period included three consecutive years when no adult steelhead were detected (1988, 1989, and 1990). A pen rearing program was established for juvenile *O. mykiss* using facilities at the Monterey Bay Salmon and Trout Project and the Granite Canyon Marine Lab; fry from the artificially spawned adults were released above San Clemente Dam in the early 1990's. Steelhead counts increased from a single adult reported in 1991, to 775 adults reported in 1997 (see additional discussion in Chapter 10, Section 10.3). The Biological Review Team (BRT) for the NMFS steelhead status review noted that the rapid increase in the number of returning adult anadromous *O. mykiss* spawners to the Carmel River could be attributed to a combination of factors, including improved freshwater conditions, improved resilience of populations, high dispersal rates, or ability of native resident *O. mykiss* to produce smolts. CRSA ran a captive broodstock and juvenile steelhead rearing project from approximately 1990 – 1994, which reintroduced supplemental juvenile fish into the river, and may have enhanced the recovery of the steelhead run after the 1987-1991 drought for a few years through at most 1998. The final isolated years of supplemental releases in 2000, did not appear to conclusively boost the run two to five years later (K. Urquhart, pers. comm.). The BRT also noted that while some component of the increase is probably due to improved ocean conditions during this period, it should not be assumed that comparable increases have occurred in other watersheds for the SCCCS DPS (National Marine Fisheries Service 2013).

Recent trends, based on the reported annual count (May 2009) of adult steelhead showed a significant decrease to new lows of 95 fish at San Clemente Dam (since removed), and 21 fish at Los Padres Dam. These counts compare to average counts of 383 and 118 fish at San Clemente Dam and Los Padres Dam, respectively, in 1994 (Urquhart, pers. comm.). More recent (2012-2013) counts for the Carmel River indicate 452 adults at the San Clemente Dam, and 204 adults at the Los Padres Dam, and reflect a rebound from the effects of the most recent drought years 2007-2009 (MPWMD 2012) to modern average run sizes. The numbers once again dropped through the next three years of drought cycle to a new low of 7 at SCD and 0 at LD in 2015.

The steelhead populations in this region have declined dramatically from estimated annual runs totaling 27,000 adults near the turn of the century to approximately 4,740 adults in 1965 to several thousand total adults, with a large degree of inter-annual variability (Busby et al. 1996, Good et al. 2005, Williams et al. 2011). However, this run-size estimate is based only on qualitative information from four of the five major watersheds with steelhead (Pajaro, Salinas, Carmel, Little Sur, and Big Sur Rivers) located in the northern portion of the SCCCS Recovery Planning Area (National Marine Fisheries Service 2013). The only quantitative numbers are from counts at the Carmel River's two dams.

2.14.1.4 Large woody debris and Its Role In Steelhead Ecology

Large woody debris (LWD) can influence physical and biological functions of aquatic habitat throughout an entire watershed. Large wood manipulates surface flow and sediment transport. It also provides cover, substrate and food used by fish and aquatic invertebrates. LWD is recruited within a river channel by mortality from the adjacent riparian forest, windstorms, flooding, fire, bank erosion, and landslides (Keller and Swanson 1979; Benda et al. 2003.) Output processes of LWD are leaching, fragmentation, microbial decay, invertebrate consumption, and fluvial transport (Keller and Swanson 1979).
LWD affects river geomorphology by manipulating and redirecting surface flows. This influences pool frequency, rates of bank erosion, and routing of sediment and organic matter (Montgomery et al. 2003; Cherry and Beschta 1989; Bilby and Ward 1989). LWD creates pools by providing an obstruction within

the channel, which concentrates flow and causes scouring of the bed. The type of pool created is dependent on its orientation and position above the bed (Montgomery et al. 2003). LWD can provide an armoring effect by deflecting the flow away from channel bank, sequentially stabilizing the bank.

LWD has an important biological role by influencing flow, channel morphology, storage of organic material and providing cover and substrate. This influences the food supply of fish, the habitat available and the amount of energy they expend when swimming. Invertebrates use wood in all stages of their life cycle. They use wood for resting and reproductive activities, refuge, substrate and as a source of food. In addition, the accumulation of organic matter and sediment LWD entraps, creates habitats favored by certain types of aquatic invertebrates (Dudley and Anderson 1982). Productivity, abundance and biomass of macro-invertebrates tend to be greatest in areas of high organic matter availability (Wallace et al. 1995). Pools created by LWD provide low velocity habitats where fish can maintain their position and expend the least amount of energy, yet are in close proximity to swift currents to maximize access to invertebrate drift. Pools that are deep enough, can thermally stratify, providing coldwater refuge during increasing stream temperatures (Smith et al. 2013).

An inventory of large wood (LW) conducted by California State University at Monterey Bay's (CSUMB) Watershed Institute, which is defined as branches and pieces of trunks greater than six inches in diameter and five feet in length, was conducted in the channel bottom in 2002 and 2003 between the Carmel River Lagoon and Stonepine Resort at RM 16 The study, which documented 471 occurrences of LW (Figure 2-45) , showed a considerable range in the frequency of single pieces and accumulations found in each reach, but the trend showed that frequency decreases in the downstream direction (Smith *et al.* 2004). LW in the lower river tended to be larger and more stable than in upstream reaches, a condition that is to be expected as winter streamflows normally increase in the downstream direction and wash smaller pieces out to the ocean.

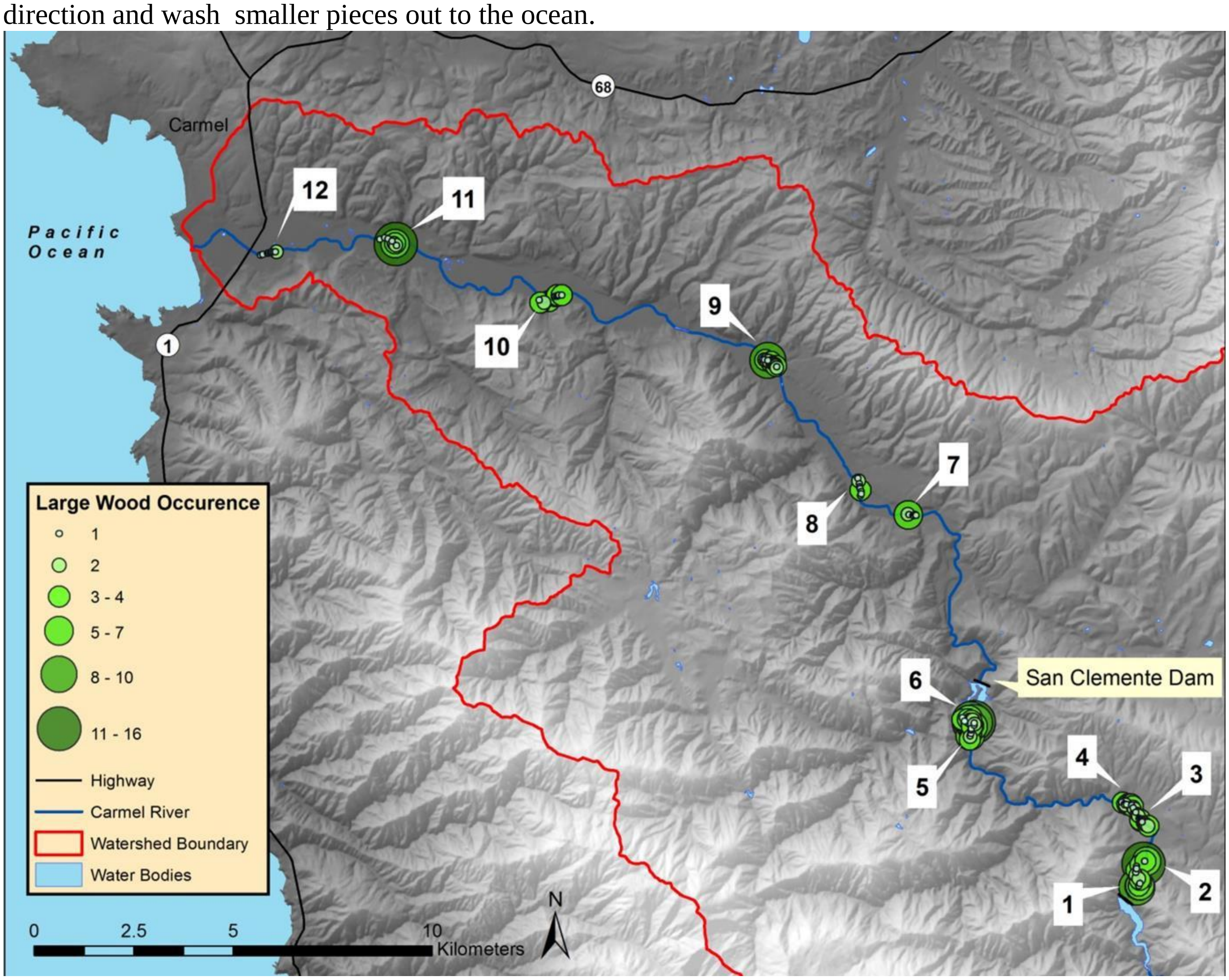


Figure 2-45. Large wood occurrence in CR watershed (CSUMB 2013).

Almost 30% of wood was fostering pool habitat in the bed. About 70% of LW had no significant impact to lateral channel stability. Less than 4% was found to encourage bank erosion. About 7% of LW had been deliberately placed to enhance aquatic habitat. In general, higher frequencies of LW were associated with higher densities of steelhead, although there were notable exceptions. In reaches where LW was relatively abundant, but steelhead numbers were low, it is likely that the availability of LW was not a limiting factor and that other factors such as substrate condition, food availability, and water quantity and quality were more significant.

2.14.1.5 Steelhead Fishery Mitigation Efforts

The following mitigation measures have been identified to reduce impacts to the Carmel River steelhead population, including: (a) expansion of the program to capture and transport smolts during spring, (b) prevent stranding of early fall and winter migrants, (c) rescue juveniles downstream of Robles del Rio during summer, and (d) implement an experimental smolt transport program at Los Padres Dam.
Monitoring of adult returns and juvenile populations provides an indication of the overall success of the steelhead mitigation measures.

The MPWMD, occasionally in some cases assisted by the Carmel River Steelhead Association, and other agencies and organizations have carried out several activities to improve habitat conditions, help restore the steelhead resource, or provide additional key data on the steelhead resource. These include: (a) rescue and transportation of steelhead kelts, (b) spawning habitat restoration and monitoring, (c) assessment of the benthic macro-invertebrate (BMI) communities, (d) Carmel River Lagoon water quality monitoring, and (e) assessment of steelhead migration barriers.

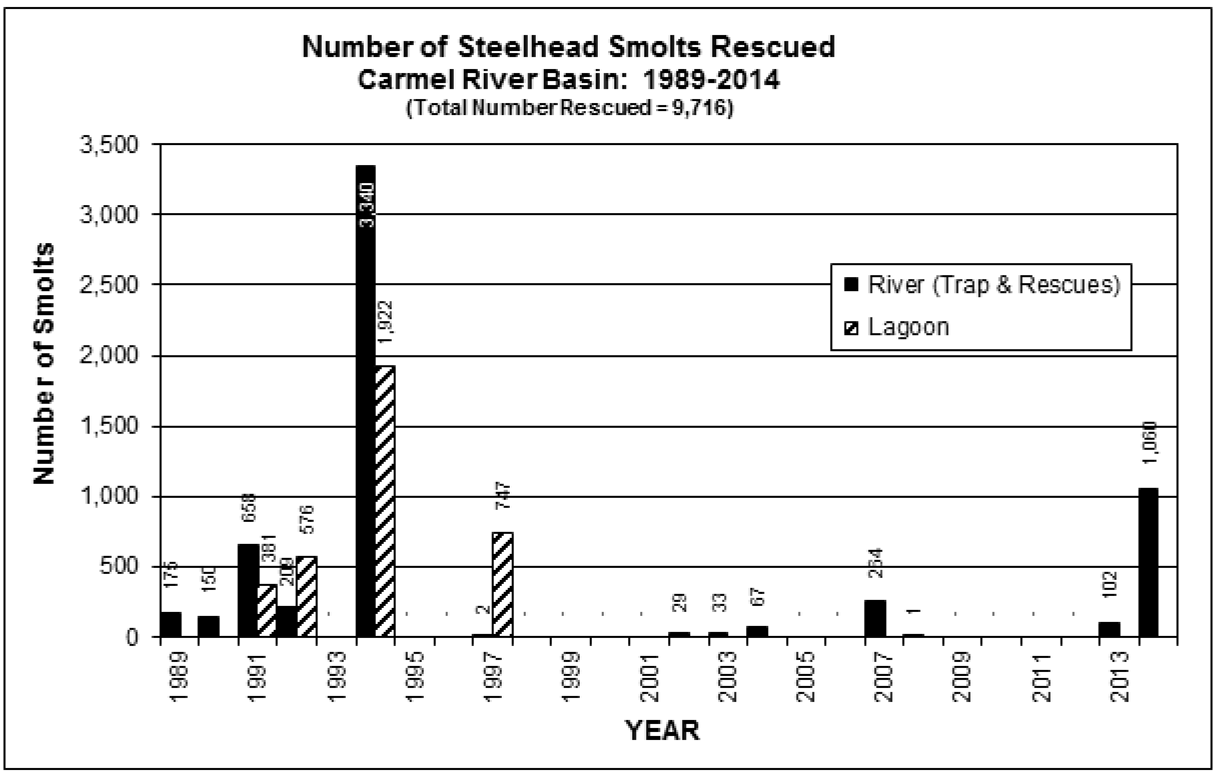


Figure 2-46: Number of Steelhead Smolts Rescued in Carmel River Watershed (MPWMD 2013**).**

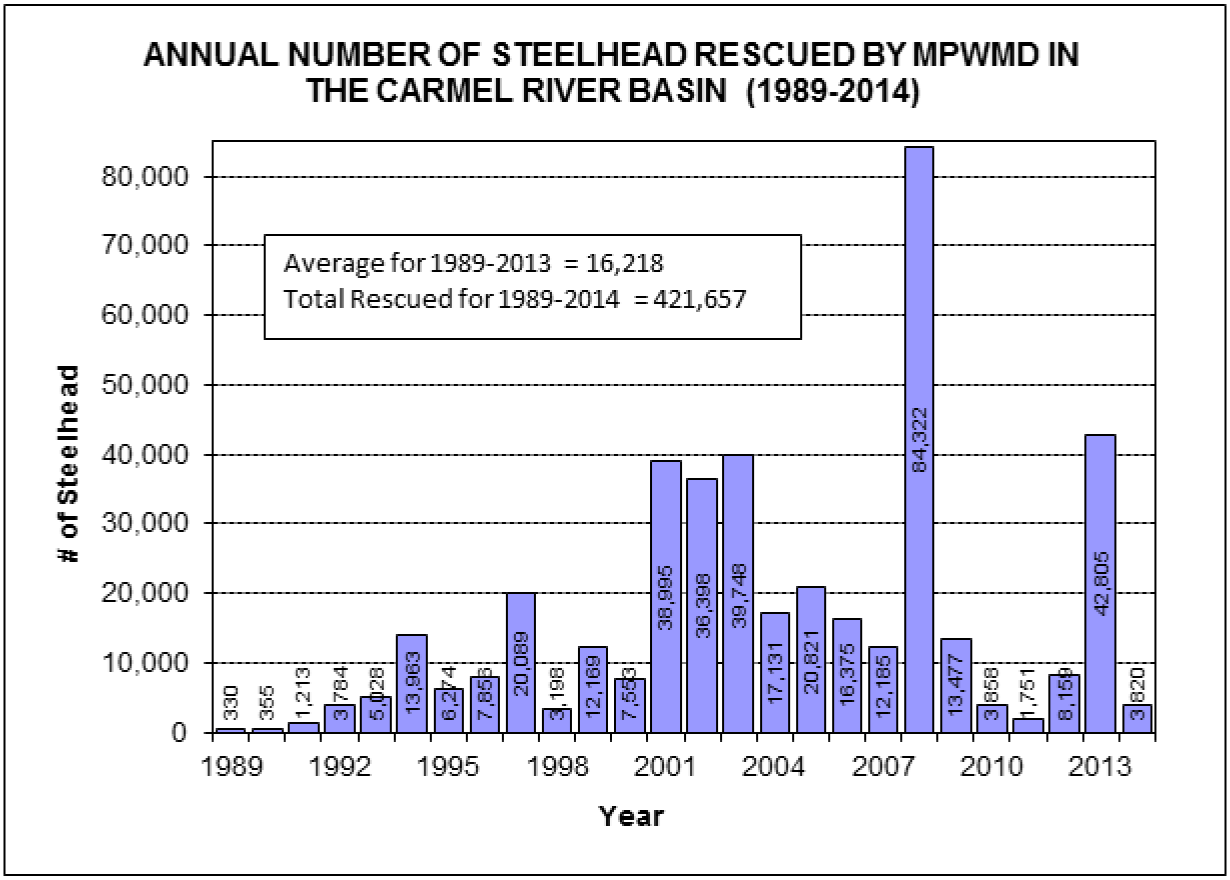


Figure 2-47: Annual Number of Steelhead Rescued by MPWMD in the Mainstem Carmel River (MPWMD 2013).

2.14.1.6 Limiting factors and uncertainties

Threats and threat sources:

The threat sources that determined the poor to very poor conditions in the National Marine Fisheries Service 2013 study repeatedly pointed to a limited number of anthropogenic causes, including: passage barriers caused by excessive surface and groundwater diversions; passage impediments caused by dams; loss or degradation of spawning substrates below both Los Padres and San Clemente Dams as a result of sediment trapped behind the dams and water management practices, including substantial groundwater use for golf course irrigation; agriculture, urban development. Residential and commercial development and stream bank modifications for flood protection have constricted the lower floodplain of the river. Artificial breaching of the sandbar (both the timing and location) to alleviate flooding of adjacent encroaching residential development has reduced and degraded steelhead rearing habitat within the Carmel River Estuary. Watershed developments have increased erosion and fine sedimentation, particularly in the lower mainstem of the Carmel River, but also within some tributaries, and have contributed to habitat degradation of spawning and rearing habitats (ESA PWA 2012; California Department of Fish and Wildlife 2011b; MPWMD and Carmel River Watershed Conservancy 2004; Monterey Bay National Marine Sanctuary Advisory Council 2003; Dettman 1984, 1989, 1993; Dettman and Kelley 1986, 1987; D. W. Alley & Associates 1992, 1997, 1998; D. W. Kelley & Associates 1984, 1987, 1996; Kondolf and Curry 1984; Hecht 1977; Stone 1971; Zinke 1971; U.S. Army Corps of Engineers 1967; National Marine Fisheries Service 2013).

A pervasive threat to anadromous *O. mykiss* throughout the Carmel River Watershed BPG are impediments to upstream and downstream fish passage (Figure 2-37 above), either in the form of dams and surface water diversions, or excessive groundwater extraction that creates dry stream reaches, and connectivity with the Carmel River Estuary. Several miles of the mainstem Carmel River below San Clemente Dam that would otherwise have perennial surface flows frequently dry up or are reduced to isolated pools by late spring and early summer, primarily due to surface and subsurface water withdrawals. Annual fish rescue and relocation efforts (including relocation to the estuary) are intended to deal with this situation on an interim basis (with rescued fish reared and subsequently released from the Sleepy Hallow Rearing Facility located downstream of the San Clemente Dam). Spawning habitat in the mainstem below the Los Padres and San Clemente Dams has been degraded since 1921 by the retention of spawning gravel and the consequent armoring of the stream bed with large cobbles and boulders downstream of the dams, athough there have been about six gravel replenishment projects by MPWMD between 1993 and 2014, totaling approximately 4,900 tons of spawning gravels placed between Los Padres Dam and the Sleepy Hollow Reach thus improving steelhead spawning habitat over approximately seven miles of river. (Beverly Chaney, pers. comm.).

As noted above, the Los Padres Dam and San Clemente Dams have also constrained the natural movement of steelhead, both upstream migrating adults and downstream emigrating juveniles, as well as deprived downstream reaches of the Carmel River of significant sediment (and large woody debris) necessary to sustain productive steelhead spawning and rearing habitat. The approved removal of San Clemente Dam will restore volitional access to 25 miles of spawning and rearing habitat, the majority of which is in tributaries between San Clemente Dam and Los Padres Dam (Capelli 2007; Entrix 2006; Raines, Melton & Carella, Inc 2001; MPWMD 2000; D. W. Alley & Associates 1998, 1992b; D. W. Kelley & Associates 1982, 1984, 1987, 1996; Dettman 1984, 1989, 1993). See Figure 2-37 for an overview of the dams and other fish passage impediments within the Carmel River Watershed BPG, but note the status of fish passage impediments is in flux, with old impediments being removed or modified, while new impediments may be installed, or discovered through updated inventories; a current list of fish passage impediments can be found on the California Department of Fish and Wildlife website: http://www.cafishpassageforum.org/ and as reported by Beverley Chaney in her report, *Assessment of Steelhead Passage Barriers in Portions of Four Tributaries to the Carmel River* (MPWMD 2014).

Surface and groundwater extractions artificially modify the pattern of sandbar formation and natural breaching at the estuary. The sandbar is also breached artificially for flood control and by people recreating on the beach, which causes premature draining of the estuary, and can also affect surrounding groundwater levels which help maintain summer water levels in the estuary; these artificial breachings can result in the loss of important juvenile steelhead rearing habitat, as well as the flushing of rearing juveniles to the ocean (California Department of Parks and Recreation 2008, Watson and Casagrande 2004, National Marine Fisheries Service 2002, Dettman 1984, U.S. Fish and Wildlife Service 1980).

The presence of exotic fish species, particularly striped bass (*Marone saxatilis*), has the potential to prey upon and compete with *O. mykiss* and require further monitoring and evaluation of their impacts on steelhead and steelhead habitat. A related potential issue is the expansion of some marine mammal populations (*e.g.*, California sea-lions *Zalophus californianus*) which may prey upon steelhead, particularly when steelhead are temporarily concentrated in enclosed areas or waiting to enter river mouths, making them more vulnerable to predation. Marine mammals are protected under the Marine Mammals Protection Act of 1972 (MMPA), and their management is subject to the provisions of the MMPA (National Marine Fisheries 2011; Steele and Anderson 2006; Middlemas et al. 2005; Hinton 2003; Yurk and Trites 2000; Fresh 1997; United State General Accounting Office 1993; Lowry and Folk 1987; DeMaster et al. 1985; Seagers et al. 1985). Efforts to control predation by pinnipeds on threatened or endangered salmon stocks are under way in Oregon and Washington.

The spread of other exotic, and invasive species, including plant species, continues to increase with the increasing human population and related changes in land uses within the Carmel River BPG; the early detection, rapid response to, and preferably prevention of, these introductions is a secondary component in any comprehensive steelhead recovery effort within the Carmel River Watershed BPG. With the exception of potential impacts from predatory brown trout above Los Padres Dam, nonnative crayfish in the mainstem river, and striped bass in the lagoon, most other nonnative or invasive species are not abundant enough to be having a dominant impact, but that could change in the future. Finally, because the lower Carmel River runs through a populated suburban area, with a long angling tradition, taking adult steelhead illegally through poaching is a threat that has been recognized by resource agencies and conservation organizations, particularly during low flow periods when adult fish may be most vulnerable to being trapped in shallow pools with limited opportunities for escape (National Marine Fisheries Service 2013).

Summary of limiting factors and uncertainties
Factors limiting the steelhead population include obstructions of fish passage, water diversions from the watershed, and degradation of spawning and rearing habitat. The most significant fish passage problems are at the mainstem dams and reservoirs, but passage in some tributary drainages is also significantly hindered by poorly designed and constructed culverts (MPWMD 2014). Water diversions from the watershed reduce flows for adult migration and juvenile rearing. Habitat degradation from within stream channels, loss of riparian vegetation, and reductions in water quality also limit the population (Water Management Group 2007).

Dams and diversions (including groundwater extractions) on the Carmel River have historically had the most severe adverse impacts on steelhead populations in this BPG by reducing access to upstream spawning and rearing habitats and altering the magnitude, and timing of flows necessary for immigration of adults and emigration of juveniles. While considerable planning has been conducted and efforts are underway for the removal of both the Old Carmel River and San Clemente Dams, similar investigations have not yet been initiated for the Los Padres Dam, and are essential for the future removal or modification of this facility. At Los Padres Dam, Cal-Am constructed a downstream smolt passage facility in 2015, and MPWMD and Cal-Am initiated an upstream adult passage evaluation in 2016 (Urquhart, pers comm. 2016) Urban and agricultural developments within the Carmel River watershed are also significant threats. For example, residential development around the estuary and along some reaches of the lower mainstem has encroached on and degraded estuarine and riparian habitats, and generated pressure to clear river channels and artificially breach the sandbar to reduce flooding of residential properties. Generally, road density, population density, and fire frequency are relatively low; however these factors can be expected to increase in the future (National Marine Fisheries Service 2013).

To protect steelhead in the Carmel River, direct diversions from surface storage in Carmel Valley are no longer used to meet municipal supply. Instead, stored water is released from Los Padres Reservoir during dry periods to meet instream flow requirements and partially offset environmental damage from summer groundwater extraction farther downstream. Thus, the Region is mostly dependent on a system of wells in Carmel Valley and in the Seaside Groundwater Watershed to meet municipal demand for potable water.
Approximately 970 AF per year of wastewater from the Carmel Area Wastewater District treatment plant is reclaimed and piped within the Region for turf irrigation, golf courses and other areas in Pebble Beach, partially reducing historic impacts to the river. Several of these effects limit the population of steelhead and other species in the watershed by dramatically reducing instream flows in the summer and fall, decreasing pool habitat and large woody debris for summer and winter rearing, restricting steelhead migration and limiting the potential for lagoon rearing (National Marine Fisheries Service 2013).

Amphibians and Reptiles

2.14.2 California red-legged frog, *Rana aurora draytonii* (CRLF)

The Carmel River Watershed and the Santa Lucia mountain range have been identified as a core critical habitat area where recovery and management actions are monitored and managed by federal and state agencies (USFWS 2002). The CRLF is listed as threatened under the Federal Endangered Species Act, and is a California Department of Fish & Wildlife "species of special concern" (Jennings and Hayes 1994; CDFG 2005a).

Numerous observations of CRLFs have been made, documenting a wide distribution of the species throughout the Carmel River Watershed (these are cited in the 2000 RDEIR by Denise Duffy & Associates, MPWMD, EIR Associates (Dr. David Mullen), Dr. Jeffery Froke, Zander and Associates, and ENTRIX). These surveys and rescues indicate that CRLFs are nearly ubiquitous wherever bordering cover and low gradient slope is contiguous with the waterway in the upper mainstem and tributaries (DWR 2012).

The watershed contains multiple types of CRLF habitats including ponds and river/creek environments with backwater and off-channel pools along the Carmel River and its tributaries (EcoSystems West Consulting Group 2001; Reis 2003). These ponds and pools can provide breeding habitat that is associated with still water. Upland habitat is important during periods of wet weather as refuge away from floods. CRLF also spend considerable time in upland riparian areas resting and feeding in moist foraging habitat (USFWS 2002). CRLFs have been observed in the slow-moving backwaters, adjacent-pools and tributaries to the Carmel River as these areas provide ideal breeding habitats (EcoSystems West Consulting Group 2001; Monterey Peninsula Water Management District 2004; Reis 2003). Riparian vegetation provides foraging ground and refuge while emergent vegetation has been shown to play a crucial role in egg mass attachment (Chubb 1999).

CRLFs spawn in marshes, springs, natural and artificial ponds, slack water pools of rivers and streams (Jennings and Hayes 1994; Hayes and Jennings 1988, Stebbins 2003), and tidally influenced freshwater marshes (Smith and Reis 1996). Typical spawning pool habitat includes moderately deep water (to 4 feet in depth), dense bordering and emergent vegetation (e.g., tules, (*Scirpus*), cattails (*Typha*), sedges and rushes (*Carex* and *Juncus*), and willows (*Salix*)), mud or silt substratum, nearly full to full sun exposure, and abundant forage for adults and tadpoles including benthic and suspended algae, benthic macroinvertebrates, and small terrestrial vertebrates such as tree frogs and mice (Jennings and Hayes 1994). CRLF tadpoles are typically found within dense aquatic vegetation, where they are cryptic and also readily find forage (Weins 1970). CRLF tadpoles generally consume benthic and suspended algae.

Adult CRLFs may remain nearly all year along the margins of suitable spawning habitat, but during the summer in many regions adult frogs may move from sunlit spawning pools to well-shaded streams with bank undercuts and exposed root masses, so-called “summer habitat” (USFWS 2002). Stream corridors are often considered to be potential “dispersal habitat” for this species (USFWS 2002), but these frogs may use virtually any vegetated non-saline habitat to move among spawning and summer sites (S. Barry, pers. obs.). These frogs typically enter hibernation sites beginning in late October and emerge by mid-January or somewhat later, depending on region (USFWS 2002).

The recovery plan for this subspecies (USFWS 2002) states that “Habitat loss and alteration are the primary factors that have affected the CRLF negatively throughout its range.” Exotic aquatic predators (bullfrogs, crayfish, and fish), habitat degradation from agricultural and grazing practices, and decreased water quality due to human manipulation of habitats and from water diversion all have been suggested as factors that may explain the decrease in populations. Although predation and competition by bullfrogs (*Rana catesbeiana)* is frequently postulated to explain declining CRLF populations, bullfrog control or eradication programs have not always proven effective. Bullfrogs and CRLFs co-occur in seemingly stable relative numbers at many ponds in coastal California (Barry 1999; USFWS 2002).

The recovery plan for the CRLF (USFWS 2002, p. 24) states that introduced bullfrogs, crayfish, and species of fish have been a significant factor in the decline of the CRLF. The plan acknowledges that “Changes in habitat that are unfavorable to CRLFs tend to be favorable to a suite of introduced non-native aquatic predators, making it difficult to identify detrimental effects of specific introduced species on CRLFs.”

The USFWS has indicated that proliferation of bullfrog populations along the central California coast (e.g. Monterey County) is a substantial threat to the persistence of the CRLF in this area. Insufficient data are available to conclusively determine the extent or mechanism of potential negative impacts of bullfrog populations on coastal CRLF populations in Monterey County or specifically in the Carmel River watershed. However, both species share habitat along the Carmel River and the evidence presented by Hayes and Jennings (1988) suggests that the coexistence is over 100 years old. It is not known whether populations of either species are relatively stable or variable within the watershed under baseline conditions, and monitoring would be needed to determine population trends if habitat conditions change.

The USFWS and CAL-AM have collaborated on the San Clemente Dam removal project and devised an enhancement program for CRLF. The program involves extensive bullfrog eradication in riparian stream and small pool settings. Enhancement sites have been monitored and improved, and bullfrog eradication has been implemented at these sites. Implementation of the program since 2003 appears to have benefited CRLF recruitment and overall numbers are benefiting markedly (Froke 2004, 2005, 2007). In and around management sites, CRLF numbers have benefited by releases and natural recruitment has taken place; simultaneously bullfrog numbers have been diminished. Furthermore, downstream of the reservoir, from the Dam to Highway 1, Cal-AM has, for at least seven years, intensively monitored and managed for CRLF reproduction; management that includes rescue and relocation of hundreds of tadpoles each summer (i.e., from stranding conditions), and capture and sacrifice of every bullfrog encountered. The monitoring program is designed to detect and ultimately predict environmental stress to natal populations caused by changes to water level and temperature.

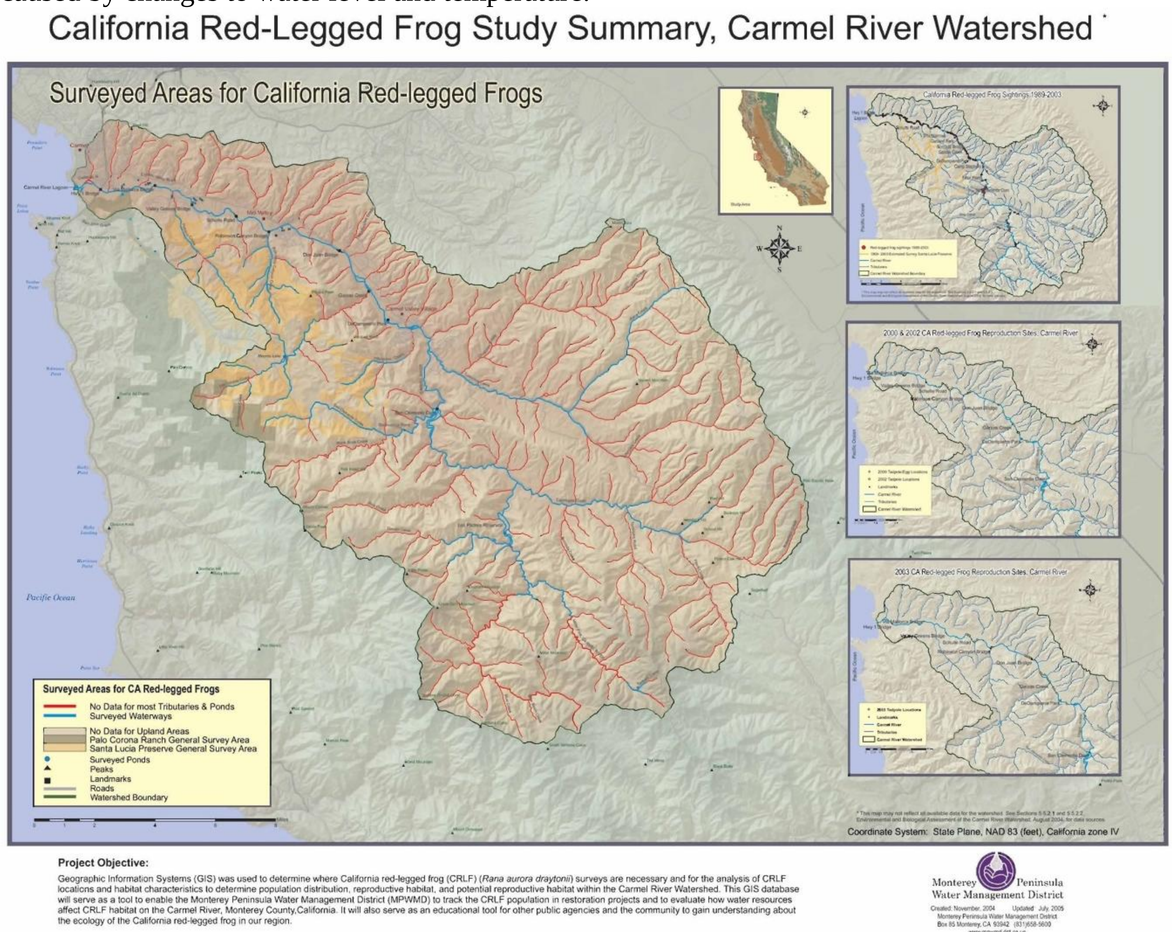


Figure 2-47. Documented habitats and sites of CRLF population in the Carmel River watershed (Wheeler 2004).

2.14.2.1 Limiting factors and uncertainties

Limiting factors for this species includes dams, water extraction, and the introduction of non-native species such as bullfrogs,crayfish, bass, and mosquito fish, habitat fragmentation and degradation due to urbanization and water extraction practices. Upstream of Los Padres Reservoir, the only known limiting factor for CRLF is the presence of bullfrogs. Limiting factors increase downstream of Los Padres Dam, with the highest number of limiting factors found between Carmel Valley Village and the Lagoon. The number of potential reproductive sites along the mainstem varies from year to year and depends on hydrologic conditions. Mainstem habitat surveys in 2002 and 2003 showed 67 and 54 potential reproductive sites, respectively, with the majority concentrated around San Clemente Reservoir and in the alluvial reach between the Lagoon and Carmel Valley Village. Actual reproduction occurred in 37% of the sites in 2002 and 52% of the sites in 2003 (Reis 2003; Monterey Peninsula Water Management District 2004).

Surveys and incidental sightings in the Carmel River Watershed indicate that CRLF is well distributed throughout the drainage, especially in the mainstem (Monterey Peninsula Water Management District 2004). But mapping of potential reproductive sites and actual sightings of egg masses and larvae in the mainstem during 2003 indicates that the population is not fully utilizing the potential or available reproductive habitat. Sampling in selected tributaries within the watershed during 1999-2003 surveys also indicates patchy utilization of suitable habitat, as known reproductive sites are not used consistently on a year-to-year basis. Although the distribution and abundance of CRLF may be limited, there is general agreement that the Carmel River Watershed is extremely important to the current distribution of CRLF.

Many factors contributed to the historical decline or loss of CRLF populations in their native range, including introduction of predators, loss of habitat and degradation from urbanization, agriculture, mining, overgrazing, recreation, invasion from non-native plants, impoundments, water diversion, and degraded water quality. Of special interest in relation to planning in the watershed are the impoundments and water diversions in the Carmel River Watershed.

The existing dam and water extractions affect CRLF in the following ways:

• The Los Padres dam fragments habitat in the watershed by blocking or hindering dispersal of individuals.

• In most years, summer releases from Los Padres Reservoir contribute enough water to the lower alluvial Carmel Valley to help prevent premature draw down of reproductive sites in a portion of the lower Carmel River.

• Water diversions via well pumping in the lower Carmel Valley can significantly impact CRLF by rapidly dewatering reaches of the Carmel River, as the combined well production during late spring through summer is often 2 to 4 times the stream flow.

Conclusion

Many factors in combination can lead to declines in CRLF populations. In general, CRLF are threatened by more than one factor in streams (U.S. Fish and Wildlife Service, 2002). The upper Carmel River Watershed (above Los Padres Reservoir) is not impacted by urbanization, agriculture, and water extraction. CRLF reproduction locations occur upstream of and around Los Padres Reservoir and in Cachagua Creek. However, urbanization, agriculture, channelization, bullfrogs, and water extraction are factors that can damage habitat in the lower Carmel River. Groundwater extraction and reservoir operations are currently being managed to reduce the threat to CRLF. Bullfrog control and urbanization are more tenuous problems.

CRLF would benefit from a management plan that addresses: pond management, water quality, non-native predators, habitat fragmentation, and water diversion. The Carmel River Watershed Council could help CRLF by educating private landowners on issues such as pesticide residues, fertilizer contamination, and non-native predator control. Although CRLF are found throughout the whole watershed, Table 2-21 summarizes some of the top limiting factors for defined reaches on the mainstem of the Carmel River (Reis 2003).

Table 2-21. Reach-by-reach assessment of limiting factors for CRLF on the Carmel River.		
Subreach	**Upstream Station**	**Downstream Station**
	Limiting Factors	
1	**Upstream limit of watershed**	**Confluence with Miller Fork**
	Native predators and bullfrogs	
2	**Confluence with Miller Fork**	**Danish Creek**
	Native predators and bullfrogs	
3	**Danish Creek**	**Los Padres Dam**
	Reservoir operations, bullfrogs, and dam dispersal barrier issues	
4	**Los Padres Dam**	**Cachagua Creek**
	Reservoir operations, bullfrogs, dam dispersal barrier issues, and urban run-off	
5	**Cachagua Creek**	**Upstream end of San Clemente Reservoir**
	Native predators and bullfrogs	
6	**San Clemente Reservoir**	**San Clemente Dam**
	Reservoir operations, bullfrogs, and dam dispersal barrier issues	
7	**San Clemente Dam**	**Sleepy Hollow**
	Native predators and bullfrogs	
8	**Sleepy Hollow**	**Tularcitos Creek**
	Native predators and bullfrogs	
9	**Tularcitos Creek**	**Hitchcock Canyon Creek**
	Native predators, bullfrogs, and stock pond management	
10	**Hitchcock Canyon Creek**	**Garzas Creek**
	Bullfrogs, Carmel Valley Road, and urbanization	
11	**Garzas Creek**	**Randazzo bridge**
	Bullfrogs, Carmel Valley Road, and urbanization	
12	**Randazzo bridge**	**Robinson Canyon Road bridge**
	Bullfrogs, Carmel Valley Road, and urbanization	
13	**Robinson Canyon Road bridge**	**Schulte Road bridge**
	Bullfrogs, Carmel Valley Road, urbanization, agriculture, groundwater pumping	
14	**Schulte Road bridge**	**Valley Greens Drive bridge**
	Bullfrogs, Carmel Valley Road, urbanization, agriculture, groundwater pumping	
15	**Valley Greens Drive bridge**	**Highway 1**

	Bullfrogs, Highway 1, Rio Road, urbanization, agriculture, groundwater pumping, channelization	
16	**Highway 1**	**Pacific Ocean**
	Bullfrogs, Highway 1, Rio Road, urbanization, agriculture, channelization	

2.14.3 Foothill yellow-legged frog, *Rana boylii*

The foothill yellow-legged frog is a California species of special concern. Low-gradient rocky creeks and streams with dappled shade bordered by mixed chaparral or deciduous and evergreen woodlands constitute the primary habitat for this frog (Zweifel 1955). This species has been documented as occurring in the Carmel River watershed (California Academy of Sciences 2005) and from San Clemente Creek (Museum of Vertebrate Zoology 2005).

2.14.4 California tiger salamander, *Ambystoma californiense*

The California tiger salamander *(Ambystoma californiense) (CTS)* is listed as threatened under the Federal ESA, and under the California Endangered Species Act is a California species of special concern. The California tiger salamander is a terrestrial species that spawns for a few days in water but spends the rest of the year aestivating (a state of dormancy or torpor especially during hot or dry periods) in subterranean habitat, using the burrows of California ground squirrel (*Spermophilus beecheyi*) and valley (Botta) pocket gopher (*Thomomys bottae*) (Storer 1925, Stebbins 2003). These salamanders emerge with the first fall rains and move at night to pools when they have impounded enough water to support spawning (Stebbins 1951, Barry and Shaffer 1994). Spawning habitat includes rain pools and ditches and other still water such as stock ponds, small lakes, and (rarely) vernal pools (Barry and Shaffer 1994). After a spawning period that may last as little as a day or two, the adult salamanders leave thespawning pool and return to aestivation habitat. They may re-emerge and revisit spawning pools if late-season rains occur (Stebbins 1951).

California tiger salamanders are well documented from the Carmel Valley, especially the vicinity immediately adjacent to the Hastings Reservation upstream of San Clemente reservoir where life history and demographic variation in the species have been studied since the early 1990's through the year 2000 (Barry and Shaffer 1994, Trenham et al. 2000).

2.14.5 Coast Range newt (*Taricha torosa torosa*)

The Coast Range (western or California) newt is a California Species of Concern where it occurs from Monterey County south (California Department of Fish and Wildlife 2014a). Adults are found in terrestrial habitats, but they breed in slow-moving streams, ponds, and reservoirs. Numerous records for the Coast Range newt exist from the Carmel Valley (Museum of Vertebrate Zoology 2005). Suitable habitat occurs along the Carmel River and tributaries of the upper watershed.

2.14.6 Western pond turtle, *Actinemys clemmys marmorata*

The western pond turtle is a California species of special concern. It occurs in small ponds, creeks, rivers, and streams. The western pond turtle is most commonly associated with permanent or nearly permanent water within a wide variety of habitat types. Areas of dense turtle populations are typically associated with logs or large rocks used for basking. Pond turtles also require terrestrial habitats for egg laying sites and winter hibernation (Holland 1994). The species has been recorded and mapped in the watershed.

2.14.7 Coast horned lizard, *Phrynosoma coronatum*

The coast horned lizard is currently recognized as a California species of special concern. The California horned lizard occurs primarily in open grassland or chaparral with large sunlit areas for basking. Numerous records for the coast horned lizard exist from the Carmel Valley and the Santa Lucia Mountains.

2.14.8 California legless lizard, *Anniella pulchra*

The California legless lizard is a California species of special concern. It occupies sand dune and streamside habitat throughout coastal Monterey County, but it is spottily distributed and occurs only where soil and forage conditions are suitable (Miller 1943). The presence of bush lupine often indicates that habitat conditions are suitable for legless lizards (Stebbins 2003). California legless lizards are abundant in Monterey County, but the absence of sandy dune or loamy streamside habitat along the Carmel River may preclude its occurrence in the valley.

2.14.9 Two-striped garter snake, *Thamnophis hammondii*

The two-striped garter snake is a California species of special concern. It occupies the margins of sunlit rocky streams and feeds primarily on small fish (Stebbins 2003). Jennings and Hayes (1994) indicate that the two-striped garter snake still occurred along much of the Carmel River in 1994, which is near the northern limit of the species' range. Two-striped garter snakes were observed in the Carmel River arm of San Clemente Reservoir during the 2003 and 2005 drawdowns, and much of San Clemente Creek and the Carmel River above San Clemente Reservoir appears to offer suitable habitat and forage for this species.

Mammals

2.14.10 Monterey dusky-footed wood rat, *Neotoma fuscipes luciana*

This subspecies of the dusky-footed wood rat is a California species of special concern. It is common to abundant in deciduous and evergreen woodland habitats that provide dense overstory and understory cover. It can also be commonly found in chaparral, coastal scrub, and riparian habitats. Wood rats build houses of sticks, bark, leaves, and other forest debris at the base of, or within the canopy of a shrub, tree, or other structure. Suitable habitat is available for wood rats throughout the undeveloped areas of the watershed, including woodland, chaparral, and riparian habitats.

Birds

The Carmel River bird list contains 364 bird species, which amounts to about 75% of all bird species recorded for Monterey County and 56% for all of California (Roberson 2002, Western Field Ornithologists 2009). The majority of these species do not breed along the Carmel River, yet use its habitat at some point during their life cycle; these include birds that overwinter in the region or use the riparian forests and wetlands as stopover habitat during migration. Migratory stopover habitat is important because it allows birds to rest and refuel before continuing their journey north or south (Hutto 2000). Nearly 100 of these transient species represent vagrants, which are species found outside of their normal geographic range. The Carmel River mouth and lagoon areas are well known vagrant "traps" for migrating birds, and because vagrants are rarely observed, they are of particular interest to birders and provide exciting recreational opportunities (Roberson 2002). The Carmel River is therefore widely regarded by birders as an important place, but it is also an important place for bird conservation. This distinction was recently acknowledged by the Nation Audubon Society in its designation of the Carmel River as an Important Bird Area (Audubon California 2008). In addition to being important stopover habitat for migratory birds, the Carmel River also supports a diverse breeding bird community, which includes at least 85 species (Appendix 5) (DiGaudio and Gardali 2013).

Habitat loss and degradation have been identified as the most important factor in the decline of riparian birds across the west (RHJV 2004). Low reproductive success may be the primary factor limiting populations of many species (RHJV 2004), and reproduction (nesting) is the lifecycle stage that can be most managed in North America. Causes for low reproductive success include:

- Lack of suitable nesting habitat. Many bird species nest near the ground in the understory, and areas where the understory has been cleared or invaded by non-native plants reduces the amount of available nesting sites.
- Predation of nests and adult birds by native and non-native predators. Agricultural and urban land uses tend to enhance favorable conditions for native and non-native predators (Riparian Habitat Joint Venture 2004). Introduced rats (*Rattus* sp.), whose populations are often subsidized

by humans, can be significant nest predators in riparian areas (Hammond 2008). Certain native nest predators such as raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), Western Scrub-Jays (*Aphelocoma californica*), and Steller's Jays (*Cyanocitta stelleri*) are also more common near urban and suburban development, and can thus have a higher impact on bird populations than they would in remote wilderness areas (Soulé 1988). Likewise, non-native domestic cats, including outdoor pets and feral cats, can have a devastating impact on bird populations (Coleman and Temple 1996; Mitchell and Beck 1992; Loss et al. 2013).

- Brood parasitism by Brown-headed Cowbirds (*Molothrus ater*). Cowbirds contribute to lowered productivity in host species through direct destruction of host eggs and young and competition between cowbird and host chicks, resulting lowering overall fecundity within a season.
- Competition from introduced birds. Introduced cavity-nesting European Starlings (*Sturnus vulgaris*) and European House Sparrows (*Passer domesticus*) compete for limited nest cavity sites (Gowaty 1984, Kerpez and Smith 1990, Newton 1994), and thus may negatively impact local populations of native cavity-nesting species such as the Western Bluebird (*Sialia mexicana*), Ash-throated Flycatcher (*Myiarchus cinerascens*), and Purple Martin (*Progne subis*).
- Climate change. Habitat and bird populations will be impacted by climate change, though it is difficult to predict the outcome with any certainty. Within the next 50 years, the Carmel River will become increasingly important for birds under a changing climate. Riparian areas in general will be increasingly important for all wildlife given a changing climate because they serve as habitat refugia and vital dispersal corridors (Seavy et al. 2009). Indeed, an analysis done to rank the relative importance of areas in California to birds indicates that the Carmel River watershed is currently important but will become increasingly important. Nonetheless, it is widely acknowledged that wildlife species, including birds, are expected to undergo range-shifts (Stralberg et al. 2009) and certain bird species will be more vulnerable to climate change than others (Gardali et al. 2012).

2.14.11 Bald eagle (Haliaeetus leucocephalus)

The bald eagle is a fully protected species under California law. The bald eagle was added to the Federal list of endangered species in 1967, and to the California list of endangered species in 1971. The Fish and Wildlife Service removed the bald eagle from the federal list of threatened and endangered species in August 8, 2007, but the bald eagle continues to be protected under federal law by the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. The eagle remains listed as endangered in California under CESA and remains fully protected.

Bald eagles require relatively large bodies of water containing standing populations of suitable-sized fish and waterfowl. Nests, typically in large conifers in relatively secluded locations, are usually located within one mile of key foraging areas. Bald eagles are resident in California.

2.14.12 Golden eagle (Aquila chrysaetos)

The golden eagle is listed as a fully protected species in California and is protected under federal law by the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. The golden eagle is a California species of special concern. Most golden eagles in California are resident (e.g. they stay in the state yearlong), but some migrate into California for winter. Golden eagles inhabit a variety of habitats including forests, canyons, shrub lands, grasslands, and oak woodlands. The golden eagle breeds from late January through August and produces 1-3 eggs. Nests are constructed on platforms on steep cliffs or in large trees. The main prey species for the golden eagle are rabbits, hares and rodents; but eagles will also takes other mammals, birds, and reptiles. Carrion (e.g. carcasses found on the landscape) is also a part of the eagle diet, especially during winter months. These large birds nest on high (>30 ft.), vertical cliffs and in trees. They hunt mostly mammals over open habitats such as savanna or desert scrub, usually in mountainous or canyon country. Abundant foraging habitat occurs throughout the Carmel valley.

2.14.13 Cooper's hawk (Accipiter cooperi)

The Cooper's hawk is a California species of special concern. Cooper's hawk nesting habitats include riparian deciduous, live oak, or second-growth conifers, usually near stream courses in dense stands with relatively high crown closure and open understory. Although the Cooper's hawk once commonly nested throughout California, loss of riparian woodlands by logging and stream modification has resulted in a steep decline of nesting birds (Small 1994). Egg laying typically occurs in late April or early May, and young fledge in July. Suitable breeding and foraging habitat occurs throughout Carmel Valley in oak and riparian woodlands.

2.14.14Osprey (Pandion haliaetus)
The osprey is a California species of special concern. Osprey require relatively large bodies of water containing standing populations of suitable-sized fish. For nesting, they utilize snags or snag-top conifers, and tolerate a greater human presence near their nests than do bald eagles. Los Padres Reservoir and its environs are considered suitable foraging habitat and potential nesting habitat.

2.14.15Yellow warbler (Dendroica petechia brewsten)
The yellow warbler is a California species of special concern. A common to uncommon summer resident, yellow warblers breed in a variety of habitats, but primarily occur in riparian deciduous woodlands and shrub habitats. They have experienced sharp declines in lowland portions of the state, largely due to loss of riparian habitat and from nest parasitism by brown-headed cowbirds.

2.14.16Double-crested cormorant (*Phalacrocorax auritus*)
The double-crested cormorant is a California species of special concern. This species is found along the coast and at larger freshwater lakes and reservoirs, rivers, and marshes; it nests on offshore islands, and inland on the margins of lakes, sloughs, and large rivers. Nests are located on cliffs and tall trees or snags. Their decline is attributed to habitat loss and human disturbance of nesting sites, especially by boats.

2.14.17Sharp-shinned hawk (*Accipiter striatus*)
The sharp-shinned hawk is a California species of special concern. Sharp-shinned hawks nest in a variety of habitats including deciduous riparian forest but are more commonly associated with dense stands of smaller conifers. They often hunt near openings, using adjacent woodland for cover.
Sharp-shinned hawks were formerly a common summer resident in adjacent Santa Cruz County, and there are historical nesting records along the river bottom of the Carmel River (Grinnell and Miller 1944). There is suitable nesting habitat for sharp-shinned hawks in the upper watershed.

2.14.18Yellow-breasted chat (*Icteria virens*)
The yellow-breasted chat is a California species of special concern. Yellow-breasted chats use riparian thickets and other brushy habitats near water when breeding. They have experienced sharp declines throughout much of California, largely due to loss of riparian habitat and nest parasitism by brown headed cowbirds. Breeding thickets for this species occur along the Carmel River.

2.14.19White-tailed kite (*Elanus leucurus*)
The white-tailed kite is a California fully protected species. White-tailed kite are yearlong residents in coastal and valley lowlands, and are common winter residents in the lagoon and estuary. White-tailed kite mostly prey on voles and other small, diurnal mammals, and occasionally on birds, insects, and amphibians. White-tailed kite uses dense stands of trees such as oaks and willow for nesting and cover.

Bats
2.14.20Townsend's big-eared bat (Plecotus townsendii townsendii)
The Townsend's bigeared bat is a California species of special concern. It is widely distributed throughout California; its habitats include coastal forests and woodlands. Big-eared bats primarily use caves, but are also known to use mines, tunnels, barns, attics, and abandoned buildings that mimic cave environments. This species is most common in moist habitats.

2.14.21California mastiff bat (Eumops perotis californicus)
California mastiff bat The California mastiff bat is a California species of special concern. This large bat is uncommon in much of California. The mastiff bat occurs in semiarid to arid habitats including

deciduous and evergreen forest, coastal scrub, chaparral, grasslands, and urban areas. This species may roost with other bat species, and according to CNDDB records for elsewhere in California it commonly roosts in anthropogenic structures such as houses and out buildings.

2.14.22 Pallid bat (Antrozous pallidus)

The pallid bat is a California species of special concern. Pallid bats are very widely distributed across the lower elevations of California. The pallid bat occurs in habitats ranging from mixed conifer forest to arid desert regions. Rock outcrops and large hollow trees, for roosting appear to be an important part of the habitat structure.

Insects

2.14.23 Smith's blue butterfly (*Euphilotes enoptes smithi*)

Smith's blue butterfly is federally listed as endangered. This species typically occurs in coastal locations but can also occur on inland sites. Two species of buckwheat, dune buckwheat (*Eriogonum parvifolium*) and seaside buckwheat (*E. latifolium*), are the preferred host plants for this butterfly. Smith's blue butterflies have been observed and found to be active at locations in western Carmel Valley.

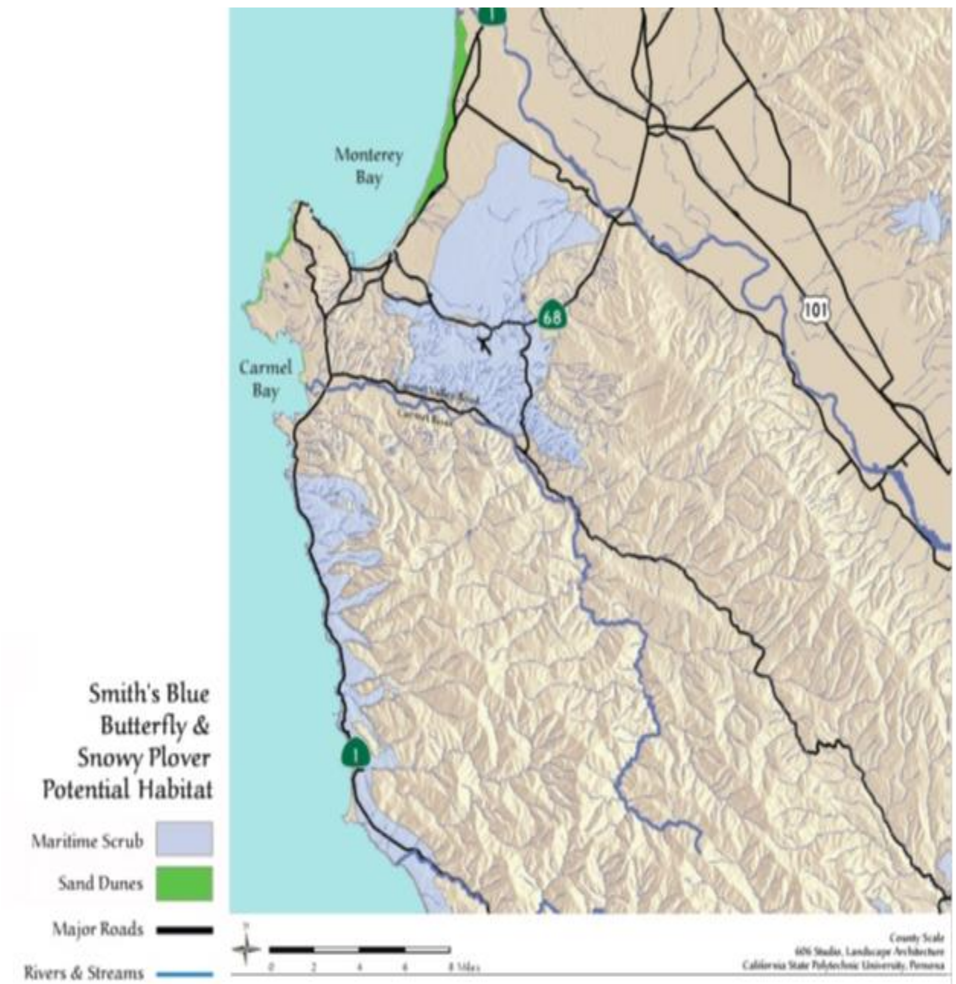


Figure 2-48. Smiths blue butterfly & western snowy plover potential habitat (Big Sur Land Trust).

2.15 Non-native species

2.15.1 Non-native plant species

Carmel Valley's climate provides suitable habitat and conditions for many non-native plant species to thrive. Non-native plants alter ecosystem functions such as nutrient cycles, hydrological cycles, and wildfire frequency, and outcompete native plants and animals. Effective control requires awareness and active participation of the public, as well as natural resource managers. In recognition of the enormous problems that these invasive weeds can cause, and the coordinated effort that is required to effectively control them, the Monterey County Weed Management Area (WMA) was formed with the objective of identifying and mapping the county's worst weeds; implementing projects designed to prevent, eradicate, or manage these invasive plants; and educating local residents about invasive non-native plant species.

New occurrences of non-native species are reported almost annually in Monterey County. Many of those species occur in the Carmel River watershed. Common non-native plant species found in the watershed are listed below.

1. Field mustard and wild radish (Brassica rapa & Raphanus sativus)
2. Italian thistle (Carduus pycnocephalus)
3. Yellow starthistle (Centaurea solstitialis)
4. Poison hemlock (Conium maculatum)
5. Pampas grass (Cortaderia selloana)
6. Cape ivy (Delairia odorata)
7. Blue gum eucalyptus (*Eucalyptus globulus)*
8. French broom (Genista monspessulana)

2.15.2 Non-native aquatic species

Non-native fishes found in the Carmel River (MPWMD 1994) are listed below.

1. Goldfish (*Carassius auratus*)
2. Carp (*Cyprinus carpio*)
3. Black bullhead (*Ictalurus melas*)
4. Brown trout (*Salmo trutta*)
5. Mosquitofish (*Gambusia affinis*)
6. Green sunfish (*Lepomis cyanellus*)
7. Bluegill (*L. macrochirus*)
8. Atlantic perch
9. Striped bass
10. Signal crayfish (*Pacifasticus leniusculus*)
11. Red swamp crayfish (*Procambarus clarkia*)

2.15.3 Non-native wildlife species

Few studies have directly measured predation of native wildlife species along the Carmel River and watershed. However, the introduction of non-native predators such as rats, cats and wild boar, are significant predators of native terrestrial and aquatic wildlife species in similar habitats. Common non-native terrestrial and bird species that occur in the Carmel River (MPWMD 1994) are listed below.

Terrestrial species:

1. Bullfrogs
2. Wild boar
3. Red fox
4. Cats

5. Rats

Bird species:

1. European starlings, *Sturnus vulgaris*
2. European house sparrows, *Passer domesticus*

3. SUMMARY OF CRITICAL ISSUES & RECOMMENDED ACTIONS

The Carmel River Task Force (CRTF) and other stakeholders identified eleven critical issues in the Carmel River Watershed. The CRTF did not establish priorities within each of the categories:

1. Water Quantity
2. Water Quality
3. Flood Management
4. Carmel River Estuary and Lagoon
5. Conservation of threatened species
6. Dam management and removal
7. Wildfire management
8. Erosion and sedimentation
9. Channel incision and geomorphology
10. Drought
11. Public safety and health
12. Public awareness and access

There are a total of 44 actions that are directly linked to the 12 critical issues. All Action items are summarized for each critical issue. Where necessary, we have cross referenced action items that cover more than one important concern. The Action Plan is based on scientific studies, mission statement objectives and input from stakeholders.

Description of the Critical Issues:

1. Water quantity

The Carmel River provides water to property owners in Carmel Valley and the Monterey Peninsula. The California American Water Company (Cal-Am) extracts water from the Carmel River Watershed and distributes it to its many residential, commercial, and municipal customers in the region. Cal-Am is responsible for approximately 85% of the total water diversions from the Carmel River system and its associated aquifer (Monterey Peninsula Water Management District 2004). The remaining diversions are due to a group of water users, including 14 non-Cal-Am entities that are responsible for an additional 12-13% of the total water withdrawn from the Carmel River (NOAA 2002). In Water Year 2012, Cal-Am produced 7,514 acre-feet of water out of the Carmel Valley Alluvial Aquifer. Of Cal-Am's total, 3,376 acre-feet are appropriated through legal pre-1914, riparian and appropriative water rights; the remainder is diverted without a basis of water right (SWRCB Order 95-10). In addition, over 650 wells on private property within the Carmel River Watershed and MPWMD boundary pumped 2,732 acre-feet of water.

The State Water Resources Control Board has ordered Cal-Am to find an alternative source of water to offset their unlawful diversion from the Carmel River by the year 2022 (SWRCB 2016). Seawater desalination is currently regarded as one of the water supply alternatives along with other options such as ASR, and groundwater replenishment using treated waste water from various sources. In addition, increasing reservoir capacity at Los Padres Dam and increased water conservation will also be considered. It is likely that a combination of two or more of the proposed alternatives will provide the most adequate solution to the water supply shortage.

ACTIONS

One of the means that could potentially mitigate this observed storage depletion trend is a program that the MPWMD has been actively pursuing since 1996 -- the Seaside Basin Aquifer Storage and Recovery Program (ASR). ASR entails diverting excess water flows (typically in Winter/Spring) from the Carmel Valley Alluvial Aquifer through existing Cal-Am facilities and injecting the water into the Seaside Groundwater Basin for later recovery in dry periods. The primary goal of the MPWMD Phase 1 and 2 ASR Projects is better management of existing water resources to help reduce current impacts to the

Carmel River, especially during the dry season. The projects are viewed as being complementary to other larger, long-term water augmentation projects that are currently being explored by various entities. These projects, now also known as Water Projects 1 and 2, entail a maximum diversion of 2,426 AFY, and 2,900 AFY respectively from the Carmel River for injection. The combined average yield for both projects is estimated at 2,000 AFY. The operation of the Phase 1 and 2 ASR Projects result in reduced unauthorized pumping of the Carmel River in Summer/Fall.

Urban Water Use Efficiency (Conservation)
Given the legal and physical constraints to water supply in the region and the demonstrated effectiveness of conservation, urban water use efficiency is considered an important ongoing strategy for the region, especially in the area of landscape and outdoor irrigation uses and is a proven strategy in reducing reliance on limited local water supplies. The Monterey Peninsula area has one of the lowest per capita water consumption levels of any urban area in California and is aggressively pursuing a water conservation program that includes education and conservation incentives.

Urban water use efficiency measures have been widely implemented throughout much of the region, including, for example, plumbing retrofits, surveys of large landscape areas, development of water efficient landscape guidelines, high-efficiency washing machine rebates, public information campaigns, school programs, residential ultra-low-flow flush toilet replacement programs, other appliance retrofit rebates, commercial, industrial, and institutional audits to identify water conservation opportunities, and internal water distribution system audits. Although many planning regions around the state should achieve substantial benefits from implementing urban water use efficiency and conservation programs in the future, the benefits of an aggressive conservation program for the Monterey Peninsula region will be incremental in comparison to other regions around the state, rather than substantial. It is expected that the region can achieve an annual reduction of at least 25 AFY for the foreseeable future. This strategy is considered an important means for helping the region meet its water supply objectives.

2. Water quality

Groundwater quality conditions in both the Carmel Valley Alluvial Aquifer have remained acceptable in terms of potential indicators of contamination from human activities. There have been no identifiable trends indicative of seawater intrusion into the principal supply sources the coastal area of the aquifer system to date (MPWMD 2013).

Surface water quality in the upper watershed above Los Padres Dam has not been impacted by human induced changes. However, it is highly susceptible to a naturally high level of bedload sediment yield which increases substantially immediately after wildfires (Smith, et al. 2004). Similarly, the Carmel River is not known for having high levels of contaminants, but fertilizers and pesticides have entered the waterway from golf course ponds, sediment catch watersheds, adjacent agricultural areas, and from urban development (USFWS 2002; Reis 2003, 2002). Water quality in the Carmel River Estuary is influenced by freshwater inflow from the Carmel River, tidal levels, and ocean waters over topping the sandbar from the Pacific Ocean (Monterey Peninsula Water Management District 2004). Water temperature, dissolved oxygen, and salinity in the Carmel River can seasonally be a limiting factor for steelhead trout. Water quality often declines during the late summer, fall and early winter months when Carmel River flows are reduced due to upstream groundwater pumping and storage, combined with wave over-wash in the early winter before natural freshwater flows are restored to the lagoon.

3. Flood Management

Flood protection along the Carmel River is a significant challenge and an important aspect of surface water related planning in the watershed. Non-governmental organizations and federal, state, and local agencies have participated in flood management activities and studies in the watershed for decades. These efforts have led to the development of comprehensive plans to identify flood sources, reduce flood risk, and improve emergency response strategies. Short and long-term flood management strategies have been implemented and continue to be studied. Currently, the Monterey County Water Resources Agency and the Resource Management Agency of Monterey County share responsibility for flood management in the watershed.

Since 1990, the MPWMD has conducted a program in the channel of the Carmel River to reduce bank erosion and remove deleterious material. Activities under this program include the removal or modification of vegetation by hand with chainsaws and loppers, modification of large wood, and the removal of undesirable materials such as tires, trash, car parts, construction debris, irrigation tubing, household goods, and other miscellaneous items. The following guidelines were developed by staff at MPWMD to maintain the quality and quantity of riparian vegetation, preserve habitat critical to sensitive species, and allow for the protection of important public and private infrastructure (CRWC 2004B 2004).

These final guidelines are intended to be part of the Regional General Permit (RGP) for maintenance and restoration activities within the Carmel River that MPWMD has applied for to the U.S. Army Corps (Corps) of Engineers. A draft set of these guidelines was circulated in January 2001 to address comments by several agencies, both public and private, on the Public Notice for the RGP. These guidelines are a refinement of the earlier set and address concerns expressed by the Carmel River Steelhead Association (CRSA), the California Department of Fish and Wildlife (CDFW), the U.S. Fish and Wildlife Service (USFWS), and the National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries) (Carmel River Watershed Conservancy 2005).

4. Carmel River Estuary and Lagoon Management

The management of the Carmel Lagoon (estuary) water level is a crucial, yet controversial process, and it has received special attention in the past two decades due to environmental concerns. Watershed and ocean processes, and the seasonal relationship between the quantity and quality of water, sediment and physical energy dynamics provided by the Carmel River control the estuary hydrology and morphology.

The estuary is generally physically closed off from the Pacific Ocean from approximately May through October, during which time water levels are sustained by the groundwater migrating down the river valley to the ocean. During winter high flows, an opening to the ocean is made through the barrier beach by the Monterey County Resource Management Agency to prevent flooding of homes and infrastructure in low-lying areas to the north. However, because the Carmel River and the Lagoon provide important habitat for endangered species, adverse environmental effects of the artificial breaching have been noted, and the National Marine Fisheries Service (NMFS) as well as local conservation groups have insisted that the county find an alternative solution to the yearly breaching activities.

The County and the Carmel River Watershed Conservancy proposed a solution that includes the construction of a protective barrier (the Ecosystem Protective Barrier, or EPB), the armoring of the adjacent bluffs and the State Beach parking area, and plans for the protection and preservation of Scenic Road. Local NGOs play a crucial role and actively contribute to the management of the Lower Carmel River through the planning and implementation of comprehensive programs in the lower watershed.

A number of estuary enhancement projects have been implemented in the State Park in recent years, funded by the California Department of Transportation, the State Coastal Conservancy, and other permitting agencies. Descriptions of the estuary morphology and function are provided in several reports developed to support the enhancement projects: (Philip Williams & Associates 1992, 1999).

5. Conservation of threatened species

Water extraction and land-use changes, flood management, dam management, and many other activities in the watershed impact steelhead and other threatened species. Efforts to restore critical habitat and to mitigate negative impacts of human activities have been taking place in the watershed now for many decades. Important components of the SCCCS and CRLF conservation programs include maintaining adequate amounts of water in the river, ensuring appropriate connectivity with the ocean and between the mainstem and the reaches that provide critical habitat. Because of their threatened status, management decisions in the Carmel River Watershed must take into account the direct and indirect effects that resource uses and activities may have on species of concern and their habitat. Several projects that have been proposed in the Carmel River watershed have among their goals to improve habitat conditions for the California red-legged frog, steelhead and other species.

6. Dam management and removal

Due to seismic instability concerns, the San Clemente dam is slated for removal in 2013. The river is expected to respond by increases in sediment supply and storage by regaining some of the dynamic channel characteristics that existed prior to the dam's construction. While this will help to restore some beneficial channel characteristics, increased sediment supply and storage can increase the risk of localized flooding, bank erosion, channel migration, and other geomorphic responses. These factors will need to be considered in the post-dam management of both the San Clemente site, as well as downstream infrastructure. The first phase of the San Clemente Dam removal project began in 2013, and it was completed in 2015.

Dam removal is not anticipated to affect vegetation downstream of the SCD, but may cause loss of vegetation upstream due to decreased water availability (Urquhart pers. comm.). If the Carmel River cuts headward through sediment left in the upper portion of the reservoir, the water table may drop slightly. This effect could lead to loss of sensitive riparian vegetation, such as white alder, that are rooted on the sand and gravel bars (Christensen pers. comm.). However, the riparian vegetation will likely reestablish fairly quickly at a slightly lower elevation as the channel form stabilizes (Christensen pers. comm.). A comparable dam removal on the Elwha River, WA, with a similar partially sediment-filled reservoir, has had upstream effects of bank head-cutting (Amy Draut pers. comm.). Downstream impacts of dam removal on the terrestrial ecosystem should be minimized as the 1,500,000 m3 of sediment behind the dam will be stabilized, revegetated, and covered with geotextiles to prevent catastrophic sediment release downstream due to flooding (Hecht 1977). Such releases would likely reduce food chain length and decrease the amount of energy available to CRLF and other riparian species (Marks et al. 2000). However, an overall increase in fine sediment loading is anticipated below the dam site after removal. This could increase substrates for emergent vegetation and habitats for terrestrial and aquatic species. The floodplain and bank width of the Carmel River could also become wider and increase lateral riparian habitat space. Bed aggradation could increase groundwater availability to streamside vegetation, reconnecting vegetation to elevated groundwater stores (ref). Increased delivery of LWD downstream will affect channel geomorphology, which will likely alter vegetative cover and composition.

Potential changes in geomorphology and vegetation have key implications for the habitat of the CRLF. Currently, CRLF populations are highly abundant along and upstream of the SCD reservoir, in areas with low gradient slope and bordering vegetative cover (URS Corporation 2012). This habitat extends at least to the edge of the deposited sediment bed. Since the reroute will occur 2,500 feet above the dam, there will be viable habitat loss once the reservoir dewatering occurs. While the reroute plans include step-pool reaches and off-channel pools, it is predicted that the natural channel migration and sediment deposition will make constructed off-channel pools temporary (Mussetter Engineering, Inc. 2002, 2003). CRLF rescues from drying pools can mitigate this problem in the short-term, but long-term habitat viability is largely unknown. However, the population may benefit from connectivity and adapt to the new habitat Terrestrial Ecosystem (Smith et al. 2012).

Los Padres Dam removal
The Los Padres Dam is an important part of a regional water supply system, and often sustains the majority of river flow in the low flow season. Its removal or modification will require additional studies, and must take into account its existing and future functions. Furthermore, as noted previously, restoring access to habitats above anthropogenic barriers will entail controlling or eliminating non-native species, such as brown trout, that have become established in artificial reservoirs above dams. In some cases, restoration of habitat conditions (*e.g.,* riparian cover, instream habitat complexity, including adequate spawning substrate) may also be necessary.

7. Wildfire management

Local, regional and state agencies are working with the communities in the watershed to develop strategic long-term plans that identify and make recommendations that reduce the threat of destructive wild-fires in the watershed. The Fire Safe Council for Monterey County and other local organizations are working with the U.S. Forest Service on the development of a proposed *Strategic Community Fuelbreak Improvement Project* that will advise County staff regarding wildfire-related matters, undertake oversight authority for fuel mitigation work, work with community groups and organizations to address wildland fire prevention planning and wildland fire hazard mitigation, apply for and manage federal and state funded grant projects related to County wildfire mitigation projects, and support County emergency services during wildfire firefighting efforts by providing technical guidance. After recent large fires, awareness and collaborative efforts for wildfire management have increased. An example of a collaborative approach is a program called *FireScape Monterey*. The goal of *FireScape Monterey* is to provide a collaborative framework to manage wildfires in the Los Padres National Forest and the Ventana Wilderness (FireScape Monterey 2016).

Fire suppression responsibility within urban and wildland areas in the watershed is shared by the City of Monterey Fire Department, the Monterey County Regional Fire District, and the State-wide California Department of Forestry and Fire (CAL FIRE); however, wildfire management activities and responsibilities are largely taken on by CAL FIRE in collaboration with other large state and federal agencies. Firefighting and emergency response, however, are only some of the components of wildfire management.

8. Erosion and sediment management

The *2004 Physical and Hydrological Assessment of the Carmel River Watershed* recognizes bedrock landslides, shallow soil slips, rock fall, stream incision and widening, and slope gullying as the main erosive processes in the Carmel Valley (Smith *et al*. 2004). For management purposes, erosive processes in the watershed are often grouped under two general categories: those that occur in the river and its banks (e.g. stream incision and widening), and those that occur in the rest of the watershed (e.g. bedrock landslides and rock fall). Erosion is a natural geomorphic process that is beneficial for ecological functions (Florsheim et al. 2008), but it can be influenced and accelerated by human disturbances, making it a threat to the processes functions of the river and its floodplain. Natural processes, such as fire and floods, and human modifications, such as the construction and use of dirt roads, deforestation, and the grading of slopes contribute to the erosion of sediment from the watershed (Smith et al. 2004).

The accumulation of sediment in the reservoirs of the Los Padres and San Clemente Dams has reduced their capacity by 60% and 95% respectively. The retention of sediment by the dams not only affects the reservoirs' functionality, but also alters the river's natural sediment regime. Adequate amounts and sizes of sediment support habitat functions and maintain channel stability (Smith et al. 2004; Florsheim et al. 2008). The retention of beneficial sediment in the reservoirs limits the quality and quantity of habitat for the steelhead and for benthic macroinvertebrates in the river (Monterey Peninsula Water Management

District 2004). The Carmel River Action Plan (Carmel River TAC 2007) recommended several actions for erosion and sedimentation control, such as assessing incised reaches, assessing roads, implementing restoration projects to stabilize stream banks, and promoting best management practices.

Watershed restoration typically includes measures that improve ecosystem function and reduce sediment input form upland and streamside sources. The methods of restoration commonly include reshaping gullied upland areas to reduce flow concentration, revegetating bare soil, repairing poorly maintained dirt roads and culverts, excluding grazing from sensitive areas, reshaping and vegetating the riparian corridor, and hardening especially chronic gullies with large rock. Stream channel restoration sites have a better chance of success if upstream disturbances are not present; therefore the typical strategy is to start watershed restoration with upland regions and roads, then headwater streams, then larger tributaries and finally the mainstem.

9. Channel incision in lower watershed/Coastal Geomorphology

The Carmel River State Beach, governed by the California Department of Parks and Recreation, is one mile long and extends between two granodiorite outcrops from Abalone (Carmel) Point to Granite Point. The beach receives the majority of its sediment from the Carmel River during winter storm events. The beach has historically experienced sediment loss through anthropogenic processes along the Carmel River. Between the 1920's and 1970's, sand and gravel mining depleted sediment from both the river and the beach. Construction of the San Clemente Dam in 1921 and the Los Padres dam in 1949, further interrupted sediment supply, which is evident through the mound of impounded sediment behind the dam. Floodplain development in Carmel Valley and bank stabilization projects has also reduced sediment supplied to the beach by the river.

During the summer and fall months, the "bar-built estuary" constricts flow of the river from the lagoon into Carmel Bay due to a natural sand berm built by wind, waves, and low rainfall. During winter storm events, the Monterey County Department of Public Works routinely breaches the sand berm to prevent flooding of private residences along the floodplain. An adaptive management plan for breaching the bar has included inlet channels engineered to shift the river flow to the north, the south, and perpendicular to the beach. An inlet channel position in the northern section of the beach threatens bluff erosion along Scenic Drive, while a southern inlet channel and perpendicular position drains the floodplain to water levels too low for certain lagoon species, such as steelhead, to survive**.**

10. Climate change and Drought

Water managers, flood control managers, and other decision-makers in Monterey County are in the early stages of analyzing and planning for the impacts of climate change on water resources in the region. Scientists, government agencies, environmental and community organizations, and other leaders throughout the broader Monterey Bay and Central Coast region are working together in the context of their respective regional Water Management Groups to obtain the most up-to-date scientific data and to refine the current analytical tools in order to develop climate change adaptation strategies.

11. Public safety

Most of the above natural resource challenges become the most tangible to residents in terms of how they affect their sense of safety whether at home or travelling through the region. Promotion of public safety from floods, road failures and other risks associated with the geology and hydrology of the Carmel River watershed must be a critical element of any resource management solution in recognition of its primacy in community and governmental prioritization. A critical challenge for natural resource managers is successfully balancing multiple resource concerns while meeting the community's basic human needs of safe refuge, transport, and sustenance. At the same time, it is the desire for maintaining a safe home and landscape that can be the initial motivation for citizen engagement in the resource issues that they see affecting them. Welcoming that engagement and reinforcing the importance of the balance and intersections between public safety and watershed protection are basic to building community support and will for the work needed to address the challenges we face in the Carmel River watershed.

12. Public awareness and access

Public awareness and access to public lands are key to broadening public engagement and support for the watershed's protection and management. Education is critical for conveying the information citizens and professionals need to understand local resource issues and effective means of addressing them, including the challenges inherent in addressing multiple resource concerns in a balanced manner. Developing and expanding volunteer opportunities for the community such as water quality monitoring (e.g. NOAA-supported First Flush and Snapshot Days) and family-friendly restoration projects can help foster stewardship values and support for larger watershed restoration and protection efforts. Providing access to 'nearby nature' for the community and visitors can deepen individuals' personal connections to the watershed's resources and enhance their support and interest in its management.

4. ACTION PLAN

To achieve the shared vision of a healthy watershed, the Carmel River Task Force developed an 'Action Plan' to address human activities and natural events that affect water quality and habitats in the Carmel River watershed. This 'Action Plan' also makes recommendations to improve natural resource management that recognizes and supports beneficial watershed activities.

There are many different actions needed for a healthy watershed. These actions include watershed coordination, community outreach and education about watershed stewardship, habitat restoration, political advocacy, and the promotion of outreach programs to support the voluntary efforts of private landowners, environmental organizations and regulatory agencies. By working together through partnerships, local communities and organizations can protect and improve the health of the Carmel River watershed.

The Carmel River Action Plan was prepared by the Resource Conservation District of Monterey County in collaboration with the Carmel River Task Force. Special thanks to the Monterey Peninsula Water Management District, Carmel River Watershed Conservancy, Carmel River Steelhead Association, Big Sur Land Trust, and Resource Management Agency of Monterey County.

No	Action Description	Action Type	1. Water Quantity	2. Water Quality	3. Flood Management	4. Estuary Lagoon	5. Special Status Species	6. Dam Management	7. Wildfire Management	8. Erosion & Sediment	9. Geo-morphology	10. Drought / Climate	11. Public Safety	12. Public Access & Awareness	Related Past & Current Projects and Programs (from February 2014 list)
1	Continue support of the Carmel River Watershed Task Force (CRTF). The CRTF meets quarterly and is open to all stakeholders in the watershed. The purpose of this group is to achieve the successful outcome of watershed projects identified in the Carmel River watershed plan, and other needs in the watershed.	Watershed Partnerships	X	X	X	X	X	X	X	X	X	X		X	Watershed Coordination (RCDMC), ongoing RTF meetings (RCDMC, tbd)
2	Acquire or accept, in fee title or easement, lands that provide multiple benefits to the watershed such as: improving natural habitat and functions, facilitating recovery of listed aquatic and terrestrial species including Steelhead trout and CRLF, reduce flood and erosion risk, and improve public access.	Watershed Management	X	X	X	X	X	X	X	X	X	X		X	
3	Cooperate with local agencies to plan and implement watershed-wide restoration projects of riparian and upland habitat to benefit California red-legged frogs (CRLF), steelhead, and other species of concern. Funding should address development of a monitoring plan for CRLF and other benchmark species.	Watershed Partnerships					X								Carmel Area State Parks General Plan Update (State Parks); CR Riparian Vegetation and Materials Management (MPWMD)
4	Maintain, restore and enhance natural stream functions & features to provide high quality habitat for steelhead, CRLF, and other species of concern.	Watershed Management					X				X	X			Steelhead Habitat Ehancement (CRSA)
5	Expand & maintain the existing network of volunteers in the Carmel River Basin to provide planning, labor, outreach, and mapping services throughout the watershed.	Watershed Partnerships												X	Carmel River Heritage Area Project (CRWC), Volunteer Monitoring Programs (CWC); Watershed Tours (CRWC)

No	Action Description	Action Type	1. Water Quantity	2. Water Quality	3. Flood Management	4. Estuary Lagoon	5. Special Status Species	6. Dam Management	7. Wildfire Management	8. Erosion & Sediment	9. Geo-morphology	10. Drought / Climate	11. Public Safety	12. Public Access & Awareness	Related Past & Current Projects and Programs (from February 2014 list)
6	Encourage the public to comply with the county's landscaping codes.	Education	X									X		X	Water Conservation Programs (Cal-Am and MPWMD), Watershed Manual (RCDMC)
7	Identify, retrofit, and label storm drains.	Education		X										X	
8	Support plans to expand public access to the Carmel River and watershed with willing landowners.	Access												X	South Bank Restoration Trail (BSLT)
9	Develop an adaptive management program for water quality and quantity in the lagoon.	Watershed Management	X	X		X	X								CR Lagoon Restoration (State Parks), CR Lagoon WQ Monitoring (CSUMB), CR Lagoon Beach Clean Up (MEarth); CR Lagoon Ecosystem Protective Barrier (EPB); CR Mitigation Bank (Caltrans)
10	Expand the Volunteer Water Quality Monitoring Program incorporating local schools, Snapshot & First Flush program participants, and other interested stakeholders to tie into existing programs and to include all the main tributaries.	Education		X										X	Pharmaceutical Drug Collection (CRWC); Volunteer Monitoring Program (CWC)
11	Establish a sediment transport monitoring program in concert with the surface flow monitoring program of MPWMD for the main stem and tributaries.	Watershed Management		X	X					X					

No	Action Description	Action Type	1. Water Quantity	2. Water Quality	3. Flood Management	4. Estuary Lagoon	5. Special Status Species	6. Dam Management	7. Wildfire Management	8. Erosion & Sediment	9. Geo-morphology	10. Drought / Climate	11. Public Safety	12. Public Access & Awareness	Related Past & Current Projects and Programs (from February 2014 list)
12	Reduce the risk of flood damage by supporting the evaluation and implementation of multi-objective flood control projects.	Watershed Management			X										Carmel River Abutment at Rancho Canada Village (Rancho Canada); CSA 50 Flood Prevention Strategies & Update to Flood Control Report (Monterey Co.); Interim Flood Management in Lower CR (Monterey Co.); CR Floodplain Restoration & Environmental Enhancement (BSLT & Monterey Co.)
13	Develop an outreach program to increase the public's awareness about how groundwater pumping in the alluvial aquifer and uplands directly impacts surface water flows in the Carmel River.	Education	X									X		X	Water Conservation Programs (Cal-Am and MPWMD); Watershed Manual (RCDMC); Watershed Tours (CRWC)
14	Support implementation of a water supply project that minimizes the export of water from the Carmel River basin during the dry season that causes the chronic reduction in flow and meets the goals of State Water Resources Control Board Order 95/10.	Watershed Management	X			X	X					X		X	Water Supply Project (Cal-Am); Aquifer Storage and Recovery Phases 1 & 2 (MPWMD)
15	Develop projects to maintain or increase water storage in the watershed.	Watershed Management	X					X				X		X	

No	Action Description	Action Type	1. Water Quantity	2. Water Quality	3. Flood Management	4. Estuary Lagoon	5. Special Status Species	6. Dam Management	7. Wildfire Management	8. Erosion & Sediment	9. Geo-morphology	10. Drought / Climate	11. Public Safety	12. Public Access & Awareness	Related Past & Current Projects and Programs (from February 2014 list)
16	Reduce the amount of water extracted from the Carmel River Basin during summer months by supporting improvements to MPWMD's Aquifer Storage and Recovery (ASR) project in the Seaside Ground Water Basin.	Project	X									X		X	Aquifer Storage and Recovery (ASR) project (MPWMD)
17	Expand water conservation programs to areas beyond the existing MPWMD boundary in the watershed. Programs may include rebates for low flow fixtures & the encouragement of drought tolerant landscaping.	Education	X									X		X	Water Conservation Programs (Cal-Am and MPWMD); Watershed Awareness Events (MCRCD); Watershed Manual (RCDMC)
18	Support studies on areas with wells located in upland areas (fractured rock) and the connection they may have to creeks and ultimately the Carmel River Alluvial Aquifer.	Watershed Management	X											X	Water Extraction Study in Upland Areas (MPWMD)
19	Restore and revegetate unstable banks and incised reaches of tributaries and mainstem areas based on Proper Functioning Condition (PFC) tributary assessments.	Watershed Management		X	X		X			X	X				Bank Stabilization Projects (MPWMD); Riparian Vegetation and Materials Management (MPWMD)
20	Implement BMPs for erosion prevention to reduce sediment deposition throughout the watershed including the main tributaries and the main stem of the Carmel River.	Watershed Management		X	X					X				X	Gravel Injection Project (MPWMD)?; Road Assessments (RCDMC); Watershed Manual (RCDMC)
21	In cooperation with Monterey County Public Works Department, conduct assessments of all roads in the watershed. Identify and prioritize treatments that will minimize erosion and restore natural stream function.	Watershed Management								X					Schulte Road Bridge Replacement (Monterey Co. PW)

No	Action Description	Action Type	1. Water Quantity	2. Water Quality	3. Flood Management	4. Estuary Lagoon	5. Special Status Species	6. Dam Management	7. Wildfire Management	8. Erosion & Sediment	9. Geo-morphology	10. Drought / Climate	11. Public Safety	12. Public Access & Awareness	Related Past & Current Projects and Programs (from February 2014 list)
22	Conduct outreach program to inform watershed residents about the impacts past and present activities have on streambank stability.	Education								X	X			X	Environmental Quality Incentives Program(NRCS); Watershed Awareness Events (RCDMC); Watershed Manual (RCDMC); Watershed Tours (CRWC)
23	Continue to develop, update and support MPWMD's ground water and surface water flow model.	Watershed Management	X												
24	Conduct periodic trash removal and outreach events throughout the watershed to remove urban debris and trash from the Carmel River and its tributaries.	Watershed Management		X										X	Pharmaceutical Drug Collection (CRWC); Watershed Awareness Events (RCDMC)
25	Continue and expand the MPWMD and CRSA Large Woody Debris (LWD) program, including further LWD recruitment location studies and installation of redwood & Douglas fir root balls in reaches of the river that would benefit most from the introduction of LWD.	Watershed Management					X								MPWMD Project - upper/mid watershed
26	Expand programs that create a watershed-wide coordinated riparian vegetation restoration program that includes post-project monitoring and maintenance.	Watershed Management					X			X					Post San Clemente Dam Removal Impact Monitoring (CSUMB)
27	Encourage public and private landowners to adopt and employ nutrient source reduction practices.	Education		X			X							X	Environmental Quality Incentives Program(NRCS); Watershed Awareness Events (RCDMC); Watershed Manual (RCDMC)

No	Action Description	Action Type	1. Water Quantity	2. Water Quality	3. Flood Management	4. Estuary Lagoon	5. Special Status Species	6. Dam Management	7. Wildfire Management	8. Erosion & Sediment	9. Geo-morphology	10. Drought / Climate	11. Public Safety	12. Public Access & Awareness	Related Past & Current Projects and Programs (from February 2014 list)
28	Plan and implement monitoring programs of key indicator species (Benthic macroinvertebrates and birds) in areas where riparian vegetation has been restored.	Watershed Management					X								Bird and Wildlife Surveys and Projects (BSLT), Bird Monitoring and Research (VWS); The CR Bird Conservation Plan (BSLT)
29	Continue and expand existing resource conservation and stewardship programs for the community and actively disseminate information to residents and landowners through peer to peer groups and multi-media outreach.	Education												X	MEarth Projects; Watershed Education Center at Garland Park (MPRPD); "Experience Carmel River" Interpretive Panels (BSLT); Environmental Quality Incentives Program(NRCS); Pharmaceutical Drug Collection (CRWC); Watershed Awareness Events (RCDMC); Watershed Manual (RCDMC); Watershed Tours (CRWC)
30	Expand volunteer activities, and maintain the existing network of volunteers in the Carmel River Basin to provide planning, labor, outreach, and mapping services throughout the watershed.	Watershed Partnerships												X	Steelhead Habitat Enhancement (CRSA), Volunteer Monitoring Program (CWC); Watershed Awareness Events (RCDMC); Watershed Tours (CRWC)

No	Action Description	Action Type	1. Water Quantity	2. Water Quality	3. Flood Management	4. Estuary Lagoon	5. Special Status Species	6. Dam Management	7. Wildfire Management	8. Erosion & Sediment	9. Geo-morphology	10. Drought / Climate	11. Public Safety	12. Public Access & Awareness	Related Past & Current Projects and Programs (from February 2014 list)
31	Expand the current fisheries assessment and monitoring program to include tributaries and multiple mainstem locations to quantify steelhead habitat utilization and migration patterns throughout the Carmel River Watershed. This expansion should include funding to evaluate methods to count fish at selected monitoring stations.	Watershed Management					X								Steelhead Barrier Assessments in Potrero Creek and Garzas Creek (MPWMD); Steelhead Tagging Project (Hopkins)
32	Continue fish rescue programs in main stem and tributaries when appropriate.	Watershed Management					X								Steelhead Rescues (CRSA); Sleepy Hollow Facility Improvements (MPWMD)
33	Redesign and install the fish screen at the entry to the outlet at LPD.	Watershed Management					X	X							Steelhead Passage Improvements (MPWMD)
34	Support efforts to modify the Los Padres Dam spillway for downstream fish migration.	Watershed Management					X	X							Los Padres Reservoir - Management of Capacity Loss (Cal-Am); Los Padres Water Release for Habitat Management (MPWMD)
35	Develop and implement plan to identify, remove or modify fish passage barriers within the watershed	Watershed Management					X								San Clemente Dam Removal and River Reroute (Cal-Am); Steelhead Barrier Assessments in Potrero Creek and Garzas Creek (MPWMD)
36	Provide fish passage around dams and diversions	Watershed Management					X	X							San Clemente Dam Removal and River Reroute

No	Action Description	Action Type	1. Water Quantity	2. Water Quality	3. Flood Management	4. Estuary Lagoon	5. Special Status Species	6. Dam Management	7. Wildfire Management	8. Erosion & Sediment	9. Geo-morphology	10. Drought / Climate	11. Public Safety	12. Public Access & Awareness	Related Past & Current Projects and Programs (from February 2014 list)
37	Develop and implement a non-native vegetation and wildlife education, monitoring, and eradication program.	Watershed Management					X							X	Watershed Manual (RCDMC)
38	Support the development and implementation of a lagoon/estuary and barrier beach restoration and management plan.	Watershed Partnerships	X		X	X	X				X				Interim Flood Management in Lower CR (Monterey Co.); CR Lagoon Ecosystem Protective Barrier (EPB)
39	Support efforts to provide supplemental water to lagoon.	Watershed Partnerships	X	X		X	X								CR Lagoon Water Augmentation (CAWD)
40	Develop and implement an integrated wildland fire and hazardous fuels management plan	Watershed Management							X			X			
41	Develop and maintain a public-accessible database of CRLF data for the Carmel River Watershed.	Watershed Management					X							X	
42	Identify and map all essential, priority and potential habitat for CLF and other species of concern in the watershed.	Watershed Management					X								
43	Develop educational public outreach materials that summarize recommendations for restoration, protection, and conservation efforts to improve and expand CRLF habitat and the habitat of other species of concern in the Carmel River watershed.	Education					X							X	Watershed Education Center at Garland Park (MPRPD); "Experience Carmel River" Interpretive Panels (BSLT); Watershed Awareness Events (RCDMC); Watershed Manual (RCDMC); Watershed Tours (CRWC)

No	Action Description	Action Type	1. Water Quantity	2. Water Quality	3. Flood Management	4. Estuary Lagoon	5. Special Status Species	6. Dam Management	7. Wildfire Management	8. Erosion & Sediment	9. Geo-morphology	10. Drought / Climate	11. Public Safety	12. Public Access & Awareness	Related Past & Current Projects and Programs (from February 2014 list)
44	Implement landowner outreach program to recruit participants with achievable projects to improve extent of CRLF habitat and the habitat of other species of concern in the Carmel River watershed.	Watershed Partnerships					X							X	Environmental Quality Incentives Program(NRCS); Watershed Manual (RCDMC)

5. REFERENCES

Allan, J. D. and M. M. Castillo. 2007. Stream Ecology - Structure and function of running waters. Springer Science & Business Media, The Netherlands.

Anderson, M. K. 2005 Tending the Wild: Native American Knowledge and the Management of California's Natural Resources. University of California Press, Berkeley.

Armitage, P.D. 1989. The application of a classification and prediction technique based on macroinveterbrates to assess the effects of river regulation. *Alternatives in Regulated River Management*. J.A. Gore and G.E. Petts. CRC Press, Boca Raton, Florida.

Association of Monterey Bay Area Governments. 2008. Monterey Bay Area 2008 Regional Forecast Population, Housing Unit and Employment Projections for Monterey, San Benito and Santa Cruz Counties to the Year 2035.

Audubon California. 2008. Important Bird Areas of California.

Bakke, P. 2008. Physical Processes and Climate Change: A Guide for Biologists. U.S. Fish and Wildlife Service - Western Washington FWO.

Barbour E. and L. Kueppers. 2008. Conservation and Management of Ecological Systems in a Changing California. Public Policy Institute of California.

Barnhart, R. A. 1986. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest): Steelhead. U. S. Fish and Wildlife Service Biological report (82) 11. U. S. Army Corps of Engineers, Technical Report EL-82-4.

Barry, S. J., and H. B. Shaffer. 1994. The status of the California tiger salamander (Ambystoma californiense) at Lagunita: a 50-year update. *Journal of Herpetology* 28:159-164.

Beck, E., E. Geisler, M. Gehrke, A. Goodmansen, S. Leiker, S. Phillips, J. Rhodes, A. Schat, A. Snyder, A. Teaby, J. Urness, D. Wright. 2013 . A Survey of Large Wood on the Carmel River: Implications for Bridge Safety Following San Clemente Dam Removal. Publication No. WI-2013-04. The Watershed Institute, California State Monterey Bay.

Benda, L., D. Miller, J. Sias, D. Martin, R. Bilby, C. Veldhuisen, and T. Dunne. 2003 .Wood recruitment processes and wood budgeting. Pages 49-74 in S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. *The ecology and management of wood in world rivers*. American Fisheries Society, Symposium 37, Bethesda, Maryland.

Bilby, R. and J.W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in western Washington. *Transactions of the American Fisheries Society* 118:368-378.

Bond M. H., S. A. Hayes, C. V. Hanson, R. B. MacFarlane. 2008. Marine survival of steelhead (Oncorhynchus mykiss) enhanced by a seasonally closed estuary. *Can. J. Fish. Aquat. Sci*. 65:2242-2252.

Borchert, M., D. Segotta, M. D. Purser. 1988. *Coast Redwood Ecological Types of Southern Monterey County, California.* Gen. Tech. Rep. PSW-107. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 27 p.

Breschini, G. and T. Haversat. 2004. *The Esselen Indians of the Big Sur Country*. Coyote Press, Salinas, California.

Brungs, W. and B. Jones, 1977. *Temperature Criteria for Freshwater Fish: Protocol and Procedures*. Environmental Research Lab-Duluth, Minneapolis, Minnesota. EPA/600/3-77/061.

Busby, P. J, et al. 1996. Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-27. National Marine Fisheries Service, Seattle, WA.

California Academy of Sciences. 2005. Online collections catalogue, Department of Herpetology, San Francisco, California. http://calacademy.org/research/herpetology/catalog/.

California Department of Fish and Game. 1986. Proposal Presented to the Monterey Peninsula Water Management Districtat Workshop in Yountville, California, by W. M. Snider.

California Department of Fish and Game. 2002. Culvert Criteria for Fish Passage. California Department of Fish and Game, Sacramento, California.

California Department of Fish and Game. 2005. Summary Report. Coast Road Watershed Erosion and Restoration Planning Project. Monterey County, California. Contract GS-C/P469. Prepared for the Monterey County Department of Public Works.

California Department of Fish and Wildlife. 2011. *California Department of Fish and Game Instream Flow Program. Annual Report 2011*. California Department of Fish and Wildlife, Water Branch, Instream Flow Program, Sacramento, California.

California Department of Fish and Wildlife. 2014a. California Natural Diversity Database (CNDDB). Electronic database. California Department of Fish and Wildlife, Sacramento, California. Accessed March 2014. https://www.wildlife.ca.gov/Data/CNDDB

California Department of Fish and Wildlife. 2014b. *State and Federally Listed Endangered and Threatened Plants and Animals of California.* Electronic database. California Department of Fish and Wildlife, Sacramento, California. Accessed March 2014. http://www.dfg.ca.gov/wildlife/nongame/t_e_spp

California Department of Parks and Recreation. 2008. *Initial Study Mitigated Negative Declaration. Carmel River State Beach Lagoon Water Level Management Project.* California Department of Parks and Recreation, Monterey District, Monterey, California.

California Department of Water Resources. 1978. *Land Use Within the California Coastal Zone*. Vol. 207.

California Department of Water Resources. 2012. Final Supplement to the San Clemente Dam Seismic Safety Project Final Environmental Impact Report/Environmental Impact Statement. Prepared by The California American Water Company.

California Native Plant Society. 2005. *Inventory of Rare and Endangered Plants* (online edition, v6-05b). California Native Plant Society, Sacramento, California.

Camargo, J. A. and N. J. Voelz. 1998. Biotic and abiotic changes along the recovery gradient of two impounded rivers with different impoundment use. *Environmental Monitoring and Assessment* 50: 143-158.

Capelli, M. H. 2007. San Clemente and Matilija Dam Removal: Alternative Sediment Management Scenarios. *Modernization and Optimization of Existing Dams and Reservoirs. Proceedings, U.S. Society on Dams:* 607-620. United States Society on Dams Annual Meeting 5-9 March 2007, Philadelphia, Pennsylvania.

Carmel River Watershed Conservancy. 2005. *Watershed Assessment and Action Plan of the Carmel River Watershed, California. 2004*. Final document submitted to California State Water Resources Control Board, March 31, 2005 pursuant to Agreement No. 02-041-235-2. Carmel River Watershed Conservancy, Monterey, California.

Carmel River Watershed Conservancy. 2013. Carmel River History. Accessed March 2014. http://carmelriverwatershed.org/organization/history/

Casagrande, J. M. 2006. *Wetland Habitat Types of the Carmel River Lagoon*. The Watershed Institute, California State University Monterey Bay, Report No. WI-2006-05.

Casagrande, J. M. and F. Watson. 2006. *Reclamation Ditch Watershed Assessment and Management Strategy: Part A – Watershed Assessment*. Monterey County Water Resources Agency and the Watershed Institute. California State University Monterey Bay.

Cayan, D., E. Maurer, M. Dettinger, M. Tyree, K. Hayhoe. 2008. Climate change scenarios for the California region. Climatic Change 87(Suppl. 1):21-42.

Chapman, G. 1986. *Ambient aquatic life water quality criteria for dissolved oxygen(freshwater).* EPA-440/5-86-003. Washington, D.C.: United States Environmental Protection Agency, Office of Water Regulations and Standards, Criteria & Standards Division.

Cherry, J., and R.L. Beschta. 1989. Coarse woody debris and channel morphology: A flume study. *Water Resources Bulletin* 25:1031-1036.

Christensen, T.T. 2003. *Using GIS to Quantify Riparian Area Overlying the Carmel Valley Alluvial Aquifer*. Monterey Peninsula Water Management DistrictTechnical Memo 2003-02.

Chubb, S. 1999. Letter to Ina Pisani, providing U.S. Forest Service comments on working draft of recovery plan.

Coleman, J. S., S. A. Temple, and S. R.Craven. 1997. Cats and wildlife: A conservation dilemma. University of Wisconsin Cooperative Extension Publications, Madison, Wisconsin.

DeMaster, D. P., D. J. Miller, J. R. Henderson, and J. M. Coe. 1985. Conflicts between marine mammals and fisheries off the coast of California. *In*: Beddington, R. J., J. H. Beverton, and D. M. Lavigne, (eds.). *Marine Mammals and Fisheries*. George Allen & Unwin.

De Santis A., G. P. Asner, P. J. Vaughan, D. E. Knapp. 2010. Mapping burn severity and burning efficiency in California using simulation models and Landsat imagery. *Remote Sensing of Environment* 114, 1535–1545.

Dettman, D. H. 1984. The Carmel River Lagoon and its Use by Steelhead. Appendix A to Assessment of the Carmel River Steelhead Resource: It's Relationship to Streamflow and to Water Supply Alternatives. D. W. Kelley and Associates. Prepared for the Monterey Peninsula Water Management District.

Dettman, D. H. 1989. The Quantity of Steelhead Spawning Habitat Inundated or Blocked by Alternative Water Supply Projects in the Carmel River Basin. Technical Memorandum 89-03, November 1989. Monterey Peninsula Water Management District.

Dettman, D. H. 1993. Recommended Minimum Streamflow Requirements for the Reach Between the Proposed New Los Padres Reservoir and Existing San Clemente Reservoir. Prepared for the Monterey Peninsula Water Management District. Technical Memorandum 93-03.

Dettman, D. H. and D. W. Kelley. 1986. *Assessment of the Carmel River Steelhead Resource. Vol. 1. Biological Investigations.* Prepared for the Monterey Peninsula Water Management District.

Dettman, D. H. and D. W. Kelley. 1987. Assessment of the Carmel River Steelhead Resource. Vol. II. Evaluation of the Effects of Alternative Water Supply Projects on the Carmel River Steelhead Resource. Prepared for the Monterey Peninsula Water Management District.

DiGaudio, R. and T. Gardali. 2013. *The Carmel River Bird Conservation Plan*. Prepared by the Point Reyes Bird Observatory (PRBO) for The Big Sur Land Trust, PRBO Contribution No. 1903.

Dudley, T.L., and N.H. Anderson. 1982. A survey of invertebrates associated with wood debris in aquatic habitats. *Melanderia* 39.1-21.

D. W. Alley & Associates. 1992. Instream Flow Analysis of Steelhead Spawning Habitat Between the Scarlett Narrows and San Clemente Dam, Carmel River, Monterey County, California, 1991. Prepared for the Monterey Peninsula Water Management District.

D. W. Alley & Associates. 1997. Baseline Sampling, Water Quality Monitoring and Observation of Lagoon Conditions Before Sandbar Breaching at Carmel River Lagoon, Monterey County, California 1996, Prior to Excavation of the South Arm. Prepared for Smith and Reynolds, Erosion Control, Inc.

D. W. Alley, Associates. 1998. Determination of Weighted Usable Spawning Area for Steelhead in Two Stream Segments – the Scarlett Narrows to San Clemente Dam and Between San Clemente and Los Padres Dams, Carmel River, Monterey, County, California, 1998. Prepared for the Monterey Peninsula Water Management District.

D. W. Kelley & Associates. 1982. *The Probable Effect of Carmel River Water Supply Alternatives on Steelhead Resources.* Prepared for the Monterey Peninsula Water Management District.

D. W. Kelley & Associates. 1984. The Probable Effect of Carmel River Water Supply Alternatives on Steelhead Resources Appendix A: The Carmel River Lagoon and its Use by Steelhead. Prepared for the Monterey Peninsula Water Management District.

D. W. Kelley & Associates. 1987. *Assessment of the Carmel River Steelhead Resource.* Prepared for the Monterey Peninsula Water Management District.

D. W. Kelley & Associates. 1996. Instream Flow Analysis of Steelhead Spawning Habitat to be Inundated or Blocked on the Carmel River and Danish Creek by the Proposed New Los Padres Dam, Upstream of the Existing Los Padres Dam, Monterey County, California, 1995. Prepared for Monterey Peninsula Water Management District.

EcoSystems West Consulting Group. 2001. Interim Draft of the Biological Assessment of CRLF for the Carmel River Dam and Reservoir Project. Prepared for Monterey Peninsula Water Management District, U.S. Army Corps of Engineers, California American WaterCompany, prepared by Ecosystems West Consulting Group, Dawn Reis, Principal Investigator.

EMCON Associates. 1986. *Carmel Valley Village and Robles Del Rio Pollution Study*. Prepared for Monterey County Dept of Health, Division of Environmental Health. December 19, 1986.

Entrix Environmental Consultants and California-American Water. 2006. *Environmental Impact Statement Report for the San Clemente Dam Seismic Retrofit Project.* 2 vols. Prepared for the California Department of Water Resources and the U.S. Army Corps of Engineers.

ESA PWA. 2012. *Evaluation of Erosion Mitigation Alternatives for Southern Monterey Bay*. Prepared for Monterey Bay Sanctuary Foundation and the Southern Monterey Bay Coastal Erosion Working Group. May 30, 2012.

FireScape Monterey. 2016. The Nature Conservancy, Conservation Gateway, Fire Learning Network, Regional Networks, FireScape Monterey. Accessed October 14, 2016. https://www.conservationgateway.org/ConservationPractices/FireLandscapes/FireLearningNetwork/RegionalNetworks/Pages/FireScapeMonterey.aspx

Florsheim, J.L., J. F. Mount, A. Chin. 2008. Bank erosion as a desirable attribute of rivers. *Bioscience* 58(6): 519–529.

Flosi, G., S. Downie, J. Hopelain, M. Bird, R. Coey and B. Collins. 2010. *California Salmonid Stream Habitat Restoration Manual (3rd edition)*. California Department of Fish and Wildlife: Sacramento, California.

Fresh, K. L. 1997. The role of competition and predation in the decline of Pacific salmon and steelhead. *In*: Stouder, D. J., P. A. Bisson, and R. J. Naiman (eds.). 1997. *Pacific Salmon and Their Ecosystems: Status and Future Option*s. Chapman and Hall, New York, New York.

Froke, J. B. 2004. Final report fo the San Clemente Dam Drawdown Project, 2004, California red-legged frog, Carmel River, Monterey County, California. Prepared for the U.S. Army Corps of Engineers, San Francisco, California. Prepared with support from Dawn Reis Ecological Studies. Prepared on behalf of California American Water Company, Monterey, California.

Froke, J. B. 2005. Summary of CRLF data from 2005 San Clemente Dam Drawdown Project: Reis and Froke. Email to Chrisie Robinson, ENTRIX, Inc. June 4, 2007.

Froke, J. B. 2007. Protection of California red-legged frogs in the Carmel River during the 2006 drawdown of the San Clemente Reservoir, Monterey County, California. Submitted to California American Water Company, Monterey, California and U.S. Fish & Wildlife Service, Ventura, California.

Gardali T, N. E. Seavy, R. T. DiGaudio, and L. A. Comrack. 2012. A Climate Change Vulnerability Assessment of California's At-Risk Birds. *PLoS ONE* 7(3): e29507.

Good, T. P., R. S. Waples, and P. Adams (eds.). 2005. *Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead.* National Marine Fisheries Service, Northwest and Southwest Fisheries Science Centers. NOAA Technical Memorandum NMFS-NWFSC TM-66.

Gowaty, P.A. 1984. House Sparrows kill Eastern Bluebirds. *Journal of Field Ornithology* 55:378-380.

Grinnel, J. and A. H. Miller. 1944. The distribution of birds of California. *Pac. Coast Avifauna* No. 27.

Hammond, J.L. 2008. Identification of nest predators and reproductive response of the Modesto Song Sparrow, Melospiza melodia mailliardi, to experimental predator removal. MS Thesis, Humboldt State University, Arcata, California.

Hampson, Larry. 2013. Personal communication.

Hastings Natural History Reservation. 2014. Natural History; Data/Vegetation. Accessed February 2014. http://hastingsreserve.org/VegetationData/HNHRVegDataArchive.html.

Hayes, M. P and M. R. Jennings. 1988. Habitat correlates of distribution of the California red-legged frog (Rana aurora draytonii) and the foothill yellow-legged frog (Rana boylii): Implications for management. Proceedings of the Symposium on the Management of Amphibians, Reptiles, and small mammals in North America. U.S.D.A Forest Service General Technical Report RM-166.

Hayes, S.A., M. H. Bond, C. V. Hanson, E. V. Freund, J. J. Smith, E. C. Anderson, A. J. Ammann, and R. B. MacFarlane. 2008. Steelhead growth in a small Central California watershed: upstream and estuarine rearing patters. *Transactions of the American Fisheries Society*. 137: 114-128.

Heberger, M., H. Cooley, P. Herrera, P. H. Gleick, and E. Moore. 2009. The Impacts of Sea Level Rise on the California Coast. California Climate Change Center.

Hecht B. 1977. Sequnetial changes in bed habitat conditions in the upper Carmel River following the Marble-Cone fire of August 1977. Presented at the California Riparian Systems Conference. University of California, Davis, Sept. 17-19.

Henson, P.; and DJ. Usner. 1993. *The Natural History of Big Sur.* University of California Press, Berkeley.

Hinton, T. R. 2003. *Monitoring Marine Mammal Predation on San Lorenzo Steelhead*. California State Science Fair, Project S1903.

Holland, D. C. 1994. The Western Pond Turtle: Habitat and History. Final Report. U.S. Department of Energy, Bonneville Power Administration, Portland, Oregon.

Hunt & Associates Biological Consulting Services. 2008. South-Central California Coast Steelhead Recovery Planning Area Conservation Action Planning (CAP) Workbooks Threats Assessment. Prepared for National Marine Fisheries Service, Southwest Region, Long Beach, California.

James, G. 2005. Surface Water Dynamics at the Carmel River Lagoon Water Years 1991 through 2005. Technical Memorandum 05-01. MPWMD.

James, G. 2009. Surface Water Resources Data Report Water Years 2004-2008. Prepared for the Monterey Peninsula Water Management District, Monterey, California.

Jennings, M. R., and M. P. Hayes. 1994. Amphibian and reptile species of special concern in California. Final Report to the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California.

Jones & Stokes Associates, Inc. 1998. *Draft Supplemental Environmental Impact Report for the Carmel River Dam and Reservoir Project*. November 1998. Prepared for the Monterey Peninsula Water Management District, Monterey, California.

K2 Environmental Planning and Engineering Consultants. 1992. *Carmel Valley Groundwater Quality Evaluation, with Special Emphasis on Nitrate*. Prepared for the Monterey Peninsula Water Management District, January 1992.

Karl, T. R., G. A. Meehl, C. D. Miller, S. J. Hassol, A. M. Waple, and W. L. Murray (eds.). 2008. Weather and Climate Extremes in a Changing Climate. Regions of Focus: North America, Hawaii, Caribbean, and U.S.South-Central California Coast Steelhead Recovery Plan December 2013 Pacific Islands. Synthesis and Assessment 3.3. Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research.

Karl, T. R., J. M. Melillo, and T. C. Peterson (eds.). 2009. Global Climate Change Impacts in the United States. Cambridge University Press.

Karr, J.R. and E.W. Chu. 1999. *Restoring Life in Running Waters*. Island Press, Covelo, California.

Kasey T. and S. Peterson. 2005. *A Vision Plan for the Carmel River Parkway*. June 2005. Prepared for the Big Sur Land Trust, Carmel, California.

Keller, E.A., and F.J. Swanson. 1979. Effects of large organic material on channel form and fluvial processes. *Earth Surface Processes and Landforms* 4:361-380.

Keeley, J. E. 2002. Native American Impacts on Fire regimes of the California Coast Ranges. *Journal of Biogeography* 29:303–20.

Kerpez, T.A., and N. S. Smith. 1990. Competition between European Starlings and native woodpeckers for nest-cavities in Saguaros. *The Auk* 107:367-375.

Kier Associates and National Marine Fisheries Service. 2008a. Guide to the Reference Values Used in the South-Central/Southern California Steelhead DPS Conservation Action Planning (CAP) Workbooks (DVD). Prepared for National Marine Fisheries Service, Southwest Region, Long Beach, California.

Kier Associates and National Marine Fisheries Service. 2008b. Fifty-Five South-Central/Southern California Steelhead DPS Conservation Action Planning (CAP) Workbooks (DVD). Prepared for National Marine Fisheries Service, Southwest Region, Long Beach, California.

Kondolf, G. M. 1986. Channel Erosion Along the Carmel River, Monterey County, California. *Earth Surface Processes and Landforms* 11(3):307-319.

Kondolf, G. M. 1997. Hungry water: effects of dams and gravel mining on river channels. *Environmental Management* 21:533-551.

Kondolf, G. M. and R. R. Curry. 1984. The role of riparian vegetation in channel bank stability: Carmel River, California. *In*: Warner, R. E. and K. M. Hendrix (ed.). *California Riparian Systems: Ecology, Conservation, and Productive Management.* University of California Press.

Krebs, F. 1983. Computation of Total Sediment Load of the Carmel River, CA: Report to the Monterey Peninsula Water Management District.

Largier, J.L., B.S. Cheng, and K.D. Higgason, editors. 2010. Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils. 121pp.

Larson, J., Watson, F., Masek, J., & Watts, M. 2005. Carmel River Lagoon Enhancement Project: Water Quality and Aquatic Wildlife Monitoring, 2004-5. Report to California Department of Parks and Recreation. The Watershed Institute, California State University Monterey Bay, Publication No. WI-2005-12.

Levy, R. 1978. Costanoan, In R. F. Heizer (Ed.), *Handbook of North American Indians, Volume 8 - California*, (pp.485-495). Smithsonian Institution, Washington, DC.

Loss, S. R., T. Will, and P. P. Marra. 2013. The impact of free-ranging domestic cats on wildlife of the United States. *Nat. Commun*. 4:1396.

Lowry, M. S. and R. L. Folk. 1987. Feeding Habits of California sea lions from stranded carcasses collected at San Diego county and Santa-Catalina Island, California. Administrative Report LJ-87. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, CA.

Marks J.C., M. E. Power, M. S. Parker. 2000. Flood disturbance, algal productivity, and interannual variation in food chain length. *Oikos* 90: 20-27.

Matthews, G. 1989. Evaluation of reservoir sedimentation rates in the upper Carmel river watershed: MPWMD Technical memorandum 88-03, 16pp.

Mathews, M.A. and California Native Plant Society. 2006. An Illustrated Field Key to the Flowering Plants of Monterey County and Ferns, Fern Allies, and Conifers.Mayer, K. E. and W. F. Laudenslayer, Jr. 1988. A Guide to the Wildlife Habitats of California. State of California, Resources Agency, Department of Fish and Game. Sacramento, California.

Maurer, E. P., H. G. Hildalgo, T. Das, M. D. Dettinger, and D. R. Cayan. 2010. Assessing climate change impacts on daily streamflow in California: the utility of daily large-scale climate data. Hydrology and Earth System Sciences Discussions 2010(7):1209-1243.McEwan, D. and T. A. Jackson. 1996. Steelhead Restoration and Management Plan for California. California Department of Fish and Wildlife.

McEwan, D. and T. A. Jackson. 1996. Steelhead restoration and management plan for California. California Department of Fish and Game, Sacramento, California.

McNeish, C.M. 1986. Effects of Production Well Pumping on Plant Stress in the Riparian Corridor of the Lower Carmel Valley. Prepared for the Monterey Peninsula Water Management District. Vols. 1,2,3

Mensing, S. 1991. The effect of land use changes on blue oak regeneration and recruitment. Pages 230-323 in Proceedings of the symposium on oak woodlands and hardwood rangeland management. USDA, Forest Service, Pacific Southwest Research Station, General Technical Report PSW-126, Davis, CA.

Middlemas, S. J., J. D. Armstrong, and P. M. Thompson. 2005. The significance of marine mammal predation on salmon and sea trout. *In*: Mills, D. (ed.). *Salmon at the Edge*. Blackwell Science, Ltd.

Miller, C. M. 1943. An intergrade population connecting Anniella pulchra pulchra and Anniella pulchra nigra. *Copeia*, vol 1943(1) p 2-6.

Mitchell, J. C., and R. A. Beck. 1992. Freeranging domestic cat predation on native vertebrates in rural and urban Virgina. *Virginia Journal of Science* 43:197–206.

Mitchell, M. and R. Yeager. 2011. *Wildflowers of Garland Ranch – a field guide.* Self-published.

Monterey Bay National Marine Sanctuary Advisory Council. 2008. *Agricultural Water Quality Central Coast of California.* 18 April 2008.

Monterey County Resource Management Agency. 2013. Carmel Valley Master Plan, amended 2013. Chapter 9.B. of Monterey County General Plan. Salinas, CA.

Monterey Peninsula Water Management District. 1995. Carmel River 100-year Flood Zone and Drainage Watershed Analysis.

Monterey Peninsula Water Management District. 2000. *Review of Carmel River Dam Fish Passage Facilities.* Prepared by R2 Resource Consultants.

Monterey Peninsula Water Management District. 2004. *Environmental and Biological Assessment of Portions of the Carmel River Watershed.* Prepared pursuant to the Costa-Machado Water Act of 2000.

Monterey Peninsula Water Management District. 2009. *Study Plan for Long Term Adaptive Management of the Carmel River State Beach and Lagoon.* Prepared for the California Coastal Commission.

Monterey Peninsula Water Management District. 2010. *Ten-Year Summary of the Monterey Peninsula Water Management District's Bioassessment Program on the Carmel River.* Prepared by Bioassessment Services in Association with Beverley Chaney and Thomas Lindberg, Monterey Peninsula Water Management District.

Monterey Peninsula Water Management District. 2012. Guidelines for Vegetation Management and Removal of Deleterious Materials for the Carmel River Riparian Corridor. Monterey, CA.

Monterey Peninsula Water Management District. 2013. *2011-2012 Annual Report (July 1, 2011 - June 30, 2012) for the MPWMD Mitigation Program*. Prepared for the Monterey Peninsula Water Management DistrictBoard of Directors.

Monterey Peninsula Water Management District. 2014. Assessment of Steelhead Passage Barriers in Portions of Four Tributaries to the Carmel River. Monterey Peninsula Water Management DistrictIRWM - PROJECT 3 Final Project Report - July 2014.

Monterey Peninsula Water Management District. 1991-2014. *Carmel River Monthly Fishery Reports.* Prepared for the Monterey Peninsula Water Management DistrictBoard of Directors.

Monterey Peninsula Water Management District. 2000 - 2013. *Mitigation Annual Reports.* Prepared for the Monterey Peninsula Water Management DistrictBoard of Directors.

Monterey Peninsula Water Management District. 2010-2014. Carmel River Advisory Committee quarterly meetings. Facilitated by the Monterey Peninsula Water Management District.

Monterey Peninsula Water Management District. 2014. Los Padres Dam and Reservoir Long-Term Strategic and Short-Term Tactical Plan, January 2014.

Monterey Peninsula Water Management District. 2014. *Assessment of Steelhead Passage Barriers in Portions of Four Tributaries to the Carmel River.* Appendix to Project 3 of Monterey Peninsula and South Monterey Bay IRWM Grant Project Report, July 2014.

Monterey Peninsula Water Management District and Carmel River Watershed Conservancy. 2004. *Environmental and Biological Assessment of Portions of the Carmel River Watershed.* Prepared pursuant to the Costa-Machado Water Act of 2000.

Montgomery, D.R., B.D. Collins, J.M. Buffington, and T.B. Abbe. 2003. Geomorphic effects of wood in rivers. Pages 21-47 in S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. *The ecology and management of wood in world rivers*. American Fisheries Society, Symposium 37, Bethesda, Maryland.

Mount, J.F. 1995. California Rivers and Streams: The Conflict Between Fluvial Process and Land Use. University of California Press. Berkeley, California.

Museum of Vertebrate Zoology. 2005. MVZ Data Access, University of California, Berkeley. http://mvz.berkeley.edu/Collections.html.

Mussetter Engineering, Inc. 2002. Carmel River Sediment-transport Study. Prepared for the California Department of Water Resources, Fresno, California, January 2002.

Mussetter Engineering, Inc. 2003. San Clemente Reservoir and Carmel River Sediment-transport Modeling to Evaluate Potential Impacts of Dam Retrofit Options. Prepared for American Water Works Service Company. Voohees, New Jersey, April 2003.

National Marine Fisheries Service. 2001. *Guidelines for Salmonid Passage at Stream Crossings*. National Marine Fisheries Service, Southwest Region, Long Beach, California.

National Marine Fisheries Service. 2002. Instream Flow Needs for Steelhead in the Carmel River. Bypass flow Recommendations for Water Supply Projects Using Carmel River Waters. Prepared for the National Marine Fisheries Service, Southwest Region, Santa Rosa Field Office.

National Marine Fisheries Service. 2011. North-Central California Coast Recovery Domain, 5-Year Review:Summary and Evaluation of Central California Coastal Steelhead DPS and Northern California Steelhead DPS. National Marine Fisheries Service, Southwest Region, Long Beach, California.

National Marine Fisheries Service. 2011. Marine Mammal Stock Assessment: California Sea Lion (Zalophus californianus): U.S. Stock. Marine Mammal Stock Assessment Report.

National Marine Fisheries Service. 2013. *South-Central California coast Steelhead Recovery Plan*. National Marine Fisheries Service, Southwest Region, Long Beach, California.

National Marine Fisheries Service. 2014. *Endangered and Threatened Marine and Anadromous Fish.* Accessed March 2014. http://www.nmfs.noaa.gov/pr/pdfs/species/esa_table.pdf.

Natural Resources Conservation Service. 2014. Soil survey of Monterey County, California. U.S. Department of Agriculture, Natural Resources Conservation Service.

Nedeff, Nicole. Personal Communications. 2014, 2016.

Newman, W., F. Watson, M. Angelo, J. Casagrande and B. Feikert. 2003. *Land Use History and Mapping in California's Central Coast Region.* Publication No. WI-2003-03. The Watershed Institute. California State University, Monterey Bay.

Newman, W.B., Smith, D.P. and Watson, F.G.R. 2004. The Carmel River Watershed - Map Set. Publication No. WI-2004-04. The Watershed Institute, California State University Monterey Bay.

Newton I. 1994. The role of nest sites in limiting the numbers of hole-nesting birds: a review. *Biol. Conserv*. 70: 265–276.

Petts, G. E. 1984. Macroinvertebrate response to upstream impoundment. Impounded Rivers: Perspectives for Ecological Management. John Wiley and Sons. New York, New York.

Planning and Conservation League Foundation. 2004. Proposed Scope of Work to Conduct Habitat Typing, Identification and Implementation of Priority Projects to Enhance California Red- Legged Frog habitat in the Carmel River Watershed.

Philip Williams & Associates, Ltd. 1992. *Carmel River Lagoon Enhancement Plan*. Prepared for Carmel River Steelhead Association, California State Coastal Conservancy, Monterey County Water Resources Agency, and the Monterey Peninsula Water Management Districtin cooperation with California Department of Parks and Recreation. Report No. 509.

Philip Williams & Associates, Ltd. 1999. *Carmel River Lagoon: Enhancement and Management Plan: Conceptual Design Report*. Prepared for Monterey Peninsula Regional Park District, California State Coastal Conservancy, and California Department of Parks andRecreation. Report No. 1250.

Philip Williams & Associates, Ltd. 2007. *Supplemental Carmel River Watershed Action Plan, 2007.* Prepared for The Planning and Conservation League Foundation in partnership with the Carmel River Watershed Conservancy.

Purcell, Kathryn L.; Stephens, Scott L. 2005. Changing fire regimes and the avifauna of California oak woodlands. *Studies in Avian Biology* No. 30:33–45.

Raines, Melton & Carella and EDAW. 2002. *Carmel River Dam Alternative Plan B. Plan B Project Report A.97-03-052.* Prepared for the Water Division of the California Public Utilities Commission.

Rehn, A. C., P. R. Ode, and C. P. Hawkins. 2007. Comparisons of Targeted-Riffle and Reach-Wide Benthic Macroinvertebrate Samples: Implications for Data Sharing in Stream Condition Assessments. *Journal of the North American Benthological Society*. 26:332-348.

Reis, D. 2003. California Red-legged Frog Tadpole Surveys and Translocations During the California-American Water Company 2003 Water Withdrawal in the Carmel River, Monterey County, CA: The United States Fish and Wildlife Service Biological Opinion (1-8-99-FW-7).

Riparian Habitat Joint Venture. 2004. Version 2.0. The riparian bird conservation plan: a strategy for reversing the decline of riparian associated birds in California. California Partners in Flight. http://www.prbo.org/calpif/pdfs/riparian.v-2.pdf.

Roberson, D. 2002. *Monterey Birds* (2nd ed.). Monterey Peninsula Audubon Society, Monterey, California.

Rosenberg, L. 2001. Geologic Resources and Constraints, Monterey County, California: A Technical Report for the Monterey County 21st Century General Plan Update Program, prepared for County of Monterey Environmental Resource Policy Department.

Schindler, D. E., X. Auger, E. Fleishman, N. Mantua, B. Riddell, M. Ruckelshaus, J. See, and M. Webster. 2008. Climate change, ecosystem impacts, and management for Pacific salmon. *Fisheries* 33(10):502-506.

Schueler, T. 1987. Controlling urban runoff: a practical manual for planning and designing urban best management practices. Metropolitan Washington Council of Governments, Washington, DC.

Schueler, T. 1995. The importance of imperviousness. *Watershed Protection Techniques* 1(3):00-111.

Schwing, F., S. Lindley, E. Danner, and D. Boughton. 2010. Climate Change in California: Implications for the Recovery and Protection of Pacific Salmon and Steelhead. NOAA Technical Memorandum NMFS-SWFSC TM-451.

Seagers, D. J., D. P. DeMaster, and R. L. DeLong. 1985. *A Survey of Historic Rookery Sites for California and Northern Sea Lions in the Southern California Bight.* Administrative Report LJ-85-13. National Marine Fisheries Science Center, Southwest Fisheries Science Center, La Jolla, California.

Seavy, N.E., T. Gardali, G.H. Golet, F.T. Griggs, C.A. Howell, T.R. Kelsey, S. Small, J.H. Viers, J.F. Weigand. 2009. Why climate changes makes riparian restoration more important than ever: recommendations for practice and research. *Ecological Restoration* 27:330-338.

Skinner, M.W. and B.M. Pavlik, eds. 1994. *Inventory of Rare and Endangered Vascular Plants of California. Special Publication No. 1* (fifth edition). California Native Plant Society. Sacramento, California.

Small, A. 1994. California Birds: Their Status and Distribution. Ibis Publishers, Vista, California.

Smith, D.P. and P. Huntington. 2004. *Carmel River Large Woody Debris Inventory from Tularcitos Creek to Carmel Estuary*, Fall 2003. Publication No. WI-2004-01. The Watershed Institute, California State University Monterey Bay.

Smith, D.P., Newman, W.B., Watson, F.G.R., and Hameister, J,. 2004. *Physical and Hydrologic Assessment of the Carmel River Watershed, California*. Publication No. WI-2004-05/2. The Watershed Institute, California State University Monterey Bay.

Smith, D., S. Castorani, H. Dillon, L. Dillon, J. Illse, C. Ritz, B. Spear, J. Stern, J. Frey. 2008. *Post-Fire Baseline Monitoring of Big Sur River Lagoon: November/December 2008.* The Watershed Institute. Publication No. WI-2008-7.

Smith D., Blanco S, Bohlke B, Crawford C, David C, Delay T, Keefauver S, Miller G, Perkins P, Petruccelli R, Post K, Silveus J,. 2012. *San Clemente Dam Removal and Carmel River Reroute Monitoring Plan: Carmel, CA.* The Watershed Institute, California State Monterey Bay, Publication No. WI-2012-05, 93 pp.

Smith D., Beck E, Geisler E, Gehrke M, Goodmansen A, Leiker S, Phillips S, Rhodes J, Schat A, Snyder A, Teaby A, Urness J, Wright D. 2013. *A Survey of Large Wood on the Carmel River: Implications for Bridge Safety Following San Clemente Dam Removal*. The Watershed Institute, California State Monterey Bay, Publication No. WI-2013-04, 46 pp.

Smith, J and D. Reis. 1996. Pescadero Marsh Natural Preserve Salinity, Tidewater Goby and Red-legged Frog Monitoring for 1995-1996. Report prepared for California Department of Parks and Recreation, Sacramento, California.

Snider, W. M. 1983. Reconnaissance of the Steelhead Resrouce of the Carmel River Drainage, Monterey County. Environmental Services Branch Administrative Report No. 83-3.

Snyder, M. A. and L. C. Sloan. 2005. Transient future climate over the western United States using a regional climate model. I 9(11).

Soulé, M. E., D. T. Bolger, A. C. Alberts, J. Wright, M. Sorice and S. Hill. 1988. Reconstructed Dynamics of Rapid Extinctions of Chaparral-Requiring Birds in Urban Habitat Islands. *Conservation Biology* 2(1).

Staal, Gardner & Dunne Inc. 1989. Hydrogeologic Investigation, Carmel River Aquifer, Coastal Portion, for Monterey Penninsula Water Management District.

State Water Resources Control Board. 1998. In the Matter of Decision 1632, Monterey Peninsula Water Management Districtand Order WR 95-10, California American Water Company. Division of Water Rights. State Water Resources Control Board. Order WR-95-10.

State Water Resources Control Board. 2016. In the Matter of Application of California American Water Company to Amend State Water Board Order 2009-0060. Division of Water Rights. State Water Resources Control Board. Order WR 2016-0016.

Stebbins, R. C. 1951. Amphibians of Western North America. University of California Press, Berkeley, California.

Stebbins, R. C. 2003. A Field Guide to Western Reptiles and Amphibians. Third Edition. Houghton Mifflin, Boston, Massachusetts.

Steele, M. A. and T. W. Anderson. 2006. Predation. In: Allen, L., D. J. Pondella II, M. H. Horn (eds.). *The Ecology of Marine Fishes: California and Adjacent Waters*. University of California Press, Berkeley, California.

Stephenson, J. and G. Calcarone. 1999. *Southern California Mountains and Foothills Assessment: Habitat and Species Conservation Issues. General* Technical Report GTR-PSW-172. U.S. Forest Service, Pacific Southwest Research Station.

Stillwater Sciences, Central Coast Salmon Enhancement, and Greenspace – The Cambria Land Trust. 2012. *Santa Rosa Creek Watershed Management Plan*. Prepared for the California Department of Fish and Wildlife, under a grant for the Fisheries Restoration Grant Program (P0740401).

Stone, E. 1971. *The Dynamics of Vegetation Change along the Carmel River, Monterey,* California. Prepared for the California American Water Company.

Storere, T. I. 1925. A synopsis of the amphibia of California. Univeristy of California Publications in Zoology 27:1-342.

Stralberg D, Jongsomjit D, Howell CA, Snyder MA, Alexander JD, Wiens JA, Root TL. 2009. Re-shuffling of species with climate disruption: a no-analog future for California birds? *PLoS ONE* 4:e1152.

Syphard, A., J. Franklin, and J. Keeley. 2006. Simulating the Effects of Frequent Fire on Southern California Coastal Shrublands. *Ecological Applications* 16:1744–56.

Trenham, P. C., H. B. Shaffer, W. D. Koenig, and M. R. Stromberg. 2000. Life History and Demographic Variation in the California Tiger Salamander (Ambystoma californiense). Copeia, 2000 (2), 365-377.

Urquhart, Kevan. 2013. Personal communication.

URS Corporation. 2012. San Clemente Dam Seismic Safety Project, Draft Supplement to the EIR, No. 2 Old Carmel River Dam Removal. SCH# 2012071036. Prepared for California State Coastal Conservancy and California American Water, August 2012.

U.S. Army Corps of Engineers. 1967. *Flood Plain Information on the Carmel River, Monterey County, California.* U.S. Army Corps of Engineers, San Francisco District, San Francisco, California.

U.S. Fish and Wildlife Service. 1980. *Carmel River Instream Flow Study. Final Report.* September 1980. Prepared for the Division of Ecological Services, Sacramento, California.

U.S. Fish and Wildlife Service. 2002. Recovery Plan for the California Red-legged Frog (Rana aurora draytonii). U.S. Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service. 2014. *Listed species believed to or known to occur in California*. Electronic database. US Fish and Wildlife Service, Washington , DC. Accessed March 2014. http://ecos.fws.gov/ecp0/reports/species-listed-by-state-report?state=CA&status=listed

U.S. General Accounting Office. 1993. Protected Species: Marine Mammals' Predation of Varieties of Fish. GAO/RCED-93-204.

Ward, J. V. and J. A. Stanford. 1979. Ecological factors controlling stream zoobenthos with emphasis on thermal modification of regulated streams. International Symposium on Regulated Streams (Ecology of Regulated Streams), Eds. J. V. Ward and J. A. Stanford, Erie, Pennslyvania, USA. Plenum Press, New York, New York.

Warner, R. E. and K. M. Hendrix, eds. 1984. *CaliforniaRiparian Systems: Ecology, Conservation, and Productive Management*. University of California Press, Berkeley, CA.

Water Management Group. 2007. Monterey Peninsula, Carmel Bay, and South Monterey Bay Integrated Regional Water Management Plan (IRWMP).

Water Management Group. 2014. Draft, Monterey Peninsula, Carmel Bay, and South Monterey Bay Integrated Regional Water Management Plan (IRWMP).

Watson, F. and J. Casagrande. 2004. Potential Effects of Groundwater Extractions on Carmel Lagoon. Report to California-American Water Company. The Watershed Institute, California State University Monterey Bay, Rep. No. WI-2004-09.

Watson, F., J. Larson, J. Casagrande, B. Pierce. 2007. *Carmel River Lagoon Enhancement Project: Water Quality and Aquatic Wildlife Monitoring, 2005-6*. Central Coast Watershed Studies. The Watershed Institute: California State University, Monterey Bay. Seaside, CA.

Watson, F., Anderson, T., C. Clark, Z. Croyle, J. Maas-Baldwin, K. Urquhart. 2008. *Carmel River Lagoon Water Quality and Steelhead Soundings: Fall 2007.* Publication No. WI-2007-04. The Watershed Institute. California State University, Monterey Bay.

Wedemeyer, G. A. 1997. Effects of rearing conditions on the health and physiological quality of fish in intensive culture. G.K. Iwama, A.D. Pickering, J.P. Sumpter, C.B. Schreck (Eds.), *Fish Stress and Health in Aquaculture*. Cambridge University Press, Cambridge.pp. 35–72.

Wheeler. J. 2004. Using GIS to Document California Red-legged Frogs (Rana aurora draytonii) & Their Reproductive Habitat within the Carmel River Watershed. Prepared for the Monterey Peninsula Water Management District, in the *Carmel River Watershed Assessment*, 2004.

Wiens, J. A. 1970. Effects of early experience on substrate pattern selection in Rana aurora tadpoles. *Copeia* 1970(3):543-548.

Williams, D.D., and B.W. Feltmate. 1992. Aquatic Insects. CAB International. xiii, 358pp.

Williams, T. H., S. T. Lindley, B. C. Spence, and D. Boughton. 2011. *Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest Region.* National Marine Fisheries, Southwest Fisheries Science Center, Fisheries Ecology Division.

Willis, C.J., M. W. Manson, K. D. Brown, C. W. Davenport, and C. J. Domrose. 2001. Landslides in the Highway 1 corridor: Geology and slope stability along the Big Sur coast between Point Lobos and San Carpoforo Creek, Monterey and San Luis Obispo Counties, California: California Department of Conservation Division of Mines and Geology, pp.40.

Yurk, H. and A. W. Trites. 2000. Experimental attempts to reduce predation by harbor seals (*Phoca vitulina*) on outmigrating juvenile salmonids. *Transactions of the American Fisheries Society* 129:1360-1366.

Zinke, P. 1971. *The Effect of Water Well Drawdown on Riparian and Phreatophyte vegetation in the Middle Carmel River*. Prepared for the Carmel Valley Property Owners Association, Carmel Valley, California.

Zweifel, R. G. 1955. Ecology, distribution, and systematics of frogs of the *Rana boylei* group. *University of California Publications in Zoology* 54:207-292.