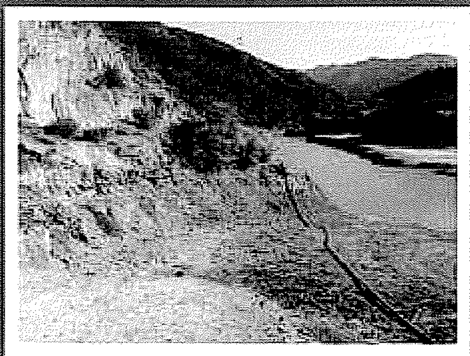
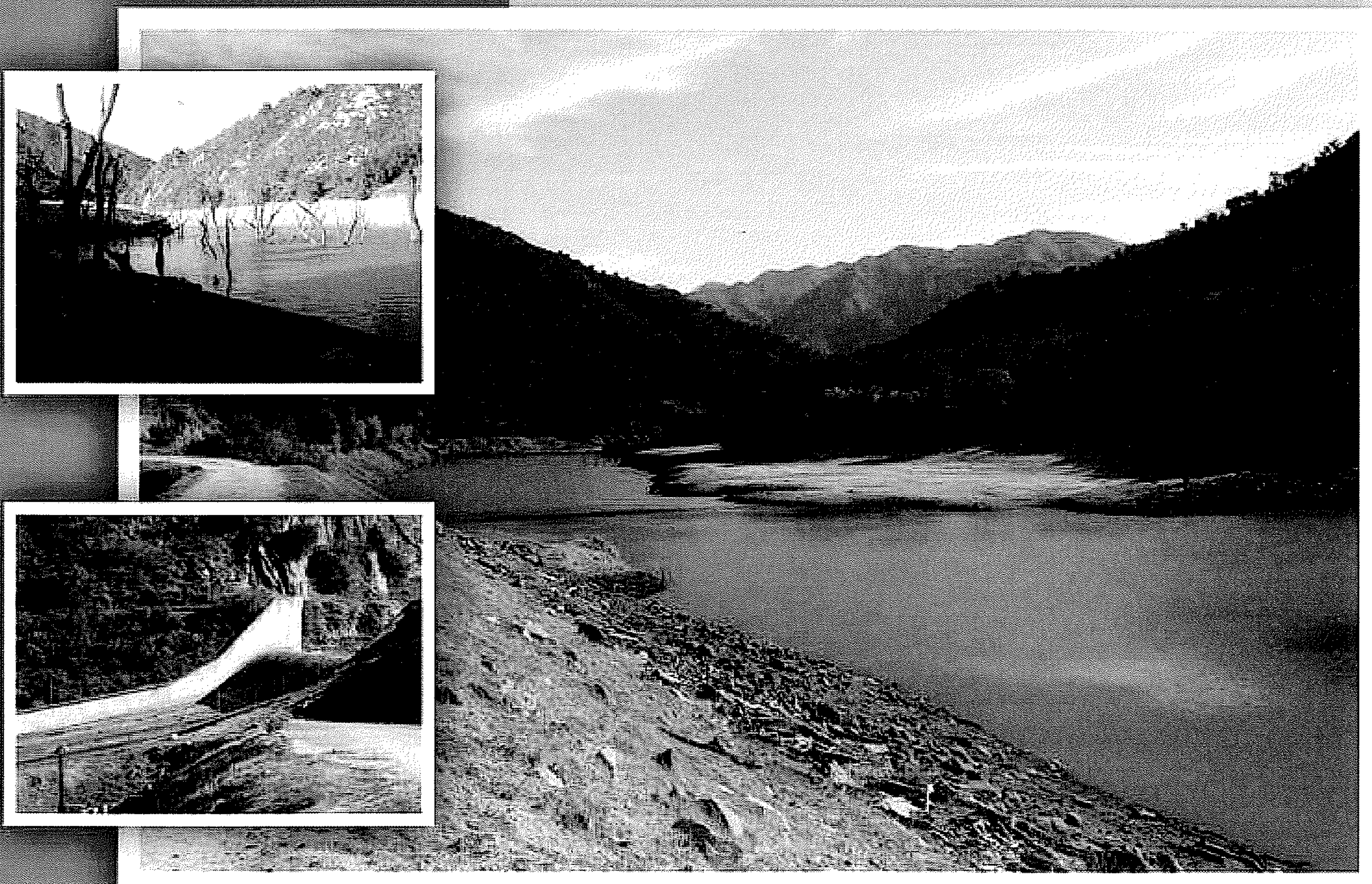


Los Padres Dam and Reservoir Long-Term Strategic and Short-Term Tactical Plan



MONTEREY PENINSULA WATER MANAGEMENT DISTRICT

Monterey Peninsula Water Management District

FINAL

May 2014

Los Padres Dam and Reservoir

Long-Term Strategic and Short-Term Tactical Plan

Monterey Peninsula Water Management District
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Executive Summary

The Monterey Peninsula Water Management District ("MPWMD") is currently engaged in arguably one of the largest and most significant challenges of its history; staving off critical anticipated shortfalls, ensuring continued water reliability, and implementing a long-term regulatory solution for the Carmel River watershed. To be sure, the multitude of technical issues, overlapping institutional influences, increasingly stringent regulatory framework, and diversity of stakeholder interests make this challenge quite complicated. A critical component of MPWMD's long term responsibilities for the Carmel River watershed involves its planned actions and management prescriptions for the *upper* watershed; the hydrological source area for the Peninsula's freshwater resources. This document, the *Los Padres Dam and Reservoir - Long-Term Strategic and Short-Term Tactical Plan* (the "Plan") is intended to provide a new perspective on water resource development in the upper watershed and use the pending fate of Los Padres Dam and Reservoir as the impetus for discussion.

Prompted in part by the State Water Resources Control Board's ("SWRCB") order for a new water supply to be developed for the Peninsula, much effort and resources have gone into developing an innovative and large scale water supply project that can meet the SWRCB's requirements within the aggressive timetable provided under the current Cease and Desist Order. The Monterey Peninsula Water Supply Project ("MPWSP") including its various functional elements (e.g., Groundwater Replenishment, "GWR" and Aquifer Storage Recovery, "ASR") is the long-term water supply solution for the Peninsula.

This Plan supports the MPWSP and is complimentary to all of its goals and objectives. However, by design, this Plan turns focus back on the *upper* watershed and revisits issues central to the various benefits/constraints associated with developing and relying on upper basin hydrology as a sustainable part of any long-term water resource solution of the Peninsula.

While reconfirming much of the hydrological and climatological characteristics of the basin, as well as the institutional and regulatory constraints that define operational functionality within the watershed, the Plan focuses on identifying new options for water development in this, the most hydrologically active part of the basin. The Plan acknowledges the unique role of the watershed and attempts to demonstrate how the basin's hydrology can serve an array of increasingly complex water needs. In this context, the Plan centered around three prescient questions:

Has MPWMD maximized the potential for water resources development within the watershed?

What new options or water development strategies are possible that, given today's growing requirements (e.g., consumptive demands, instream flows, fish bypass, water quality, climate change sensitivity, etc.) can serve a wider range of beneficial uses and better prepare for an uncertain future?

How can any new water resource development effort integrate the current challenges and constraints posed by the basin's existing facilities?

Within the perspective of these questions, the matter of Los Padres Dam and Reservoir is addressed. What is the long-term disposition of this long-time facility? Can it meet the long-term objectives of the watershed and MPWMD's vision of how it perceives future water resources within the basin to be managed? Are the various interim plans and strategies for Los Padres Dam and Reservoir such as dredging and dam raises effective means of ensuring long-term sustainability; or are they only temporary measures? Finally, the desired level of interactive collaboration between MPWMD and Cal-Am regarding the dam is considered as it represents a keenly important dynamic in upcoming deliberations and representations before adjudicating bodies (e.g., California Public Utilities Commission, "CPUC").

MPWMD has recognized the need to undertake several component studies that, together, fully evaluate the various options available for Los Padres Dam. These include:

Unimpaired Flow Analyses
Flow Analyses associated with Alternatives
Updated Instream Flow Study (IFIM)
Steelhead Habitat Evaluation for the Carmel River Watershed
Yield and Cost/Benefits Analysis for the Alternatives
Environmental Fatal Flaw Impact Analysis
Sediment Management for the Alternatives
Flood study for the Alternatives

MPMWD has already initiated work on several of these additional studies. The results of such studies will help provide the necessary foundation for making a long-term strategic decision on the future of Los Padres Dam and Reservoir.

The Plan identifies key MPWMD planning principles; around which any and all strategies must be developed. The Plan then identifies and discusses a number of water development alternatives. Several alternatives have been addressed in previous efforts and are well known. Others identified in the Plan are completely new. As the alternatives were developed; a primary theme emerged - **the development of new storage "off-mainstem".**

By capturing excess watershed runoff in surface water impoundments in one of the basin's many tributaries, key MPWMD planning principles could be met while also providing significant augmentation to the watershed's many water resource obligations and requirements. Capitalizing on the watershed's surplus flows, existing water right provisions, locational preference facilitating gravity flow, and drainage topography, new basin yield could be developed. Two such "off-mainstem" alternatives are particularly notable from this effort; **a new Pine Creek Dam and Reservoir (20,000 AF of storage) and a new San Clemente Creek Dam and Reservoir (13,000 AF of storage).**

New yield development opportunities provided by these potential reservoirs then served as the foundation for the Plan and were supported by a detailed alternative screening discussion and selection of high priority alternatives. While the alternatives discussion formed the back bone of the Plan, short-term tactics were identified that included various technical and institutional rationale statements capable of supporting anticipated upcoming discussions and negotiations. Key to these discussions was the Los Padres Dam and Reservoir *question*. Any upper basin water supply development initiative would need to determine the ultimate fate of this facility. A tactical decision process (or "if-then") sequence of steps was developed to demonstrate the interactive complexity of issues between the primary parties; MPWMD, Cal-Am, the SWRCB, and National Marine Fisheries Service ("NMFS") related to Los Padres Dam and Reservoir.

A hybrid alternative consisting of both the removal of Los Padres Dam and new off-mainstem storage development was determined to best meet the long-term needs of water supply, instream flows, and fish passage within the watershed and represented the most effective means of maximizing beneficial use of the basin's available hydrology.

A strategy that proposes new upper basin water storage development, while perhaps questionable in the past, must be considered in a different light today. Here in 2014, much has changed since the 1990s. We are facing one of the State's worst droughts on record, an increasing recognition of the uncertain effects of future climatic changes, and the Statewide acknowledgement from both the regulatory agencies and water industry of the high priority being placed on developing new water storage. Fortunately for Carmel River watershed, the *hydrology is on their side* – there is uncaptured water available in many years. New water storage development is no longer the flawed concept based on adverse environmental effects that it once was.

This Plan can hopefully provide the impetus to help rekindle interest in upper basin priorities and opportunities within the Carmel River watershed. As the established water resources management entity for the basin and, therefore, unlike other more specifically focused agencies, MPWMD is the best suited to **see all of the values, possibilities, and options available** in creating a solution that can serve all water resource interests, public and private, both now and into the future.
This Plan can provide critical guidance to:

A. **Support negotiations with Cal-Am, NMFS, other public trust resource agencies (e.g., SWRCB, CDFW, etc.), and vested watershed stakeholders, and,**
B. **Provide an immediate near-term and longer-term planning and options strategy in the form of a tactical "road-map".**

It is envisioned to represent an ongoing dynamic document that can be constantly updated, reconfigured, and reevaluated to ensure that MPWMD retains effective oversight of its various options and most importantly, does so with the full breadth of knowledge of the various interrelated issues.

1. Introduction

The Plan augments a rich archive of existing information and data and reevaluates MPWMD's long-term water supply security amidst the uncertainty associated with it's relied upon infrastructure and future plans. Watershed hydrology is reassessed to reconfirm available surplus yield within the basin and relevant sub-basins. Existing and anticipated future water supplies and demands are presented to illustrate the differential in yield demand and allocation. Threats to authorized entitlements, relative to existing claims (e.g., water rights) are presented to demonstrate regulatory security. Using the reconfirmed hydrology, Los Padres Dam and Reservoir, together with various operational prescriptions and mandates are investigated including potential options for future management of the facility. Numerous technical and institutional rationale statements are generated that address specific elements of the Los Padres Dam and Reservoir query.

The broader Monterey Peninsula Water Supply Project (or "MPWSP") is acknowledged as MPWMD's preferred or proposed project for overall water supply security on the Peninsula. This includes the Groundwater Replenishment Project ("GWR") and associated Aquifer Storage Recovery ("ASR") program that are part of the MPWSP. The large investment, time commitment, and collaborative success to date (as reflected in the recently ratified Settlement Agreement among the Parties) confirm the legitimacy of the MPWSP as MPWMD's current priority. The long-term prognosis of Los Padres Dam and Reservoir, however, remains a vital interest to MPWMD and its ultimate disposition will have a notable effect on future water management flexibility within the Peninsula. The larger Carmel River watershed, Los Padres Dam and Reservoir, and the upper source areas that define inter-annual runoff from the basin cannot be ignored regardless of the intended implementation of the MPWSP.

Ultimately, a viable permanent regulatory solution for the watershed must be established. The continually growing complexities in regulatory compliance compel a robust examination of how strategic measures planned today can best achieve synchronicity between watershed management goals and regulatory fidelity in an unknown and highly dynamic future. Current and future infrastructure, together with their range of operational parameters must be capable of ensuring that regulatory compliance can be sustained. Otherwise, any prescription identified today will only end up as an interim fix. The long-standing effects of Los Padres Dam and Reservoir on the Carmel River are well known. Keeping it intact will require creative alternatives for new water storage development and would likely detract from the potential benefits offered by recently identified off-mainstem storage options. Exploring the range of how influential Los Padres Dam and Reservoir have become under current regulatory conditions will help set the framework under which an ultimate regulatory solution for the river can be developed in the immediate next phases.

Accordingly, this Plan explores a range of options that include various levels of commitment towards continued reliance on Los Padres Dam and Reservoir. Such options include the full range of potential water supply alternatives, many which have been investigated previously and some which have not. Since the focal point of the Plan is the genuine outlook of Los Padres Dam and Reservoir, hybrid alternatives that include various elements of a retained Los Padres Dam and Reservoir are also identified. Recommendations are offered for the option(s) that not only meet MPWMD's planning principles but also achieve the highest ranking under a two-tiered screening process. The planning principles represent the initial tier and the screening criteria the second tier (see Chapter 9). Finally, to integrate the numerous interconnected and interrelated parties, issues, and objectives, a short-term decision tree or "if-then" road-map is presented. This is intended to serve as a tactical decision support tool to help MPWMD not only maintain a broad overview of its immediate decisions, but also keep focused on the many complex and sometimes competing interests that are part of any longer term strategic plan.

The Plan was not intended to focus on large scale flood control and flood damage protection measures. While flood control is a continuing issue within the watershed, both inherent hydrology and drainage configuration do not provide the means to effectively reduce seasonal flood peaks without reinstating major mainstem facilities. The mainstem of the Carmel River through the urban portion of Carmel Valley begins to flood at as little as 6,000 cfs, with large areas of the valley at risk of being flooded at flows above 10,000 cfs. Without a significantly sized new mainstem reservoir downstream of the Tularcitos Creek confluence, attenuation of seasonal flood peaks would likely not be possible as individual upper basin storage options on the tributaries would be too small. Constructing additional facilities within the tributary basins to address flood control alone would be impractical for all intents and purposes.

The Plan is consistent with the hydrologic edict that emphasizes putting as much of the available yield generated within a watershed to maximum beneficial use. The unique circumstances and physical conditions of the watershed provide tangible opportunities for MPWMD to meet many of the water supply needs of the Peninsula's water users, while also directly addressing many long standing issues related to sediment management, fisheries passage, water quality, flood control, and the uncertain effects from future climatic forcings.

The SWRCB acknowledges that, in the context of the MPWSP, "the ongoing development of unique solutions tailored to the specificconditions that apply to a given groundwater basin, reflects the understanding that <u>waters in California are too valuable not to be utilized to the maximum extent possible</u> ifbeneficial uses and other legal users' rights are maintained". [Emphasis added] (SWRCB, Draft Review of California American Water Company's Monterey Peninsula Water Supply Project, p.30).

This Plan reaffirms the SWRCB statement above, and strives to fully explore the potential to seek and establish a physical solution for natural surface water development in the Carmel River watershed, taking advantage of the unique hydrological characteristics of the basin to maximize development of available yield. With the ongoing uncertainties associated with future climatic forcings and the range of potential implications to basin hydrology relied upon by MPWMD and its watershed responsibilities, it would seem appropriate that MPWMD carefully consider how such future hydrological changes could best be put to beneficial use.

It is noteworthy to remember that MPWMD's original mandate was to *expand existing water supply* within Monterey Peninsula and protect and restore the natural resources of the Carmel River. The importance of these responsibilities was accentuated by the prolonged drought of 1988-92. In fact, by the mid-1990's, MPWMD had identified the need to improve the Peninsula's water supply system for drought protection, meet a moderate amount of future demands on the Peninsula, and maintain vital instream flows in the Carmel River. A Final EIR on the then Monterey Peninsula Water Supply Project (which used the same name as the current MPWSP) was completed in 1994. Many of the same priorities identified 20-years ago still exist today.

2. Purpose and Scope

The Project Objective is to prepare a **multi-faceted long-term strategic and short-term tactical plan** for MPWMD that, through an evaluation of the benefits and risks associated with Los Padres Dam and Reservoir, will generate technical and institutional information that can be used as critical guidance to:

A. Support negotiations with Cal-Am, NMFS, other public trust resource agencies (e.g., SWRCB, CDFW, etc.), and vested watershed stakeholders, and,
B. Provide an immediate near-term and longer-term planning and options strategy in the form of a tactical "road-map".

The Plan is envisioned to represent an ongoing dynamic document that can be constantly updated, reconfigured, and reevaluated to ensure that MPWMD retains effective oversight of its various options and most importantly, does so with the full breadth of knowledge of the various interrelated issues.

3. Key District Planning Principles

MPWMD's current challenges are guided by several key edicts or planning principles. Each of these principles represents the primary standards upon which MPWMD desires to pursue any long-term solution. These key planning principles include:

A. Water Supply Security and Sustainability
B. Enhanced Fish Passage
C. Implementation of Effective Sediment Management
D. Maintenance of Target Instream Flows
E. Consideration of non-Cal-Am Water Rights Holders

A successful strategy, both in the near- and long-term, will clearly demonstrate the ability to meet each of the key planning principles.

4. Watershed Hydrology

4.1 Watershed Climatology

The watershed of the Carmel Valley is characterized by a semi-arid Mediterranean climate with moderate to warm summers and mild winters. The combined effects of local topography and proximal marine influence result insubstantial variations in climate between coastal and inland areas. This variability often occurs over very short distances. For example, the average annual maximum temperature in Monterey is 5.4°F lower than in Carmel Valley while the average minimum temperature in Carmel Valley is 3.9°F lower than in Monterey. The warmest months of the year in Monterey are September and October, while the warmest months of the year in Carmel Valley are August and September. December and January are the coldest months in both locations.

Virtually all of the precipitation is rainfall, with about 90 percent falling between November and April. The average annual precipitation is 19.72 inches in Monterey, while it is 12% lower, at 17.39 inches in Carmel Valley. Rainfall totals vary widely from year to year, and from one location to another. Precipitation records for Monterey show a low of 8.95 inches in 1953 and a high of 41.01 inches in 1998; while in Carmel Valley the record low year was 1961, with 8.88 inches and the record high was 28.42 inches in 1969 (Donaldson, 2010). In the upper portions of the watershed (at San Clemente Reservoir), the long-term (i.e., 1922-2008) average is 21.38 inches with a maximum of over 46 inches (MPWMD, 2009).

Such variability provides challenges for water resource managers. Yet from a water supply development and long-term sustainability perspective, the years with significantly elevated precipitation levels (e.g., high standard deviations from mean) can provide the yield necessary to meet carryover needs if properly managed. More on these management options are discussed later.

As the Pacific winter storms track towards land, the Santa Lucia Range is the first topographic barrier that is encountered with elevations quickly exceeding 4,400 feet above mean sea level (msl). Atmospheric circulation rotates storm tracks in a counterclockwise direction, so the storm fronts tend to strike the Central Coast from the southwest, directly against the crest of the Santa Lucia Range at the Carmel River watershed divide. Consequently, orographic effects generate high volumes of rain along the southwestern margin of the watershed from the basin headwaters at the Ventana Cones. Locations as near as the Carmel Valley lie in the immediate rain shadow where far less precipitation falls (Donaldson, 2010).

As an example of the spatiality in precipitation distribution, three sub-basins within the watershed, Pine, Garzas, and Black Rock/San Clemente, produce 27% of the annual Carmel River flow, but account for only 15% of the entire Carmel River watershed area (Donaldson, 2010). The upland or source areas for the Carmel River are the major source of water reaching the lower valley and thus, currently represent the primary water source for the greater Monterey Peninsula. **From a surface water perspective, properly accounting for current and future anticipated yield generation from this vital area of the watershed will ensure that available water assets are put to maximum beneficial use.**

4.2 Future Climatic Forcings

The Central Coast and indeed California are subject to the strong influence of global ocean/atmosphere circulation in varying periodicities; the longer term Pacific Decadal Oscillation (PDO) which occurs every 20-30 years and the short-term El Niño/Southern Oscillation (ENSO) which occurs every 3-7 years. Both modes or oscillations are driven by the ocean's ability to retain heat longer than land masses or the atmosphere which result in contrasting temperature and pressure gradients. Depending on the PDO phase (e.g., warm or cool) as defined by ocean temperature anomalies in the northeast and tropical Pacific Ocean, it can either enhance or weaken ENSO conditions. For example, under a positive PDO with warm north Pacific sea surface temperatures, such conditions would enhance El Niño conditions, but weaken La Niña conditions and vice versa.

It is the inter-annual variability of these phenomena that affects much of the timing, magnitude, and intensity of California's winter rainy season as well as individual storm events. As noted above, the Central Coast is the first area where this moisture stream makes landfall. In the proper phasing sequence, ENSO and PDO act together and during the winter season can affect the southern branch of the Polar jet stream which is delineated by the presence of a slow or stationary frontal boundary with waves of low pressure traveling along its axis. Simplistically, moisture is driven into this frontal boundary by the equatorial rainfall pattern created by the Madden-Julian Oscillation. The combination of moisture laden air, atmospheric dynamics, and orographic enhancement results in some of the most torrential rain events to occur where this frontal boundary makes landfall. Often referred to colloquially as the *Pineapple Express,* given its origins in the equatorial mid-Pacific, these atmospheric rivers of moisture (AR^K) have also given rise to its present moniker, the ARK storm. **For the Carmel River watershed, the long-term shift in the frequency, duration, or intensity of these extreme events could have significant implications to basin yield in particular years.**

While considerable effort has been invested by the research community in determining the effects of climatic forcings (e.g., greenhouse gas or GHG loadings) on global temperature warming and its effects on long-term ENSO and PDO responses, there still exists considerable uncertainty as different models generate differing results. To date, there is no uniform consensus on how global warming will definitively affect either of these ocean/atmosphere circulation phenomena.

4.2.1 Current Knowledge

Under future climatic forcings, anticipated changes in both air temperature and precipitation have been projected for the Carmel River watershed. The Cal-Adapt program of UC Berkeley's Geospatial Innovation Facility have projected such changes from four commonly used Global Circulation Models (GCMs), the Geophysical Fluid Dynamics Laboratory model GFDL (Coupled Climate Model 2.1), the Community Climate System Model Version 3 (CCSM3), the Coupled Global Climate Model 3.1 (CNRM), and the Parallel Climate Model 1 (PCM1).

The projected long-term annual average of the four models for the Carmel area (elev. 335 ft msl) shows a general decline in precipitation between 2010 and 2060 ranging from 16 to 20 inches. Projected precipitation drops to approximately 16 inches by 2100. For the Carmel River highlands area (elev. 2,469 ft msl), the same trends occur with annual precipitation decreasing to between 28 and 36 inches. By 2090, this is expected to be about 32 inches and by 2100 further decline to approximately 27 inches. All of these projections were based on the commonly used high emission GHG scenario (A1). The declines are consistent, but not as steep under the low emission scenario (B1).

Using the analyses from the National Weather Service Cooperative Station and PRISM Climate Group gridded data, the most recent California Water Plan Update 2013 reviewed simulated projected precipitation across California including the Central Coast, but generally only concluded that the southern part of the State would be drier and that the northern portion would experience heavier and warmer precipitation. The Central Coast lies near the boundary for what the California Water Plan Update 2013 delineates between north and south.

Similar to the PRISM Climate Group analysis, other recent studies confirm that there exists no clear trend from the many models as to whether precipitation will increase or decrease over the Central Coast and California. Precipitation frequency and intensity play an important role in determining whether overall anticipated annual precipitation totals will change. Pierce et al (2013) for example, noted that 21 of their 25 model simulations showed that precipitation frequency will decrease by 2060 by a mean reduction of 6-14 days per year. Such reduced frequency they claim, could reduce annual average precipitation across the State by about 5.7%, relative to current or historical conditions. Partly offsetting this, however, are their companion results which reveal that 16 of the 25 model simulations showed daily precipitation intensity increasing by 5.3%. So, is there a net gain? Earlier studies by the U.S. Bureau of Reclamation as part of their Congressionally mandated WaterSMART program showed that precipitation across California is projected to generally experience a slight increase during the early to mid-21st century (2020s and 2050s) followed by a reversal to a slight decline during the latter part of the century (by 2070s) (USBR, 2011a; USBR, 2011b).

Observed trends in streamflow timing have been well documented in the climate change hydrology literature (Chung, et al., 2009; Cayan, et al., 2008; Mauer et al., 2007; Medellin-Azuara, 2007; Barnett, et al., 2004; Van Rheenan, et al., 2004). Most have tied decreasing precipitation, timing, and in the case of snow dominated watersheds, the onset of springmelt, to warming air temperatures. A recent study has added another mechanism, decreased orographic precipitation enhancement associated with decreases in zonal winds (Luce et al, 2013). Such winds in the lower troposphere are primarily responsible for orographic enhancement. Across the Pacific Northwest these winds have declined between 1950 to 2012.

Westerly lower tropospheric flow is thought to modulate orographic precipitation enhancement. A projected continual decrease in these zonal winds could affect high elevation precipitation and, unless there is a corresponding increase in lower elevation precipitation, overall annual precipitation could also decline. These results appear to contradict previous studies that there has been no significant decline in precipitation over the past 60-years in the Pacific Northwest. The Carmel River watershed is located slightly on the negative side of the projected future zonal wind map (based on the latest 24 model simulations of the CMIP5, 2017-2100 Version 1971-2000 RCCP8.5 (Luce et al., 2013)). This means that it too is being projected to experience future declines in lower tropospheric winds, albeit at levels much lower than that of the higher latitude States.

Long-term projected effects to runoff hydrology in the Carmel River watershed may be tempered by the differentiation in "high" versus "low" elevation precipitation as depicted by Luce et al. (2013). **As described in Subchapter 4.5.2 – Projected Future Unimpaired Flows, even the historical record, when examined using different temporal brackets may be illustrating a trend in watershed runoff timing that has already begun (but has not previously been identified).**

Air temperatures, while part of the atmospheric connection associated with the PDO, ENSO, and the continental land mass, are not as directly relevant to the Plan as precipitation. They are, however, an important element to water balance conditions of the Carmel River watershed as will be discussed later in Subchapter 4.4 – Water Balance.

4.2.2 Uncertainties

Future projections of changing hydroclimatic conditions, namely precipitation, while illustrative for gross scale policy background, cannot be used *exclusively* as the basis for regional and indeed, local water resource planning efforts. The general lack of long-term precipitation data in mountain areas limits our understanding of historical trends and the empirical framework needed to appreciate the impacts of climate variability and change to water resources. This will be discussed later in the context of the precipitation gauges (and their historic records) available from the upper portions of the Carmel River watershed.

The basis for the vast majority of contemporary hydrology-related climate change investigations is GCMs that provide the forcings necessary to alter the hydroclimate drivers that generate runoff. Despite ongoing efforts at refining the spatial scale limitations of these true global models (e.g., spatial downsizing, bias correction, and use of regionally developed climate models or RCMs), the basic premise and constraint regarding scale still exists. GCMs tend to "flatten" even the largest mountain ranges thereby minimizing their influence on air masses and precipitation. To date, GCMs have been effective at characterizing the effects of Hadley cell circulation[1] and the poleward progression of mid-latitude storm tracks. This has been the basis for many of the precipitation and streamflow related studies across the U.S. southwest and the reason for the general agreement in why both hydroclimatic parameters show future decreases. Finer scale resolution of precipitation spatiality based on known atmospheric circulatory mechanisms, inherent physical boundary conditions (e.g., orography), and changing basin runoff-generating characteristics (e.g., antecedent moisture) will help better estimate how our watersheds will respond. For the Carmel River watershed, with such a diverse topographic profile and resulting orography, this will likely have significant implications in future yield generation estimates.

Still, the projected trend sequence for the long-term future is clear and continual. In the long-term, overall precipitation is anticipated to decrease all along the Pacific coast including the Carmel River watershed. In the case of precipitation intensities, there continues to at least be the potential that short-term, intense events, may generate higher than "historic" precipitation in isolated events. **In general, this could have implications for both flood retention and yield retention for beneficial use; two objectives facilitated by a common prescription – *increased storage*.**

From a flood control perspective, several flood control alternatives for the Carmel River have been studied in detail by the U.S. Army Corps of Engineers in a 1981 document titled, "Feasibility Report on Water Resources Development, Carmel River, Monterey County".

The 1981 study estimated that channel capacity downstream of the Robles del Rio gage on Esquiline Road in Carmel Valley Village (the "Village") was 3,500 to 10,000 cfs. Since then, the January 10, 1995 flood event (about 10,000 cfs) inundated homes in the vicinity of the Esquiline Road Bridge in the Village and in the Mission Fields area. The March 10, 1995 event (16,000 cfs) flooded the same areas, as well as many others along the river. However, because the 1995 floods scoured vegetation out of the active channel and improvements were made in the wake of the flood, the February 6, 1998 flood event (14,700 cfs) caused far less flooding and many areas that were flooded in 1995 were not inundated in 1998. Since that time, channel capacity in the lower 16 miles of the river has been affected by both vegetation encroachment, which acts to reduce capacity, and downcutting, which acts to increase

[1]The Hadley cell, named after George Hadley, is a tropical atmospheric circulation that is defined by the average over longitude, which features rising motion near the equator, poleward flow 10–15 kilometers above the surface, descending motion in the subtropics, and equatorward flow near the surface. This circulation is intimately related to the trade winds, tropical rainbelts & hurricanes, subtropical deserts and the jet streams.

capacity. Currently, channel capacity may be somewhat reduced from the 1998 conditions, but it is probably somewhat greater than 10,000 cfs in most areas.

The required storage and effectiveness of various dams that would attenuate a 100-year flood at the Near Carmel gage such that flows would be contained within the existing channel are shown below:

Condition	Volume of Storage (AF)	Flood Magnitude (cfs)
Current		24,000
With Dam Located At:		
Los Padres	16,000	20,500
Cachagua	23,000	13,200
Pine Creek	24,000	13,000
San Clemente	28,000	10,000
Klondike	40,000	6,200

Data are from the 1981 U.S. Army Corps of Engineers Feasibility Report (p.C-32 to C34). Using the San Clemente location as an example, a mainstem dam with 28,000 AF of storage would be required to contain downstream flows within the existing channel. Presuming that a new mainstem dam for flood control is not an option in the Carmel River watershed, new reservoirs on all of the upper watershed tributaries would likely not be able to attenuate a flood peak at the Near Carmel gage to a point where no flooding would occur.

Ultimately, much will depend on actual global GHG loadings, their effect on the PDO and ENSO, and the corresponding robustness of future ARK storms impinging on the Central Coast. Despite continued uncertainties as what the exact magnitude and effect of these collective processes will have on the Carmel River watershed, it is well advised that water resource agencies, management districts, and stakeholders within the basin closely monitor the continued development of this area of study. Subchapter 4.5.2 discusses in more detail the assumptions and metrics used in developing projected future unimpaired flow estimates within the Carmel River watershed under anticipated climatic forcings.

4.3 Watershed Characteristics

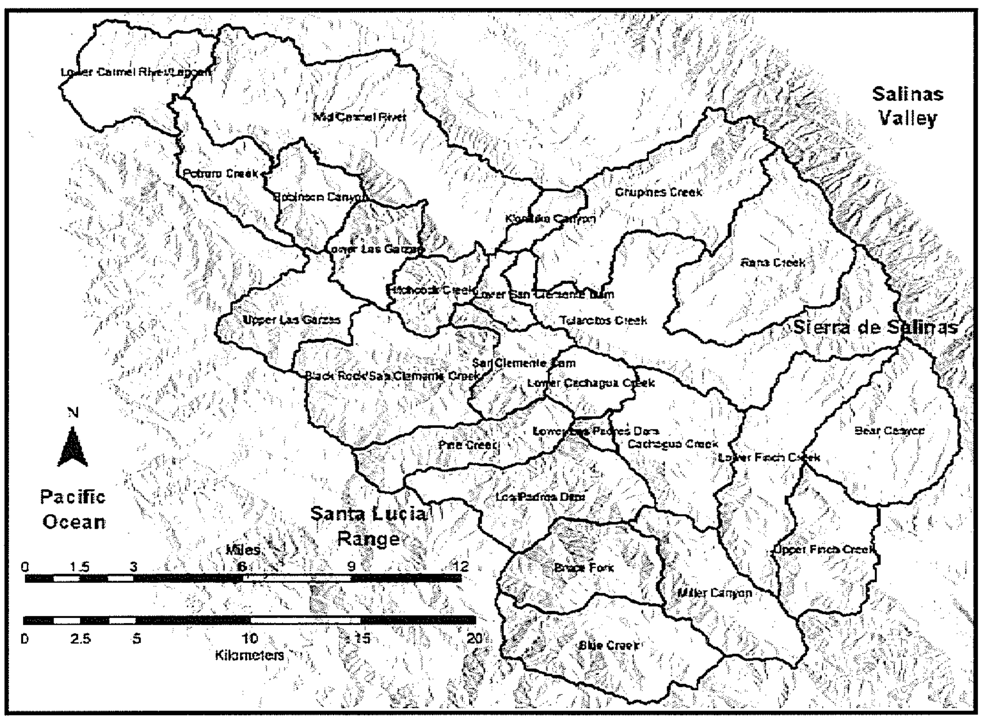
As noted previously, the Carmel River watershed lies between two northwest to southeast trending coastal ranges in Central California; the Santa Lucia Mountains and the Sierra de Salinas Range. The watershed divides rise to approximately 4,500 ft msl along the Sierra de Salinas and to 4,800 ft msl along the Santa Lucia Range with the Ventana Double Cone providing the maximum elevation of 4,853 ft msl. The drainage area covers 656 square km (256 square miles), with watershed runoff following both overland and subterranean routes to reach the coastal Carmel lagoon and Pacific Ocean.

The watershed has been intensely studied over the years and there is a wealth of data and information regarding its many characteristics; hydrologic, pedologic, aquatic, and geologic. The hydrologic function of the watershed including both surface and subsurface processes, as well as the influencing physiologic controls (including boundary conditions) have been previously detailed in Smith et al (2004).

Drainage within the watershed follows a dendritic pattern and highly erosive slopes result in significant stream dissection (approximate Strahler 7^{th} stream order). Past studies have identified 25 tributary watersheds or sub-basins within the Carmel River watershed (**Figure 4.1**). The identification of these sub-basins has relevance later in this Plan in the discussion of potential new water storage alternatives.

As noted by Smith el al (2004), the geology of the watershed plays an important role in determining the physical condition of the watershed and, therefore, its ensuing hydrologic limitations. The physical strength of the rocks and soils determine the erodibility, landslide potential, ecosystem, and land-use potential within the watershed. The combination of the highly variable annual precipitation range and complex geology gives rise to a complex distribution of soil types, erosion rates, slope stabilities, aquifers, recharge areas, and downstream flooding potential.

The watershed is tectonically active and its youthful terrain is demonstrated by the sharply incised higher order tributary sub-basins. The continually evolving geomorphic equilibrium also means that mass wasting processes are often at critical failure thresholds in many sub-basins with side slopes very susceptible to slope failure and extremely high sediment yield when disturbed. Willis et al. (2001) mapped over 1,500 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 watershed. Over steepening during road or subdivision grading has been noted as a significant cause for slope failure and subsequent erosion. From an erosion and sediment yield perspective, however, the single largest cause for massive sediment transport within the watershed results from the entrainment (during high intensity rains) of surficial detrital material from slopes removed of their vegetative cover following massive wildfires.



Source: Smith et al. 2004

Figure 4.1

Sub-basins of the Carmel River Watershed

Since the focus of this Plan centers on Los Padres Dam and Reservoir and the potential alternatives associated with its ultimate disposition, upper watershed hydrology and functionality plays an important role characterizing the hydrologic potential (and options) offered from this vital source area. From the watershed headwaters in the Ventana Wilderness, several high order tributaries drain the highlands in the vicinity of the Ventana Cones towards the Carmel Valley. These high order streams include Bruce

Fork, Miller Fork, Ventana Mesa Creek, and Blue Creek. Headwaters of the Carmel River at the Ventana Cones lie at elevations above 4,500 ft msl.

Base flows (average dry-season flows) in most South-Central California watersheds including the Carmel River are strongly influenced by groundwater which migrates to the surface through faults and fractured rock formations. Base flows are also affected when flow is lost in certain reaches to the groundwater system via faults and fractures. Accordingly, many rivers and streams in this region naturally exhibit interrupted base flow patterns (i.e., alternating reaches with perennial and seasonal surface flow) controlled by geologic formations, and the strongly seasonal precipitation pattern characteristic of a Mediterranean climate.

Hydrologic functionality in the Carmel River was significantly changed with the construction of both San Clemente and Los Padres dams and reservoirs. The Carmel River, long identified by the National Marine Fisheries Service (NMFS) as an important stream within the Central Coast is the current focus of a Final Recovery Plan (South Central Coast California Steelhead Recovery Plan) released in December 2013. Based on 30 effects indicators identified in the Recovery Plan, approximately 33 percent are considered to be in impaired (fair) condition or severely impaired (poor) condition. These indicators have repeatedly identified the lack of surface flows in the mainstem caused by water management activities (*i.e.,* dams, surface water diversions, and excessive pumping of groundwater).

Upstream of the highest impoundment, Los Padre Dam, provides a different picture. MPWMD's previous evaluation of steelhead habitat within the watershed has determined that 50 percent of the spawning habitat is upstream of Los Padres Dam and an approximate 42 percent of the watershed's juvenile rearing habitat exists above the dam. The largely undisturbed riparian attributes and instream physical conditions within the Ventana Wilderness could potentially provide this important fisheries life-cycle function. Additional studies, however, would need to be undertaken to determine the nature, quality, and viability of these areas as suitable habitat.

Details related to specific hydrologic and physical-related elements are expanded upon in later Subchapters as particular components of the Plan are described and discussed at greater length.

4.4 Water Balance

Within a watershed, all of the water falling as precipitation is either: 1) stored in the soil or groundwater, 2) returned to the atmosphere, or 3) released from the watershed via runoff or subsurface flow. A water balance provides an effective means of identifying the *magnitude* of water fluxes available in the watershed and is an important first step in any water availability evaluation.

Most water balances are developed for watersheds where topographic controls maintain water fluxes within a defined area and, therefore, provide a convenient "study" unit. However, they can also be used outside of the watershed context provided that all inputs and outputs for that area are known.

A simplistic water balance can be applied to the Carmel River watershed (**Eqn. 1**):

Eqn. 1

$$P\downarrow = E + ET + RO + GW + \Delta S$$

where, $P\downarrow$ is the annual precipitation, E is direct evaporation from free standing water, ET is vegetative and soil evapotranspiration, RO is runoff, GW is the loss to deep groundwater, and ΔS is the change in watershed storage (typically soil moisture storage). Depending on the water management issue of interest, the equation can be algebraically rearranged to solve for any of the elements. Typically, the element having the least available information or possessing the most uncertainty is isolated such as ET or ΔS.

For the Carmel River watershed, the water balance solving for ΔS can be expressed as (**Eqn. 2**):

Eqn. 2 $$P\downarrow - E - ET - RO - GW = \Delta S$$

"Closing" a water balance requires detailed in-basin data (i.e., keeping the unknown limited to a single variable). In the Carmel River watershed context, knowing the annual water balance provides an important means from which water managers can identify the magnitude and variability of water fluxes and stores within the basin. Knowing the magnitudes of these fluxes and their variability across water years, management prescriptions involving operational, infrastructural, and financial investment can be better prioritized.

The implications of what a water balance provides vary. **It is very important to delineate the difference between *hydrologic* availability and *managed* availability.** A water balance defines the former, hydrologic availability. Man-made infrastructure, operational prescriptions (e.g., accretions such as *imports* and depletions such as *diversions*), and regulatory constraints all affect the means to access this available water resource and, thus, provide a more realistic indicator of the *managed* availability.

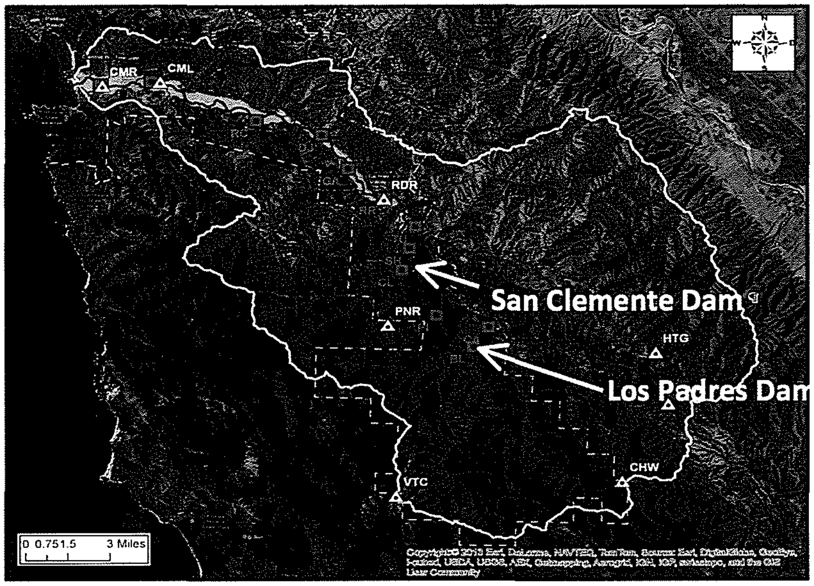
Runoff, along with precipitation, is usually a well-defined water balance parameter (through rain gauges and stream gaging records). Direct evaporation (E) can be estimated through Penman calculations. Similarly, the Penman-Monteith equation predicts net evapotranspiration (ET). Many factors affect ET including: weather parameters such as solar radiation, air temperature, relative humidity, and wind speed; soil factors such as soil texture, structure, density, and chemistry; and plant factors such as plant type, root depth and foliar density, height, and stage of growth. Without an extensive meteorological dataset of these parameters, direct E and ET must be estimated through indices.

A commonly used metric for ET is the *reference evapotranspiration*. This represents evapotranspiration from standardized grass and/or alfalfa surfaces. The California Irrigation Management Information System (CIMIS) operated by the California Department of Water Resources has developed ET Reference zone areas and ET rates for California (see CIMIS; http://www.cimis.ca.gov). The Carmel River watershed is located in Reference EvapoTranspiration (ETo) Zone 6; Upland Central Coast (higher elevation coastal areas). Total estimated annual reference ET within this zone is 49.7 inches. Actual ET is significantly lower as the leaf area index (LAI) in natural environments including forests is significantly less than standardized grass cover over flat terrain. Air temperature, incident solar shortwave, reflected longwave, and windspeed all vary considerably. The turbulent exchange mechanisms that drive transpirative loss are significantly attenuated in forested environments, relative to open grassy terrain. Consequently, in hilly or mountainous terrain, standardizing the energy fluxes (which include the turbulent exchanges such as sensible and latent heat) is complicated by the non-uniform landscape.

Direct evaporation (E) from free standing water bodies is easier to calculate than ET since the surface areas are well delineated and uniform. The energy fluxes necessary to drive the Penman equation, however, still are subject to the same degree of variability. Operational models used in the past such as CV3, CVSIM, and CVPCCALB have all incorporated an ET module including, for example, the assumed 160 acres of riparian habitat extending from San Clemente Dam to the Carmel River lagoon. However, using GIS, MPWMD estimated there were approximately 580 acres of riparian habitat in this reach in 2008 (MPWMD, 2010).

MPWMD has purchased and installed two CIMIS stations at the Pacific Grove Golf Course and Laguna Seca Golf Club. **Additional stations in the upper portions of the Carmel River watershed would help generate a broader and more representative set of ET measurements.**

Precipitation ($P\downarrow$) and runoff (RO), as noted, are the two water balance elements most easily calculated. Precipitation in the Carmel River watershed is well gauged with numerous stations providing hydrometric data. **Figure 4-2** illustrates the locations of both the streamflow gaging stations and precipitation gauges.



Source: M. Hutnak, 2013

Figure 4-2.

Stream and Precipitation Monitoring Stations within the Carmel River Watershed

As noted by Hutnak (2013), **Figure 4-2** depicts the Carmel River watershed showing mainstem of the Carmel River (thick dark blue line), tributaries (thin light blue line), alluvial aquifer (light grey region underlying mainstem), streamflow gaging stations (green squares), climate stations (yellow triangles), and MPWMD boundary (dashed grey line).

Annual measured precipitation within the watershed varies depending on numerous factors. These can be grouped into two categories; *incident atmospheric* and *gauge specifics*. Incident atmospheric factors are largely determined by the intended measurement objective, namely, precipitation resulting from atmospheric moisture content, dew point, storm track, broader scale circulatory momentum, and event intensity. Gauge specifics are related more to location factors both large (e.g., orography) and small scale (e.g., distance to wind breaks, height of adjacent wind breaks, slope orientation, etc.) as well as inherent differences in gauge mechanics (e.g., innate under-catch phenomenon).

Mean monthly precipitation recorded at the Cal-Am San Clemente Dam gauge over the 90-year record (1922-2013) is depicted in **Table 4-1**. The long-term average annual precipitation at San Clemente Dam is 21.45 inches. The period of record maximum was 46.29 inches (1998) and the minimum was 8.87 inches (1924). The 1976 and 1977 water years, commonly used as the single year "worst case" droughts for water resource planning received 9.62 and 10.40 inches, respectively.

Table 4-1

Rainfall at San Clemente Reservoir Site – Water Years 1922-Present (inches/month)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Mean	0.77	2.11	3.94	4.42	4.42	3.33	1.69	0.44	0.13	0.03	0.03	0.15	21.45
Mean YTD	0.77	2.88	6.81	11.23	15.65	18.98	20.67	21.11	21.24	21.27	21.30	21.45	21.45

Source: MPMWD, Monthly Resources Tracking, Rainfall at San Clemente Reservoir Site – Water Years 1922-Present (2011)

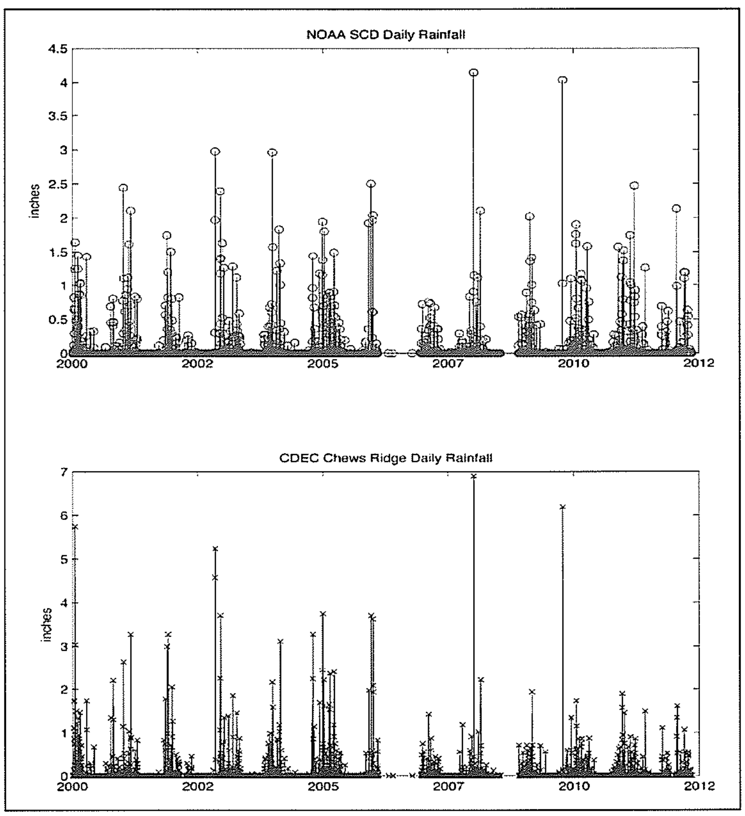
Water Year classifications based on precipitation totals are derived from equally distributed exceedence frequencies and use the following labels as shown in **Table 4.2**.

Table 4-2 Water Year Classifications – Based on Precipitation Exceedence Frequencies						
Extremely Wet	**Wet**	**Above Normal**	**Normal**	**Below Normal**	**Dry**	**Critically Dry**
>31.60	31.60-24.94	24.94-21.66	21.66-19.54	19.54-17.20	15.89-13.09	<13.09
Notes: Values in annual precipitation (inches)						

Source: MPMWD, Monthly Resources Tracking, Rainfall at San Clemente Reservoir Site – Water Years 1922-Present (2011)

Precipitation does vary between locations within the Carmel River watershed. As noted previously, the diverse topography, orientation to incident storm tracks, and local hydroclimatology can and often do result in wide variations in precipitation. As illustrated in Figure 4.2, precipitation gauges exist at various locations throughout the watershed including its headwater source areas.

A comparison of precipitation measured at San Clemente Dam, relative to gauging stations higher in the watershed is illustrative. **Figure 4-3**, for example, shows a comparison of the daily precipitation between the NOAA gauge at San Clemente Dam and the Monterey County gauge at Chews Ridge over the 2000-2012 period. Precise duplication of recorded precipitation in either timing or magnitude is not expected between these two sites as the many factors described earlier differ between the locations. Nevertheless, the temporal patterns are similar and reflect consistency in the ability to record individual storm events of suitable size. Of particular importance is the magnitude difference in recorded precipitation (note the precipitation scale difference) over this sample 6-year period.



Source: M. Hutnak, 2013

Figure 4-3.
Daily Precipitation Comparison
NOAA San Clemente and Monterey County Chews Ridge Rain Gauges (2000-2012)

At considerably higher elevation, the Chews Ridge gauge (approx. 4,307 ft msl) is along the crest line of the watershed and receives precipitation directly from incoming winter season storm tracks. It likely experiences the full effect of orographic moisture release. The San Clemente Dam gauge, situated in the lee of the Santa Lucia Range would not be expected to record similar precipitation amounts.

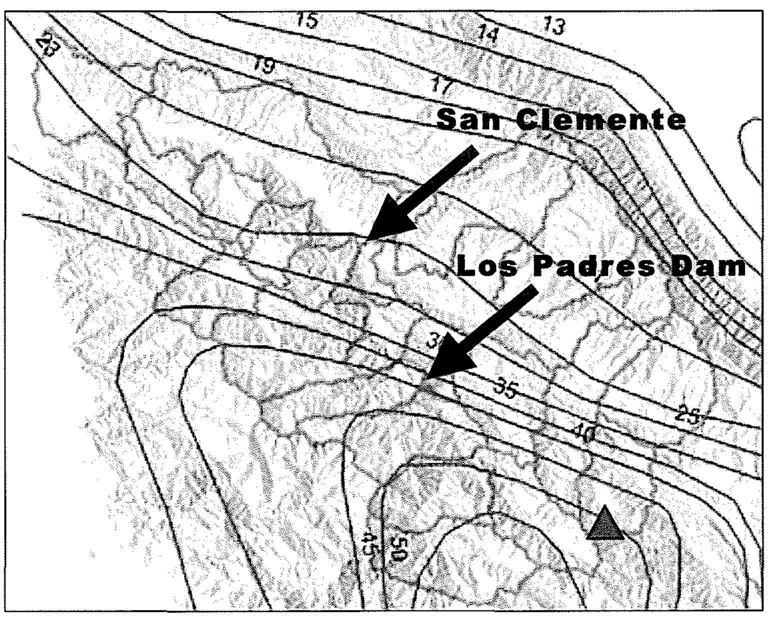
When a comparison of annual precipitation totals between Los Padres Reservoir and the San Clemente Dam is made, the difference in recorded precipitation can be readily observed (**Table 4-3**). For the period 2004-2008 (including a range of WY types), the Los Padres records showed consistently higher (↑) precipitation than the San Clemente site. This is consistent with watersheds under strong topographic control that experience orographic rainfall distribution.

Table 4-3
Precipitation Comparison – San Clemente and Los Padres Dam Sites – 2004-2008

	2004		2005		2006		2007		2008	
San Clemente Dam	18.16		29.95		28.03		11.81		19.61	
Los Padres Dam	24.33	↑33.9%	35.85	↑19.7%	37.37	↑33.3%	13.17	↑11.5%	25.94	↑32.3%

Source: MPWMD (2009)

As illustrated in **Figure 4-4**, the isohyets for the Carmel River watershed show the distinct patterning characteristic of watersheds that encounter frontal weather patterns perpendicular to their cross-watershed topographic profile. Note the higher precipitation totals on the windward slopes of both watershed boundaries (e.g., Santa Lucia Range and Sierra de Salinas). The position of both San Clemente and Los Padres dams, relative to the average annual isohyets is noteworthy, as is the location of the Chews Ridge precipitation gauge (as depicted by the red triangle).



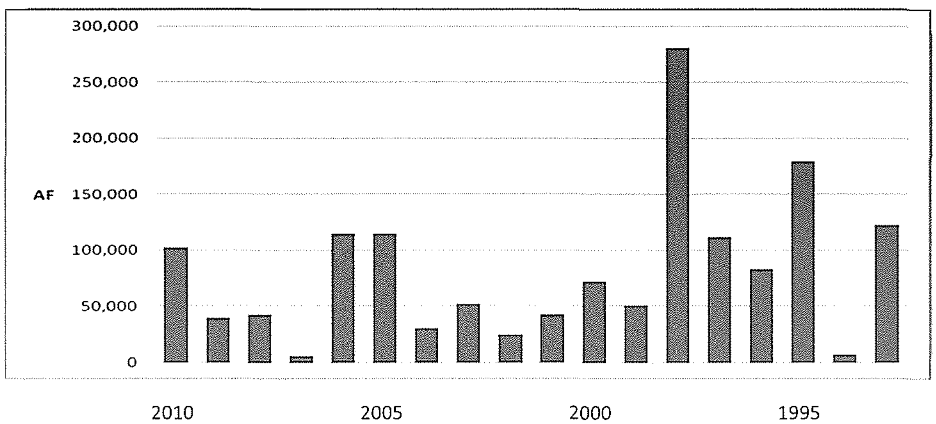
Source: Smith et al. (2004), Figure 18; original taken from Rosenberg (2001).

Figure 4-4.
Annual Average Isohyets for the Carmel River Watershed

As is characteristic with primary, first wave, orographic effects, the leeward side of the initial range shows very rapid declines in precipitation (as depicted by the spacing of the isohyets); note the rapid decline in precipitation from Chews Ridge at the headwaters of Miller Canyon, relative to the lower slopes of Bear Canyon on the Sierra de Salinas about 4.5 miles away. By the second wave, the sharpness of the initial orographic effect has dissipated (as seen by the wider spaced isohyets).

Future water supply assessments involving upper basin runoff potential and, especially those involving anticipated climatic forcings should bracket the entire gauge network with particular emphasis on source area high elevation monitoring. Various methods of areal weightings (e.g., Thiessen polygons) can be applied to establish baseline spatial distributions from historical records. Exclusive reliance on lower elevation rain gauges in the lee of known orographic precipitation deposition will likely under represent watershed potential in incident precipitation.

As described previously, runoff within the watershed and flows observed in the Carmel River are not maintained within and between years. In many water years, flows within the tributaries cease by late summer and in the mainstem Carmel River, it is not unusual for flows in the downstream portions of the river (below near the mouth) to cease altogether during this time. The Carmel River at the Hwy 1 Bridge over the past 18-years shows a wide range of total annual flows ranging from 280,900 AF in 1998 to 6,470 AF in 2007 (**Figure 4-5**).



Source: Data from MPWMD, unpublished, H1 Notepad, modified March 6, 2013

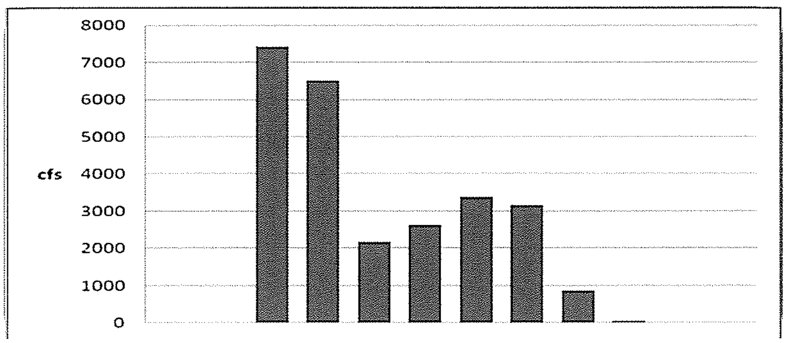
Figure 4-5.
Total Annual Flows at the Carmel River/Hwy 1 Bridge (2010-1993) (AF)

Some investigators have noted this interrupted flow condition as river "dryback" (Cal-Am, 2000). Essentially it defines a condition where the *river front* or point of furthest downstream migration of the permanently flowing stream progresses upstream over the course of the summer season as upstream source flows diminish. Dryback, though not used in contemporary hydrological literature, is a convenient means of describing and quantifying that portion of a stream's discontinuous flow reach that grows and extends upstream over the summer months.

As noted previously, the watershed, owing to numerous factors both natural and operationally related, cannot maintain baseflows throughout the year. **Figure 4-6** shows the total monthly flows in the Carmel River at the Hwy 1 Bridge during a sample normal water year (e.g., 2003). The hydrograph response is marked by a distinct wet and dry season with the onset of seasonal rains and corresponding river flows reaching the mouth by December, followed by streamflow response during and after cessation of the rainy season. In a normal water year such as 2003 (e.g., total annual discharge at the Hwy 1 Bridge of

52,000 AF), five months (i.e., July-November) recorded no measurable flows. In many coastal watersheds defined by sub-basins exhibiting substantial bedrock control, generating limited subsurface baseflow potential, such temporality or "flashiness" in the downstream mainstem hydrograph is not uncommon.

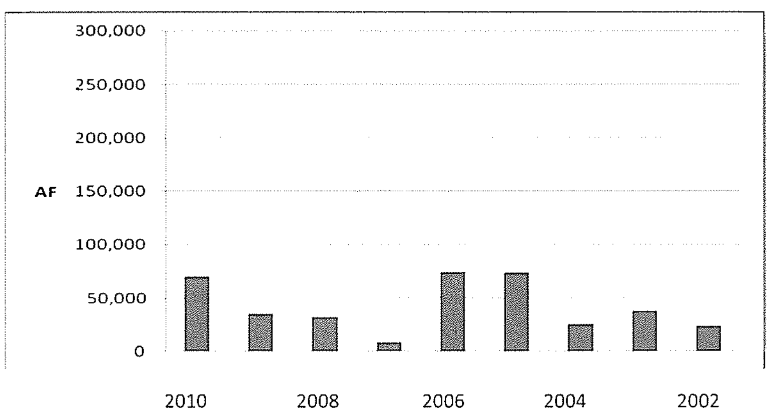
The interaction between upstream reservoirs releases, transmissivity of the subsurface aquifer units (see Subchapter 4.7 – Groundwater), groundwater pumping, and the hydraulic gradients that establish whether the river replenishes the alluvial aquifer or vice versa represents a dynamic process. Antecedent conditions for any of these variables influence the nature of the river at any given geographic point and this state is also temporally highly variable. For example, between Sleepy Hollow weir (RM 17.2) one mile downstream of San Clemente Dam and Robles del Rio (RM 14.3), the river is generally considered to be losing (i.e., recharging the alluvial aquifer), yet continuous flow commonly occurs. From Robles del Rio (RM 14.3) to Don Juan (RM 10.2) the river is generally gaining (i.e., receiving inflow from the alluvial aquifer) and from Don Juan (RM 10.2) to near Carmel (RM 3.6) the river is again losing (Cal-Am, 2000).



Source: Data from MPWMD, unpublished, H1 Notepad, modified March 6, 2013

Figure 4-6.
Total Monthly Flows at the Carmel River/Hwy 1 Bridge in a Normal Water Year (2003) (cfs)

Similarly, in the Carmel River watershed upstream reservoir releases also vary. **Figure 4-7** shows the flows in the Carmel River below Los Padres Dam during the period 2002-2010.



Source: Data from MPWMD, unpublished, H1 Notepad, modified March 13, 2013

Figure 4-7.
Total Annual Flows Downstream of Los Padres Dam (2010-2002) (AF)

From a runoff perspective, flows within and from the Carmel River watershed are indeed highly variable. The two existing upstream impoundments (e.g., San Clemente and Los Padres dams and reservoirs) provide a moderating effect to unimpaired flows, but both facilities have experienced significant reductions in their retention capability over the years. Accordingly, their ability to both store and maintain prolonged releases has been significantly curtailed (see Subchapter 4.8 – Sediment Budget).

Long-term water resources management and planning are often guided by thresholds that help define inherent characteristics (or trends) in hydrology that can provide useful boundaries or standards across which analytical comparisons can be made. Water Year (WY) types are one such threshold. **Table 4-4** identifies the WY types used by MPWMD in defining WY types based on unimpaired runoff at San Clemente Dam. WY types are classified based on the exceedence frequencies from the historical record. The implications of WY types, especially under changing hydrologic regimes are discussed in more detail later.

Table 4-4
Water Year Classifications
Based on Unimpaired Runoff Exceedence Frequencies at San Clemente Dam

Extremely Wet	Wet	Above Normal	Normal	Below Normal	Dry	Critically Dry
<128,900	128,900-102,900	102,900-71,500	71,500-41,900	41,900-29,700	29,700-14,700	>14,700

Notes: Values in annual unimpaired flow (AF)
Classifications are based on selected exceedence frequency values computed from the long-term reconstructed unimpaired flow record at the San Clemente Dam site (1902-2010). "**Extremely Wet**"refers to flows exceeded less than 12.5% of the time; "**Wet**" refers to flows exceeded between 12.5% and 25% of the time; "**Above Normal**" refers to flows exceeded between 25% and 37.5% of the time; "**Normal**" refers to flows exceeded between 37.5% and 62.5% of the time; "**Below Normal**" refers to flows exceeded between 62.5% and 75% of the time; "**Dry**" refers to flows exceeded between 75% and 87.5% of the time; and "**Critically Dry**" refers to flows exceeded more than 87.5% of the time. The exceedence frequencies and associated classes are updated every five years. The next update will occur in WY 2016 based on the 1902-2015 period of record.

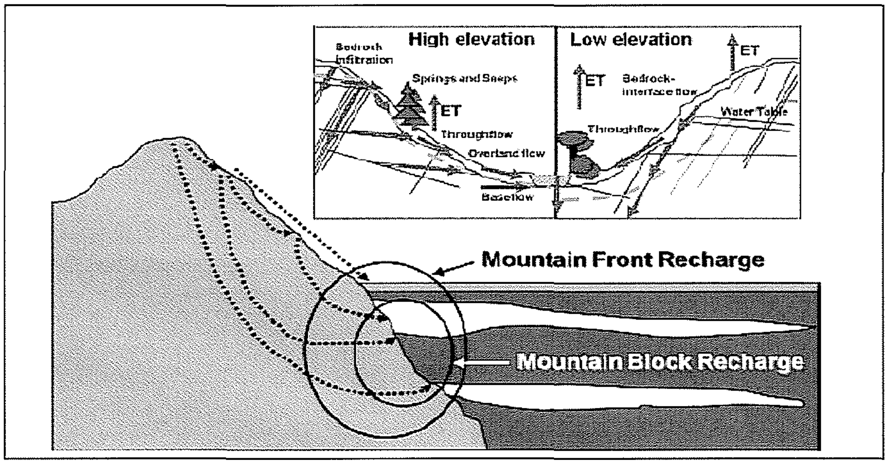
Source: MPMWD, Flow Classes

Groundwater *loss* (GW) is a difficult parameter to calculate. Typically, it represents the residual of that infiltrated and percolated portion from incident precipitation that is not translated into subsurface flow and remains isolated from surface streams (i.e., it does not re-enter the stream as a streambed baseflow flux and thus, is representative of a true loss in the water balance).

Infiltration into bedrock or fractured bedrock has largely been assumed negligible in most rainfall-runoff simulations. Yet the role of bedrock in catchment water balances is both important and unique in its hydraulic connections between mountains and adjacent aquifer systems. Known as mountain front recharge (MFR), this runoff component is an important source of water to valley aquifers in arid and semi-arid regions and potentially applicable to the Carmel Valley. The subsurface component of MFR, referred to as mountain block recharge (MBR) hydraulically connects upland catchments through bedrock flow paths to valley aquifers (**Figure 4-8**).

The MFR/MBR model is likely applicable to at least some portion of the Carmel River watershed and indeed most coastal range watersheds as well as those of the Sierra Nevada and Cascade mountains. Quantifying MBR at the downgradient end of mountain block flow paths (i.e., the valley aquifer) is common where flow is estimated using Darcy equations applied to the bedrock/alluvium contact.

In contrast, quantifying MBR at the upgradient end at the beginning of mountain front flow paths is not common. Here, bedrock hydrology often complicates upland catchment water balance and runoff generation studies. The paucity of information about infiltration into bedrock is a primary reason for this uncertainty and is due to the difficulty in applying hydrometric methods to measure and estimate bedrock infiltration, particularly where bedrock permeability is dominated by fractures beneath the soil mantle. Water that infiltrates bedrock may be routed to adjacent streams or move into deep bedrock groundwater systems and be treated as a "loss", in the water balance. As noted by many authors, this interaction of catchment water within bedrock has received a variety of labels including *deep seepage, deep percolation*, *bedrock infiltration*, and *net groundwater recharge*. As noted above, consistent among all of these terms is that groundwater does not re-emerge within the watershed boundary.



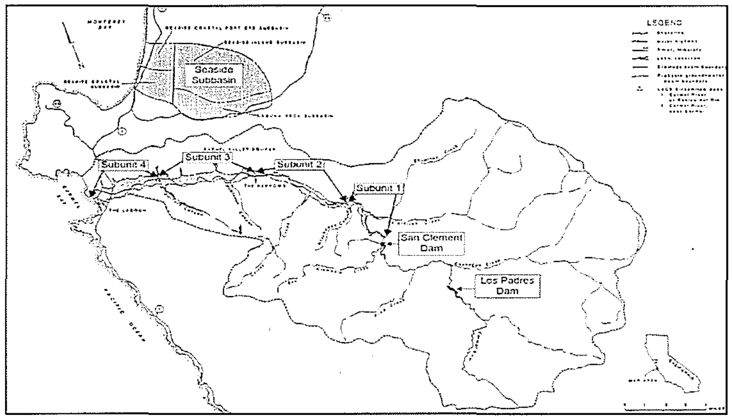
Source: P, Aishlin and J.P. McNamara (2011)

Figure 4-8.
Conceptual diagram for MFR and MBR.
Insert diagram depicts sub-catchment routing of precipitation that may include discharge of groundwater to streamflow and subsequent streamflow loss to groundwater recharge via channel seepage.

For the Carmel River watershed, it seems likely that upland subsurface flow provides some of the baseflow in the upper basin mainstem and tributary streams. Whether this flux remains as a subsurface contributory mechanism along the entire reach of the Carmel River is uncertain. While some have suggested that the watershed subsurface flux may have been sufficient to maintain flows in the Carmel River year round prior to construction of San Clemente Dam (e.g., Williams, 1984), it is unlikely given the watershed's steep topography, shallow overburden, primary alluvial aquifer (for the mainstem), and truncated rainy season. **Each of these factors work against the likelihood that perennial flows (in all water years) could have been maintained prior to the construction of either San Clemente or Los Padres dams.**

To date, most groundwater simulation models for the watershed have assumed that primary inflows begin downstream of San Clemente Dam. The subsurface flux is translated through four sequential and distinct subsurface units (**Figure 4-9**).

In water balances, that portion of subsurface water often lumped together with groundwater is the unsaturated portion that exists in the upper soil zones (e.g., vadose water). This is water that has infiltrated the surface, percolated to some depth, but is physically distinct from groundwater. Since this water did not reach the potentiometric surface (commonly known as the water table) where the total pressure head is zero, it does not adhere to the same transmission principles as groundwater. Water in the vadose zone exists under negative total pressure head (i.e., it takes positive pressure to *extract it*). This water is a vital element of the water balance as it is often represented as soil moisture; thus, supplying the water necessary to maintain surface vegetation, soil weathering processes, and microbial activity (e.g., L,F, and H soil horizons). Its total volume is also temporally variable and at any one time is often referred to as antecedent soil moisture.



Source: From Hutnak (2013), Figure 1-1, original taken from Fuerst and Litwin (1987), CVGWM91 groundwater domain

Figure 4-9.
Groundwater Subunits in the Carmel River Watershed

Water balances for certain areas within the Carmel River watershed have been developed previously. Smith et al. (2004) for example, referenced an earlier effort by RSC (1994) where, a water balance for the region above the upper Garza Creek watershed was identified. In that water balance, water balance components were expressed as a percentage of incident rainfall. They presented the following:

Water use	% of rainfall
Evapotranspiration	64%
Stream flow	23%
Groundwater recharge	13%

Smith et al. (2004) confirm that rainfall is the only source of new inter-annual water in the watershed (i.e., it assumes the basin is "closed"). For all intents and purposes this is accurate. There is always some limited amount of inter-basin transfer through the phreatic stores since potentiometric gradients rarely align precisely with surface topography and vadose water flow paths are very event-specific and difficult to characterize at the watershed scale. But for the most part, the watershed can be considered isolated from inter-basin transfer. In the Carmel River watershed, therefore, what falls as precipitation during the rainy season is the total amount of new water available for the ensuing (and carryover) water years.

While the streamflow and ET proportions in the Smith el al. (2004) depiction seem generally appropriate, the groundwater recharge component is left for discussion. As described previously, groundwater recharge is a process that does not define the ultimate steady-state for phreatic water. In other words, groundwater may be transient, permanent, or lost to the system completely.

Robust water balances of the kind defined by Eqn. 2 noted previously have not been meticulously developed for the Carmel River watershed at large or, its many tributaries. As with most watershed

management efforts, reliable, continuous, and spatially representative data monitoring stations are required to provide the base level information to reliably calculate the watershed balance. Many individual elements have been documented in past investigations within the watershed. Moreover, agencies and interested stakeholders continue to expand the data network necessary to generate such data.

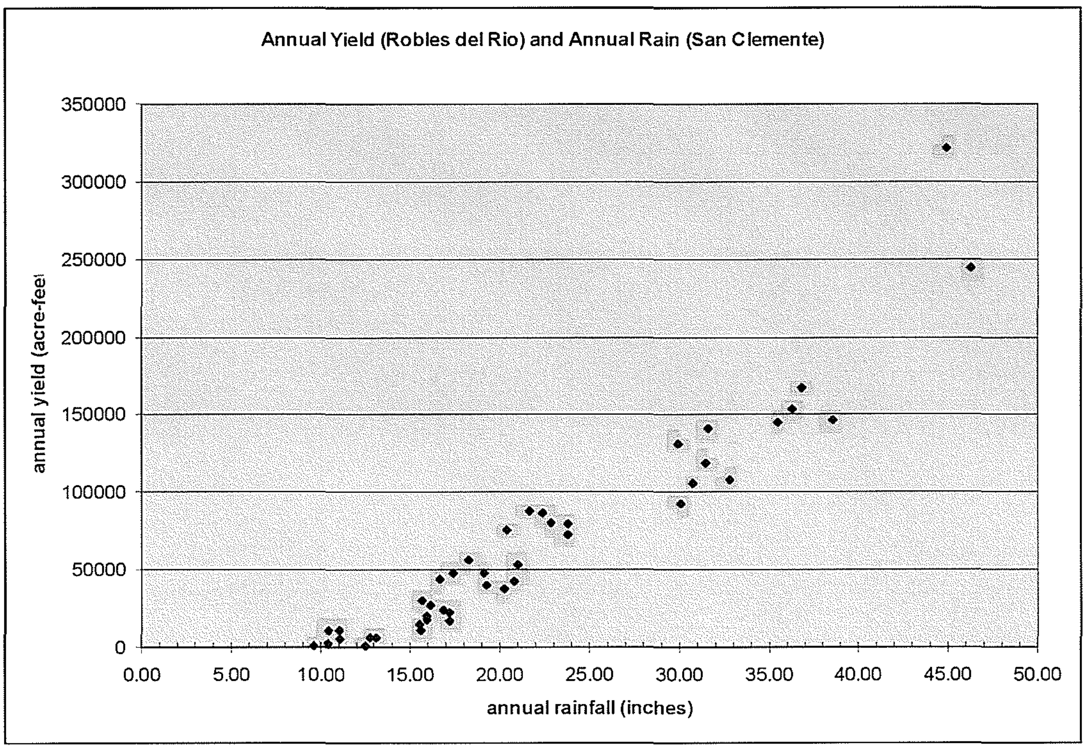
4.5 Baseline Hydrology

Understanding the baseline hydrology of the Carmel River watershed is important to help define the limits of any proposed operational prescriptions including potential water supply options. As part of the development of this Plan, existing Carmel River watershed streamflow runoff information were evaluated in order to verify the hydrologic constraints and opportunities that exist in the watershed. This section focuses on various aspects of the watershed's baseline and anticipated future hydrology.

4.5.1 Historical Unimpaired Flows

There has been significant evaluation previously regarding impaired and unimpaired flow in the Carmel River watershed. Information presented here constitutes a brief technical summary of that information.

The U.S. Geological Survey reports the streamflow of the Carmel River at gage "Carmel River at Robles Del Rio" (USGS No. 11143200).The Carmel River drains 193 square miles at this gage site which is located about 0.2 miles downstream of Hitchcock Canyon. Flow information represented by this gage is the total annual runoff past the Robles del Rio Gage as a function of the rainfall at San Clemente Dam. Flow at this site is regulated by both Los Padres Reservoir and San Clemente Reservoir located upstream. **Figure 4-10** below plots the Annual Carmel River Runoff at Roble del Rio Stream Gage and Annual Precipitation at San Clemente Reservoir.



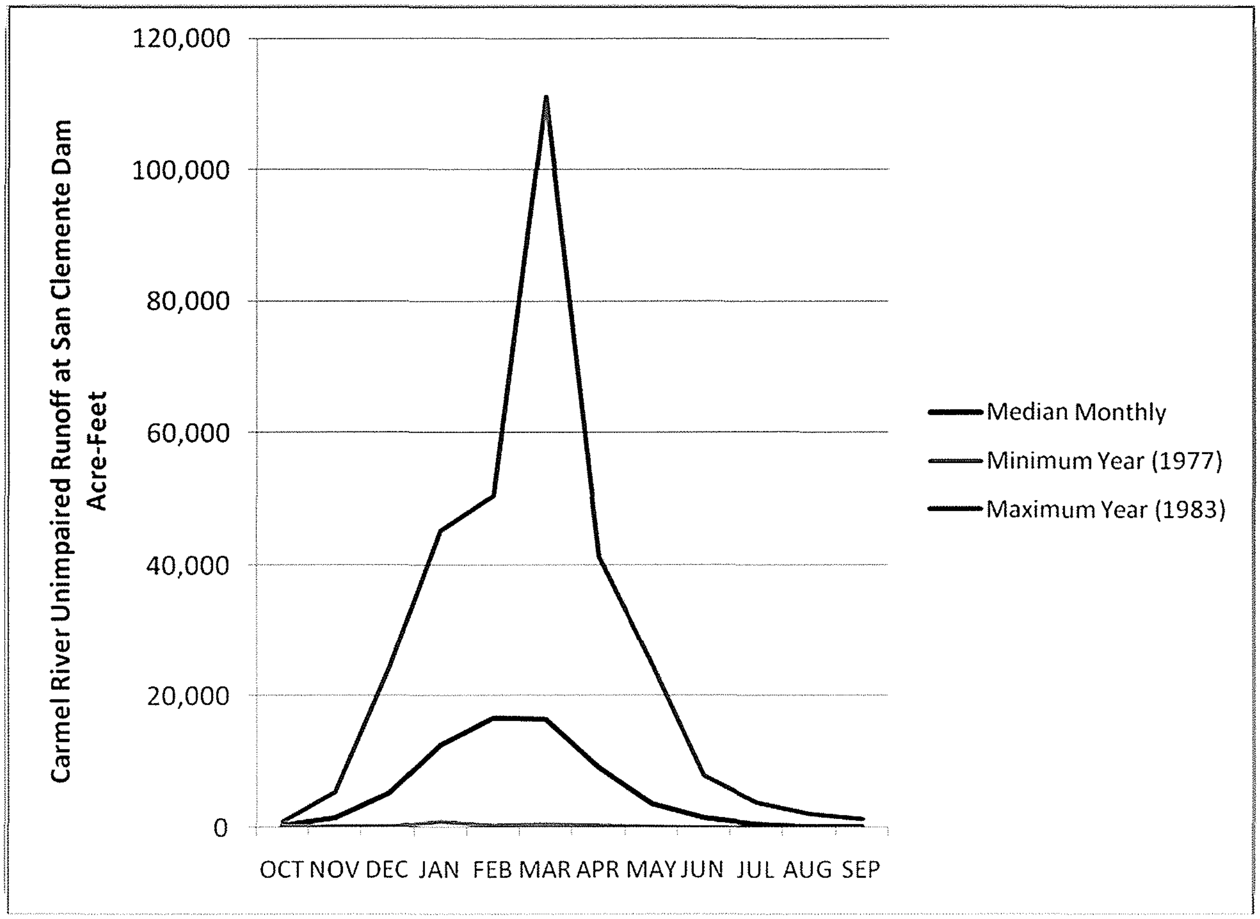
Source: Smith et al.(2004).

Figure 4-10.

Annual Carmel River Runoff at Roble del Rio Stream Gage and Annual Precipitation at San Clemente Reservoir

Historical annual runoff at the Robles del Rio stream gage ranges from very low (2,600 AF in water year 1977) to over 300,000 AF (320,000 AF in water year 1983). During 1977, a critically dry year, records indicate no flow during April through November in the Carmel River at this location.

Unimpaired runoff of the Carmel River at the existing San Clemente Dam site has been estimated by the MPWMD for the period of 1902 through 2013. **Figure 4-11** below plots the Annual Carmel River Unimpaired Runoff at the San Clemente Dam site.



Source: Developed from information provided by MPWMD.

Figure 4-11.
Monthly Unimpaired Carmel River Runoff at San Clemente Dam

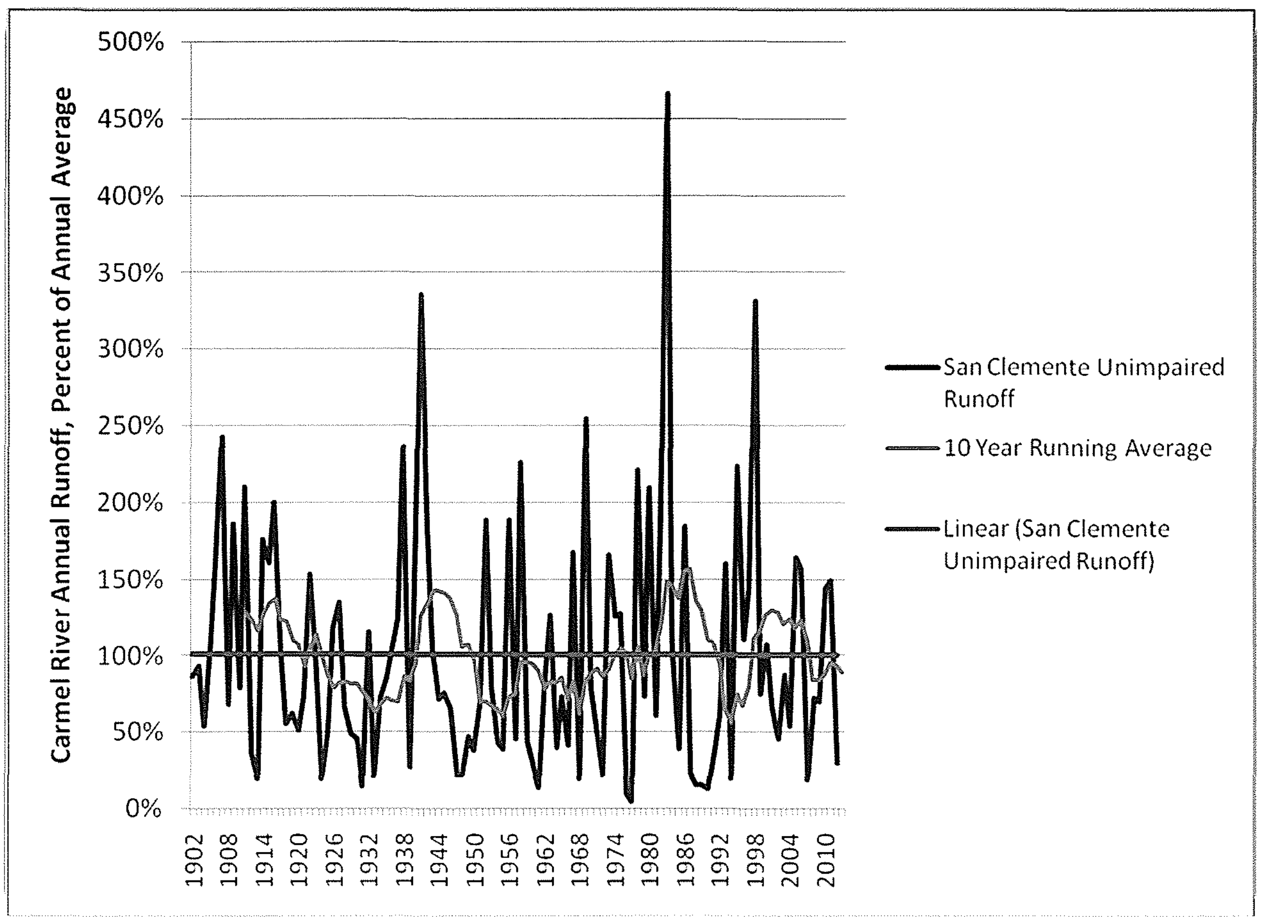
Estimated unimpaired runoff of the Carmel River at San Clemente Dam site varies significantly over the year and over different year types. Annual unimpaired flow at this location ranges from a low of 2,855 AF in water year 1977 (the single driest year of record) to about 318,000 AF in water year 1983 (the single wettest year of record). On average, about 75% of the annual precipitation falls in the watershed during the four month period of December through each year. This corresponds to the runoff hydrograph shown in Figure 4-11.

The significant variation of runoff occurring in the Carmel River both throughout the year as well as from year to year, make water storage within the watershed very attractive as a means of capturing and holding runoff during times of high flow and making it available in times of reduced runoff in order to meet a variety of instream demands (e.g., Cal-Am diversions, non-Cal-Am water right holder withdrawals, ASR, Table 13 water rights, instream flows, fish passage, and some, although limited, flood retention benefit).

4.5.2 Projected Future Unimpaired Flows

Itis typical to utilize historical runoff information when evaluating watersheds and formulating project alternatives. Future changes to expected runoff (due to climate changes for example) is important to consider as it can, in some instances, directly influence water resource strategies and specific formulation of potential water supply alternatives. The potential implications of continued (or even accelerated) climatic forcings on the hydrology of the Carmel River watershed were discussed earlier.

One way to evaluate possible future changes in watershed runoff is to examine the historic runoff information for potential trends that might appear historically and consider if these trends might continue into the future. Review of the historical annul runoff information of the Carmel River at the San Clemente Reservoir is shown below in **Figure 4-12** for the period of 1902 through 2013 in percent of annual average.



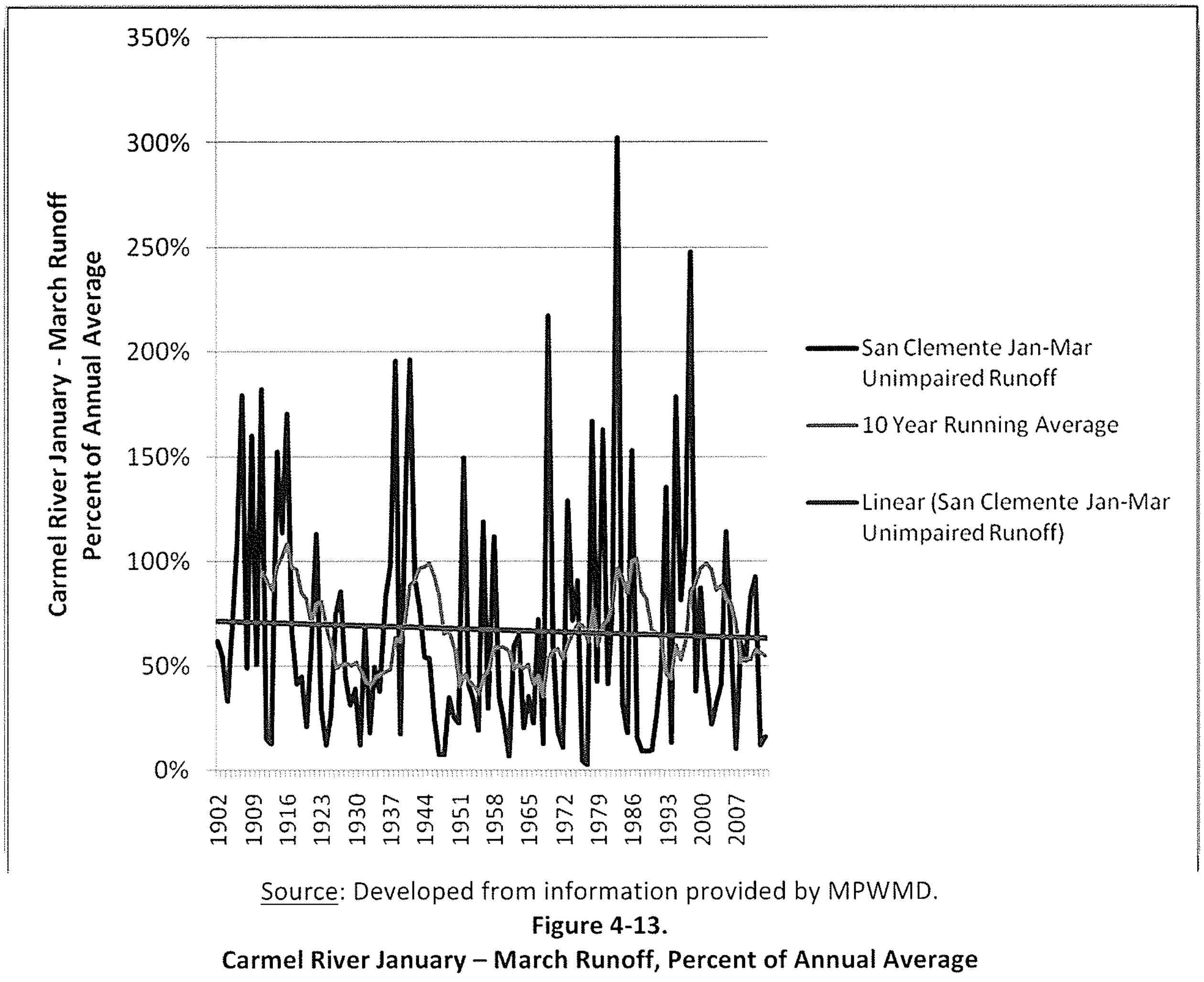
Source: Developed from information provided by MPWMD.

Figure 4-12.

Carmel River Annual Runoff, Percent of Annual Average

The 10-year running average of annual runoff information of the Carmel River is shown in Figure 4-12 as well as the linear trendline of the annual values. There does not appear to be a significant trend that would indicate more or less annual runoff in the Carmel River Basin at the San Clemente location over the 1902 through 2013 period. It is interesting to note that in this 112-year flow record, the driest three years all occurred in the second half of the period (i.e., in 1976, 1977, and 1990) and 3 of the 4 wettest years also occurred during the second half of the record (i.e., in 1969, 1983 and 1998). Water year 1941 was also a very wet year, the second wettest on record. Observing that the driest and wettest years all occur in the second half of the flow record could be an indication that while the annual runoff of the Carmel River seems to be consistent *over time*, the annual variation in runoff could be increasing with more drier years and more wetter years.

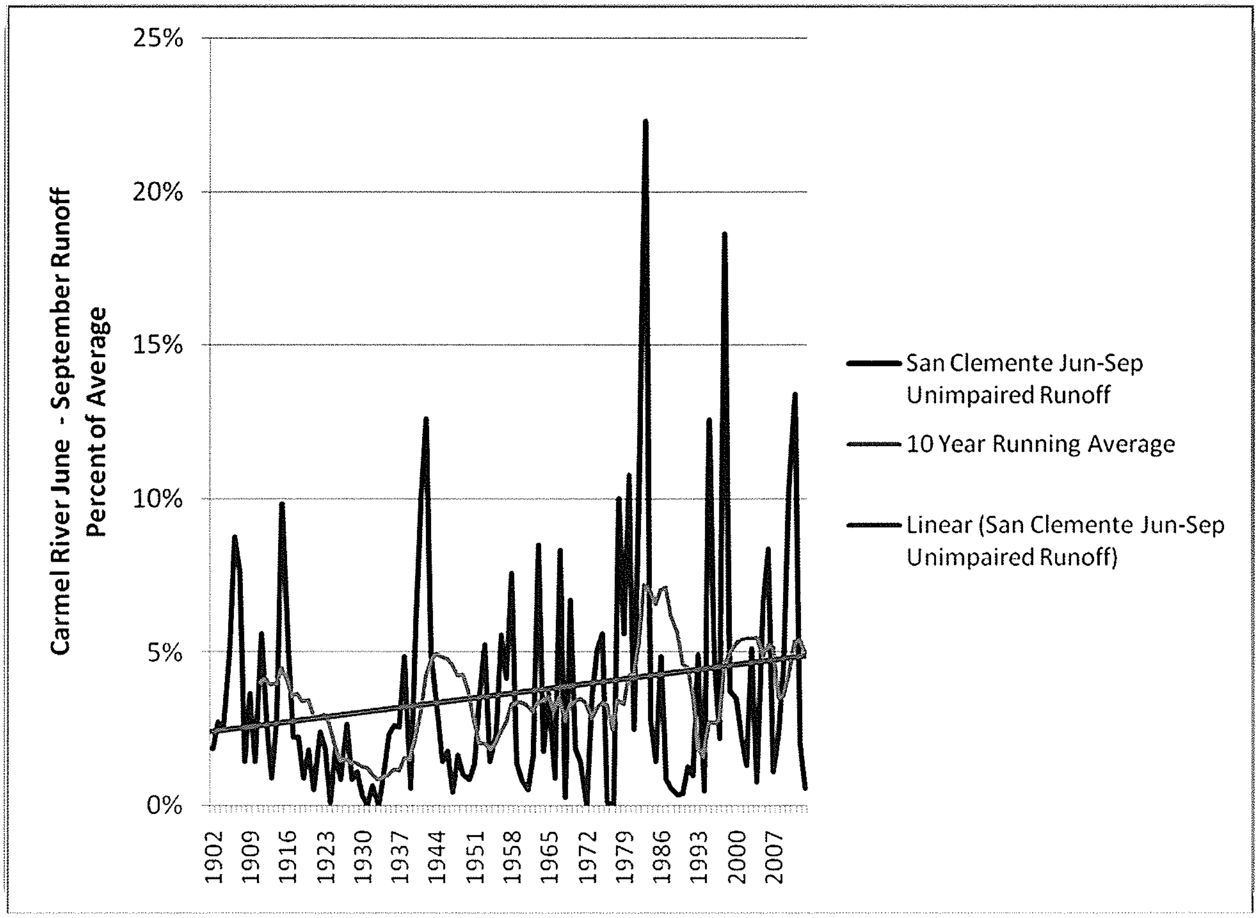
The monthly unimpaired runoff information of the Carmel River was examined in a number of different ways seeking possible trends that might be expected to continue into the future. Many of the examinations did not indicate a significant trend in hydrology. An interesting possible trend, however, was revealed when considering the wettest three month period of the year in terms of runoff which occurs during January through March. **Figure 4-13** below is a plot of the January through March runoff at San Clemente as percent of the water year runoff.



Source: Developed from information provided by MPWMD.

Figure 4-13.
Carmel River January – March Runoff, Percent of Annual Average

There seems to be a slight downward linear trend in January – March Carmel River runoff. Since the annual runoff of the Carmel River seems to be remaining about the same over time, this could indicate that there is a trend towards more runoff occurring outside of the wettest three months of January through March. The Carmel River runoff occurring during the January – March period seems to be increasingly representing less of the total water year runoff. To see if other parts of the year may be contributing more, an evaluation of the June through September period was undertaken. **Figure 4-14** below is a plot of the June through September runoff at San Clemente as percent of the water year runoff.



Source: Developed from information provided by MPWMD.

Figure 4-14.
Carmel River June – September Runoff, Percent of Annual Average

There seems to be a slight upward linear trend in June – September Carmel River runoff, as a percentage of total annual runoff. Albeit small (e.g., 2.5% increase over the 105-year record), this increase, if real, seems to be counter to climatic shifting trends involving increased air temperatures. Increasing air temperatures over the past century would have the general effect of enhancing the turbulent exchanges within the watershed; increasing both sensible and latent heat fluxes that drive evapotranspirative losses. With a notable change in precipitation, such basin water losses would have the effect of reducing not increasing streamflow during these times of the season.

The Carmel River runoff occurring during the June – September period seems to be increasing as a percentage of the total water year runoff, though part of this could be reflected from dry season reductions in pumping by Cal-Am since the early 1980s.

4.5.3 Water Year Type Trends

Since water year type definitions for the Carmel River watershed are based on thresholds established that equally distribute year types over the historical record (i.e., it generates an equal number of Extremely Wet, Wet, Above Normal, Normal, Below Normal, Dry and Critically Dry water years), potential water year type trends over time are compensated as additional years of runoff information become known. This is a dynamically generated water year type partitioning. MPWMD updates these water year types every 5-years.

Under this scheme, there is the potential for past individual years to "switch" year types over time. For example, if a series of dry years are experienced, then the dry year thresholds would decrease, potentially moving years previously classified as dry years into a wetter year type category. With continued climatic changes, in many areas it is accepted that the current "dry" and "critically dry" years of today (and yesterday) will look more like the "normal" years of the future.

Since current water operations in the Carmel River watershed are not dependent on water year type classifications, potential water year type changes over time are not considered as important as those areas where WY types are closely tied to allowable water management actions. If, however, water management decisions in the future are to be made in part based on the water year types (e.g., SWRCB permits and/or NMFS prescriptions), care should be taken in order to establish how, or if water year types will be allowed to vary in the future. MPWMD must strive to ensure that any WY types that are tied to regulatory prescriptions or compliance thresholds must remain flexible and that the resource agencies support this position.

An interesting exercise would be to examine each of MPWMD's past changes to water year type categories and examine how the historic record, by distinct periods perhaps, have shifted their water year type designations over time. An equally informative examination would be to explore further, the seasonal trends (as discussed in Subchapter 4.5.4 – Projected Future Unimpaired Flows) to see if the noted seasonal shifts are protracted or the result of more recent changes. Unlike various forms of State or federal WY indices where, unimpaired inflows are categorized into fixed ranges that can provide long-term trend analysis of WY type shifts over say decades, MPWMD adopts a more dynamic real-time process. WY types reflecting gauged basin hydrology are adjusted approximately every 5-years as part of MPWMD's water reporting.

4.5.4 Extreme Event Probabilities

One significant effect of climate change is its likely influence on the frequency and magnitude of extreme events. Water resources "systems" have traditionally been designed and rely on the assumption that the available flow records for a specific location reflects stationary climatic conditions. It is now accepted that it is increasingly risky to rely on historical flow information as a planning standard when future extremes are what will determine success or failure in water resources management planning.

This idiom holds true for both in terms of drought as well as flooding. Indications are, and history has shown, that we should expect both driers periods and wetter periods in the future. Design of water supply systems should include potential extreme events that fall outside the historical flow regime parameters and give additional consideration to projected "outliers". This expanded technique has long been adopted when considering the safety of infrastructure, such as dam safety, and should also be considered when evaluating basin water availability.

DWR's 2010 Urban Water Management Plan guidance documents for example, require purveyors to select the worst-case single year drought (usually 1977) as well as consecutive 2, 4 and 6-year droughts. Typically, the 1928-34 period; the 1988-92 period; and the more recent 2006-2007 periods are selected. The goal is to try and isolate and re-consider the effects of those worst periods.

Droughts, however, must be viewed in their temporal context. Droughts, in almost all cases in contemporary water management, are still addressed on an annual and/or inter-annual basis. Periods of high precipitation or indeed high intensity individual events can result in significant effects to water operations (and infrastructure), but may be masked when looking only at historic annual records.

For the Carmel River watershed, future increases in extreme event probabilities may prove useful, especially if new storage is developed. Much will depend on siting since, as will be discussed later (see Chapter 8.0 – District Alternatives), off-mainstem storage alternatives, relative to those on the mainstem possess very different flood flow capture potential and offer a suite of environmental benefits.

Exploration of the types of trends that may occur in an extreme flow record, which include changes in the timing of extreme events, and changes in the extreme event magnitudes should be considered as part of the baseline analysis in any water resources planning effort.

It should be noted that MPWMD has, along with various partners on the Peninsula, embarked on a proposal to the U.S. Bureau of Reclamation to develop a Basin Study for the Carmel and Salinas Watersheds. Authorized under the SECURE Water Act of 2009, this federal initiative is focused on ultimately developing new water supplies across the western U.S. through federal and non-federal partnerships. It is intended to address the uncertainties associated with climatic changes and related threats to short- and long-term water supplies.

4.6 Primary Tributary Flows

As part of the development of this Plan, runoff information in selected Carmel River tributaries were evaluated in order to understand the distinct hydrologic constraints and opportunities that exist in each tributary.

4.6.1 Pine Creek

Pine Creek is a tributary to the Carmel River located upstream of San Clemente Reservoir. The watershed drainage area of Pine Creek is about 7.8 square miles. Estimated annual unimpaired flow from Pine Creek within the watershed varies greatly depending on the wetness of the year. Flow in Pine Creek was originally gaged beginning in February 1987.Records are available starting with WY 1992.The location of the stream gage is 565 feet upstream of the confluence with Carmel River.

Mean, minimum and maximum monthly runoff recorded at the Pine Creek stream gage over the period of record (1992-2012) is depicted in **Table 4-5**. The average annual runoff of Pine Creek is 5,400 AF. The period of record maximum was 15,610 AF (in 1998) and the minimum was 849 AF (in 2007).

Table 4-5
Pine Creek Runoff – Water Years 1992-2012 (Acre-Feet)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Mean	5.0	26	166	531	1,150	1,020	504	264	123	39	9	2	4,395
Minimum	0	0	3.0	91	214	236	95	53	14	2	0	0	849
Maximum	71	250	1,680	4,280	6,830	3,940	3,260	1,000	494	247	104	58	15,610

Source: MPMWD, Surface Water Resources Data Report, Water Years 1992-2012. Only annual information is available for years 2009-2012.

4.6.2 San Clemente Creek

San Clemente Creek is a tributary to the Carmel River and drains into the existing San Clemente Reservoir. The watershed drainage area of San Clemente Creek is about 15.6 square miles. Similar to Pine Creek, estimated annual unimpaired flow from San Clemente Creek within the watershed varies greatly depending on the wetness of the year. Records of flow in San Clemente Creek are available starting with water year 1992. The location of the stream gage is about one quarter mile upstream of San Clemente Reservoir.

Mean, minimum and maximum monthly runoff recorded at the San Clemente Creek stream gage over the period of record (1992-2012) is depicted in **Table 4-6**. The average annual runoff of San Clemente Creek is 9,340 AF. The period of record maximum was 33,380 AF (in 1998) and the minimum was 1,360 AF (in 2007).

Table 4-6
San Clemente Creek Runoff – Water Years 1992-2012 (Acre-Feet)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Mean	13	55	205	923	1,800	1,340	767	493	236	56	12	5	6,490
Minimum	1	5	44	124	381	267	95	68	20	3	1	1	1,360
Maximum	107	333	2,230	7,330	16,260	8,440	5,710	1,890	968	482	179	64	33,380

Source: MPMWD, Surface Water Resources Data Report, Water Years 1992-2012. Only annual information is available for years 2009-2012.

4.6.3 Cachagua Creek

Cachagua Creek is a tributary to the Carmel River. The watershed drainage area of Cachagua Creek is about 46.3 square miles. Like other tributaries, unimpaired flow from Cachagua Creek within the watershed varies greatly depending on the water year. Records of flow in Cachagua Creek are available starting with water year 1992. The location of the stream gage is about 50 feet upstream of Nason Road in Princes Camp, Cachagua.

Mean, minimum and maximum monthly runoff recorded at the Cachagua Creek stream gage over the period of record (1992-2012) is depicted in **Table 4-7**. The average annual runoff of Cachagua Creek is 4,160 AF. The period of record maximum was 23,800 AF (in 1998) and the minimum was 237 AF (in 2007).

Table 4-7 Cachagua Creek Runoff – Water Years 1994-2013 (Acre-Feet)												
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Mean	0	0	0	243	698	466	186	87	7	0	0	0	1,990
Minimum	0	0	0	0	53	73	41	0	0	0	0	0	237
Maximum	115	174	377	3,220	12,570	9,630	3,370	1,700	889	433	156	74	23,800

Source: MPMWD, Surface Water Resources Data Report, Water Years 1992-2012. Only annual information is available for years 2009-2012.

4.6.4 Carmel River at Los Padres Dam

The watershed of the Carmel River at Los Padres Dam drains about 44.9 square miles. Records of flow in Carmel River at Los Padres Dam are available starting with water year 1958 through 2013 (with the exception of 2003-2006 which are unavailable).

Mean, minimum and maximum monthly runoff recorded at the Carmel River at Los Padres Dam over the 52 year period of record is depicted in **Table 4-8**. The average annual runoff of the Carmel River at Los Padres Dam is 51,972 AF. The period of record maximum was 250,283 AF (in 1983) and the minimum was 3,392 AF (in 1977).

Table 4-8 Carmel River at Los Padres Runoff – Water Years 1958-2013 (Acre-Feet)													
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Mean	230	572	1,888	4,659	7,146	7,473	3,360	1,777	954	397	132	99	36,828
Minimum	61	61	87	82	133	641	409	218	83	61	36	59	3,392
Maximum	5,278	6,348	22,621	40,947	78,621	88,785	49,373	19,121	5,851	2,872	1,803	1,057	250,283

Source: MPMWD, Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Management District Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003 (1958 - 2002 information), Excel Spreadsheet provided by MPWMD, Copy of est_dailyq_wy07.xls, (2007 – 2013 information), information for 2003-2006 is unavailable.

4.7 Groundwater

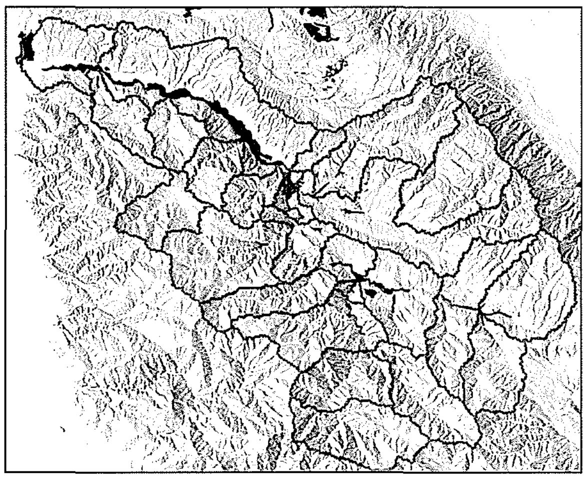
As noted by Smith et al. (2004), the two predominant groundwater aquifers in the Carmel River watershed are the unconfined alluvial aquifer and the upland bedrock aquifer. They are separate and distinct from the Seaside Groundwater Basin.

The Carmel Valley alluvial aquifer (or lower aquifer) exists as a sequence of alluvium that has been deposited over time as the valley progressed through various mass wasting episodes. Similar processes have helped establish the aquifers in the Tularcitos and Cachagua Creek sub-watersheds. The upland bedrock aquifer is composed of metamorphic, granitic and sedimentary rocks. The sedimentary rocks include both sandstone and the Monterey Shale. All of these rock types hold exploitable groundwater resources in either intergranular porosity or fracture porosity (Smith et al., 2004). Available storage within these two aquifers has been estimated (**Table 4-9**). Not surprisingly, higher storage is contained in the broader water bearing unconsolidated materials found in the Carmel Valley Alluvial Aquifer.

Table 4-9 Storage in Carmel Valley Aquifers – December 1987 – September 2010 (AF)		
	Carmel Valley Alluvial Aquifer	Upland Carmel Valley Aquifer
Mean	18,882	6,237
Minimum	8,793	5,643
Maximum	21,927	6,531
Median	20,122	6,228

Source: Hutnak, 2013, From Appendices, Monthly Resource Tracking, Usable storage estimates

This lower aquifer is highly permeable, recharging rapidly after extended dry periods. It is estimated that about 85% of the aquifer's recharge is through the bed of the Carmel River, with additional water coming from tributaries, direct precipitation, inflow from subsurface bedrock, and return flow from septic, and irrigation systems (MPWMD/ACOE, 1994) (**Figure 4-15**). The aquifer provides a water supply source that is utilized by both the natural ecosystem and human consumption.



Source: Smith et al. (2004), Figure 29; originally taken from Rosenberg (2001).

Figure 4-15
Alluvial Aquifer Recharge Areas within the Carmel River Watershed

Most of the small headwater streams located high in the watershed are not sustained by subsurface flows through the summer. Overburden depths are thin, gradients are steep, and while annual precipitation totals are higher, much of the seasonal rainfall flux infiltrates rapidly, seeps to the deeper groundwater stores, or runs off as surficial flow.

Smith et al. (2004) raise interesting issues regarding the ultimate role of the upland aquifer in maintaining stream flow in the lower reaches of the valley. They note the earlier conclusions of Rosenberg (2001) which discounted any significant contribution of the upland aquifer as a water supply source. While *direct use* of upland aquifer yield is marginal at best, owing to its many limitations (e.g., proximity to consumptive users, access, transiency, etc.), its inextricable linkage to both downstream surface and subsurface waters cannot be discounted. In fact, all tributary flows as well as the upper Carmel River mainstem following cessation of the seasonal rain storms are exclusively sustained by subsurface stores. Whether this is true groundwater, perched groundwater, transient subsurface water, or macropore water, is irrelevant. Flows are being maintained in many tributaries by some subsurface flux. What is less clear is how the gross subsurface stores ultimately affect downstream river flows and groundwater flow in the alluvial aquifer.

A simple and common technique for determining source water makeup in natural streams is through the use of chemical tracing. Various constituents can be used depending on objective, precipitation form, temperature, and natural basin conditions. A reliable technique that has long been a staple in runoff hydrology investigations is the use of naturally occurring stable isotopes of oxygen (e.g., ^{16}O, ^{18}O) or deuterium (e.g., ^{2}H or D) (Sklash et al., 1976; Moore, 1989; McDonnell et al. 1991; Buttle, 1994; Kendall and Caldwell, 1998).

These studies confirm that the stream hydrograph response in many instances is made up of *pre-event* as opposed to *event* water (i.e., old water versus new water). Essentially, the original objective was to determine the source of water in a stream during a storm event. Was it incident precipitation or, water that already existed in the watershed prior to a rain event? Conventional hydrology had always assumed the former. The direct rainfall-runoff relationship was treated as a black box in terms of actual in-basin processes. Whatever fell as rain, minus losses, ended up in the stream. Many processes, however, including groundwater ridging, translatory flow, macropore flow, and kinematic waves have been suggested as possible reasons why the chemical signature of these sampled water sources no longer necessarily support these older theories. Today, in fact, it is virtually accepted that a much greater portion of streamflow is actually made up of pre-event water and not necessarily incident precipitation from a particular rain event. The fact that a hydrograph responds coincidentally with the event hyetograph (accounting for basin-lag and time to concentration) does not mean that it is the same water that ends up in the stream.

For the Carmel River watershed, one such experiment could be implemented where, various sampling stations could collect stream water as well as reference samples from high elevation precipitation gauges. Samples could be taken in many key tributaries including Cachagua, Pine, San Clemente, and Tularcitos creeks, various points along the Carmel River mainstem all the way down to the Hwy 1 Bridge and Carmel lagoon. Moreover, samples could also be taken from various locations within and along the longitudinal profile of the alluvial aquifer. Results could prove enlightening and while the findings may, in certain instances appear counter intuitive to long-standing model depictions of how both the surface and subsurface systems function, the hydrochemical data evidence could prove compelling.

Ongoing questions about the role and interrelationship between surface and subsurface waters, their storage limitations, and pathways of transmission can be addressed using standard water chemistry. Such questions may include:

- How much of the water infiltrating near the Ventana Cones from a rain event in January, makes up the baseflow at Robles del Rio in June?
- How much of the seasonal refill in Los Padres Reservoir is water from the current WY precipitation or water from a previous WY?
- How much of the flow at the Sleepy Hollow Weir is water released from Los Padres or return water flow from the upland aquifer?
- What is the source of water in the Carmel River at the Hwy 1 Bridge?

Hydrochemical tracing offers extended means of answering many challenging queries such as these. Again, while the results may, in some cases, appear counter intuitive, one is left with the reality that certain waters will possess similar chemical signatures that sometimes belie traditional explanations.

From a water resources supply perspective, both aquifers within the Carmel River watershed are important. Groundwater clearly plays a significant role in overall watershed hydrology and water management. While the managed use of the lower aquifer has been the primary focus of water resource prescriptions and supply reliability, **the upland aquifer, and its relation to upstream storage (both old and proposed future facilities) should represent an equally important component in future watershed management planning. To date, this subsurface reservoir represents the most significant unknown within the watershed and should be explored further with new linked surface/subsurface flow modeling.**

4.8 Sediment Budget

Sediment budget information for the Los Padres Reservoir subwatershed is reviewed and a discussion including a description of natural conditions, a preliminary reservoir sediment budget, the primary causes of extreme sediment yield events, and the issues related to the long-term disposition of Los Padres Dam and Reservoir from an enhanced operational or removal perspective are given. The implications of subwatershed sediment erosion and yield characteristics on watershed sediment management, and issues related to flooding risks are also discussed. Recommendations for next steps to develop a multi-faceted sediment management plan capable of meeting all water supply, instream flow, and riparian function including downstream flood control is identified.

4.8.1 Natural Conditions

Sediment Production

The Los Padres Reservoir subwatershed is 44 square miles in size and occupies the southern portion of the Carmel River watershed (**Figure 4.16**). Sediment production is reported to be the highest in the Carmel River watershed because of several contributing factors (Matthews 1989a; Smith et al. 2004; Cal-Am 2013):

- The subwatershed is located in the Santa Lucia Mountains which consists of steep, rugged terrain and includes the highest peaks in the Carmel River watershed at around 4,800 ft msl elevation;
- Watershed geology is largely composed of highly fractured granitic rocks that are easily eroded, particularly in the Bruce Fork and Blue Creek drainages which form the majority of the subwatershed;
- Due to orographic rainfall effects, the highest average annual rainfall in the Carmel watershed occurs in the Los Padres Reservoir subwatershed at over 40 inches/yr, declining toward the north to 17 inches/yr at the mouth of the Carmel River;
- Previous fires in the Los Padres Reservoir subwatershed, particularly the Marble-Cone Fire in 1977, have resulted in extreme sediment production events;
- Watershed physiography and rainfall results in frequent slope failures in the basin, primarily in the form of debris flows, landslides, and soil slips;
- Point source erosion along abandoned dirt roads, typically in very rugged terrain, is a major anthropogenic source of sediment yield[2].

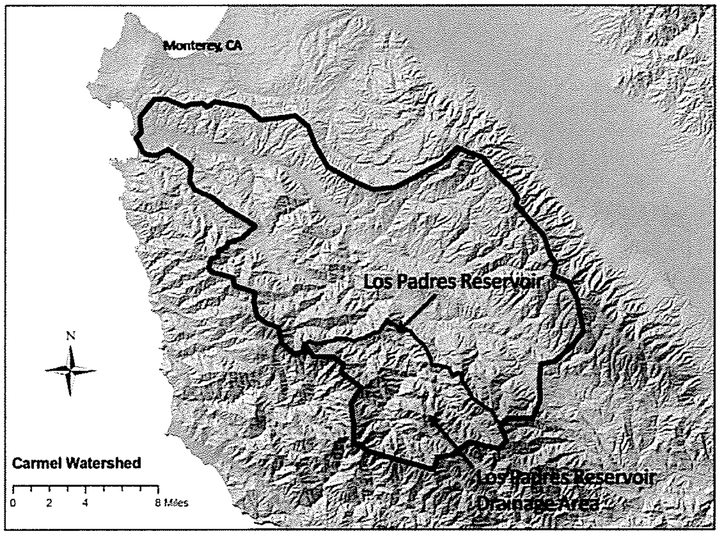
Although the Los Padres Reservoir subwatershed exhibits the highest rates of sediment production overall, almost all other parts of the Carmel River watershed have also been identified as highly susceptible to erosion (Smith et al., 2004).

Los Padres Reservoir Sedimentation

Flow velocities decrease dramatically as the Carmel River enters the Los Padres Reservoir, due to the expansion of channel width and decline in water surface slope. This results in a rapid decline in

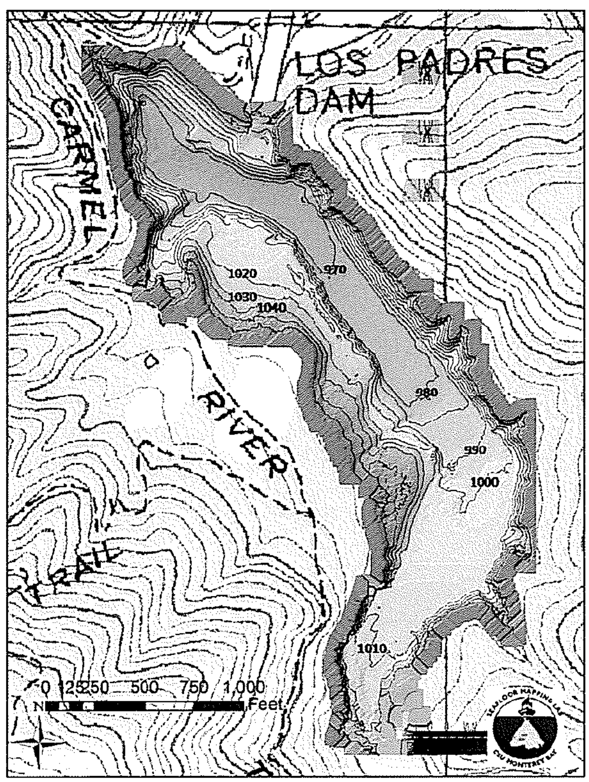
[2] The subwatershed draining to Los Padres Reservoir contains fire breaks, but very few roads.

sediment transport capacity such that the bulk of the river's sediment load is deposited in the upstream portion ofthe reservoir (**Figure 4-17**). Sediment accumulation has formed a delta that has prograded into the reservoir.



Source: Smith et al. (2009)

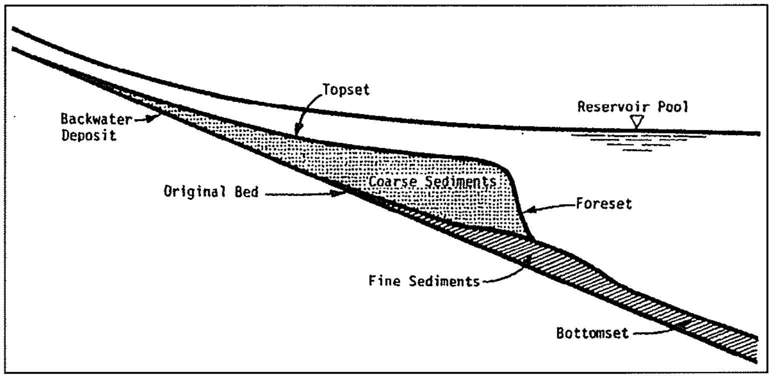
Figure 4.16
Los Padres Reservoir drainage area



Source: Smith et al. (2009)

Figure 4.17.
Los Padres Reservoir Bathymetry from 2008 survey

The delta exhibits a more gradually sloping section from elevation 1010 ft to 1000 ft in Figure 4-17, nearest tothe river mouth at the upstream end of the reservoir, then a steeper section from elevation 1000 ft to 980 ft, followed by a more gradually sloping section from elevation 980 ft to the dam face. These deposits represent the topset, foreset, and bottomset beds of the prograding delta (**Figure 4-18**).



Source: Mahmood (1987)

Figure 4-18
Generalized longitudinal section of reservoir sedimentation

Typically, the finest fraction of the sediment load is deposited last, furthest out into the reservoir, forming bottomset beds roughly parallel to the reservoir bottom ahead of the prograding delta. Coarser sediments form the more steeply sloping foreset beds of the actively prograding delta, that gradually cover the bottomset beds under the advancing delta front. Lastly, topset beds overlay the foresets, and typically consist of less coarse material deposited away from the main channel flowing on the delta plain.

Los Padres Reservoir Sediment Budget

Since completion of dam construction in 1949 (Matthews 1989a), sediment eroded from the Los Padres Reservoir subwatershed has reduced reservoir capacity from the original 3,070 AF in 1949[3] to 1,785 AF in 2008, a decline of about 42%. **Figure 4-19** summarizes the changes in reservoir capacity over time, based on bathymetric surveys conducted in 1977, 1978, 1984, 1998 and 2008 (Smith et al., 2009). The 1998 bathymetric survey is thought to be in error because the later 2008 survey revealed greater capacity in the reservoir than in 1998, despite no dredging during this period (Smith et al., 2009). Consequently, the 1998 survey point was not used in this analysis.

The 590 AF reduction in reservoir capacity from 1977 to 1978 is due to a major sediment transport event caused by the Marble-Cone Fire, which burned about 90% of the Los Padres Reservoir subwatershed. Sediment was reportedly removed from the reservoir between 1978 and 1984 (Smith et al., 2009), that according to the authors could have resulted in a 200 to 250 AF net increase in reservoir capacity as illustrated by the increase in reservoir capacity during this period (see Figure 4-19). However, there is no indication in the record including Cal-Am records confirming reservoir dredging during this period. The 1977 and 1978 estimates were provided by USGS. The 1984 estimate, which showed an increase in volume over time, was provided by Cal-Am. A small release of sediment-laden water occurred in 1981,

[3] The initial volume was based on the "Los Padres Dam on Carmel River in Monterey County, Reservoir Map, Area & Capacity Curves. California Water & Telephone Company, Monterey Peninsula Division, 1947."

one that covered about two miles of the stream with fine material, but was nowhere near 250 AF. MPWMD does not normally use the 1984 estimate when estimating the sedimentation rate of the reservoir.

Excluding the Marble-Cone Fire, Figure 4-19 shows the average annual rate of sediment accumulation to be 18.9 AFA; this includes the time periods from 1949 to 1977 and 1984 to 2008. Including the Marble-Cone fire in long-term estimates of reservoir sediment accumulation increases the average annual rate between 1949 and 2008 to about 29.7 AFA, based on 1949 to 1978 and 1984 to 2008 data in Figure 4-19. Note that increases in reservoir sediment accumulation caused by the Basin-Complex fire of 2008 have not been measured since the last reservoir survey was completed that same year. However, cross-section surveys collected in the upstream part of the reservoir in 2009 and 2011 did not show abnormal rates of sediment accumulation (Cal-Am, 2013).

Figure 4-19
Los Padres Reservoir capacity over time

Matthews (1989a) reported an average trap efficiency of 76% in Los Padres Reservoir and a unit weight of 135 lbs/ft^3 for reservoir sediments. Using these values, **Table 4-10** summarizes changes in reservoir capacity and total sediment yield entering and exiting the Los Padres Reservoir between 1949 and 2008.

Table 4-10
Los Padres Reservoir Sediment Budget

Time Period	Reservoir Sediment Accumulation		Total Sediment Yield[3] (entering Los Padres Reservoir)		(exiting Los Padres Reservoir)	
	AF	AFA	tons/yr	$tons/mi^2/yr$	tons/yr	$tons/mi^2/yr$
1949 – 1977	590	21.1	81,520	1,850	19,570	450
1977 – 1978	590	590	2,282,600	51,880	547,820	12,450
1984 – 2008	394	16.4	63,510	1,440	15,240	350
1949 – 2008[1]	984	18.9	73,210	1,660	17,570	400
1949 – 2008[2]	1,574	29.7	114,900	2,610	27,580	630

[1] – excludes sediment yield from 1977 - 1984 to remove effects of 1977 Marble-Cone fire
[2] – includes sediment yield from 1977-78 Marble-Cone fire, but excludes 1978 - 1984
[3] – computed based on a trap efficiency of 76% and unit weight of 135 lbs/ft^3 for reservoir sediments

The effects of the Marble-Cone fire on sediment yield are dramatic, resulting in a thirty-fold increase in basin sediment yield the year after the fire as compared to the overall 1949 to 2008 trend of 1,660 tons/mi^2/yr that excludes the fire. In contrast, the long-term trend in total sediment yield entering the Los Padres Reservoir from 1949 to 1977 and from 1984 to 2008 are comparable, at 1,850 tons/mi^2/yr and 1,440 tons/mi^2/yr respectively. These sediment yield rates fall within the expected range of 0.2 to 0.5 AFA/mi^2 for mountainous areas along the Central California Coast (SCS 1974).

Based on the results in Table 4-10, the total inflowing sediment load to Los Padres subwatershed is estimated to be between 73,210 tons/yr and 114,900 tons/yr with corresponding reservoir sediment accumulation rates of between 18.9 AFA and 29.7 AFA. This range of values represents the effects of variability in the frequency and severity of basin fires. These estimates are higher than those produced by Cal-Am (2013) who estimated reservoir deposition rates of between 14.3 AFA and 21 AFA as part of a recent reservoir sediment removal study. Discrepancies occur due to differences in the date of dam closure, records of sediment removal, and estimates of inflowing sediment load. Cal-Am (2013) identifies dam closure in 1947, whereas this study uses 1949 from MPWMD sources (Matthews 1989a)[4]. The Cal-Am (2013) estimate of 14.3 AFA is based on a total average annual sediment load of 42,000 tons/yr arriving at the reservoir, but this value is reported to account only for the bedload portion of the total load (MPWMD, 1994; Smith et al., 2004). The higher Cal-Am estimate of 21 AFA does not account for sediment reportedly removed from the reservoir between 1978 and 1984 (Smith et al. 2009).

Comparison with Other Tributary Sediment Yields

Measurements of average annual bedload are available for several tributaries of the Carmel River, including tributaries above Los Padres Reservoir. Bedload measurements do not include the portion of sediment carried in suspension, and thus are not representative of total sediment load. Nonetheless, bedload measurements afford an opportunity to make relative comparisons of sediment production from different parts of the Carmel River basin.

MPWMD and the U.S. Army Corps of Engineers (Corps) estimated the average annual bedload produced by the Los Padres Reservoir subwatershed to be 42,000 tons/year or 955 tons/mi^2/year (MPWMD 1994, Smith et al., 2004). As shown in **Table 4-11**, this ranges from 10 to 80 times higher than average annual bedload estimates reported for other tributaries of the Carmel River watershed (Mussetter, 2002; Smith et al., 2004). Note that all the other subwatersheds listed in Table 4-11 are located downstream of Los Padres Reservoir.

Table 4-11
Average Annual Bedload Sediment Yield in Carmel Basin Subwatersheds

Subwatershed	Drainage Area (mi^2)	Average Annual bedload (tons/mi^2/yr)
Los Padres Reservoir	44	955
Tularcitos, Chupines, and Rana Creeks	52	12
Garzas Creek	13.2	24
Robinson Canyon	5.4	84
Potrero Creek	5.2	17
Hitchcock Creek	4.5	94

[4] The 1981 DSOD safety inspection report states that the dam was constructed from mid-1948 to early 1949.

The average annual bedload of the Carmel River upstream of Los Padres Reservoir is extraordinarily high compared to other subwatersheds in Table 4-11. Causes of this are thought to be due to physical conditions in the subwatershed such as steep, erodible slopes; few areas for sediment storage; effects of the Marble-Cone fire, and the highest average annual precipitation in the Carmel watershed. Matthews (1989b) reported that about 75% of the runoff reaching the Carmel Valley at Hitchcock Creek (RM 14.57) is generated in the watershed upstream of Los Padres Reservoir.

4.8.2 Sedimentation Effects

General Setting

The Carmel River downstream of San Clemente Dam can be characterized as an incised, meandering river that is supply limited due to engineered bank protection and sediment capture by upstream reservoirs. This section examines current and historical geomorphic conditions on the Carmel River downstream of San Clemente Dam, with a specific focus on river response to historical changes in sediment supply. In this discussion, the 'lower Carmel River' refers to the area between the river mouth and the Narrows (RM 10.4) and the 'middle Carmel River' is between the Narrows and San Clemente Dam (RM 18.61).

There has been an overall decline in sediment load on the Carmel River downstream of San Clemente Dam for a range of flows, causing a transition from a transport-limited system to a supply-limited system since dam construction in 1921 (Hampson 1997). Other significant events contributing to a reduction in sediment supply include the construction of Los Padres Dam in 1947, gravel mining, placement of bank protection works after damaging floods in 1983, restoration projects from 1985 to 1994 that stabilized eroding streambanks, and reductions in groundwater pumping upstream to improve water availability for riparian vegetation.

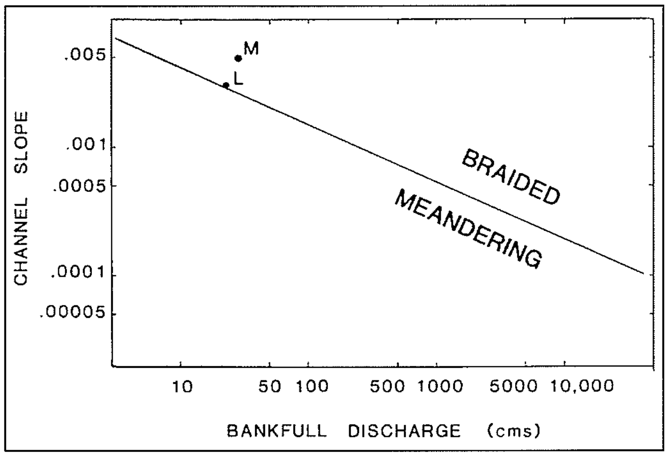
Consequently, the Carmel River downstream of San Clemente dam is sediment starved, with the most significant effects immediately downstream of San Clemente Dam. These effects include channel incision, narrowing and armoring of the channel bed resulting from sediment entrainment by 'sediment-hungry' flows that exit San Clemente Dam (Kondolf and Curry, 1986; Hampson, 1997).

Historical River Response to Changes in Sediment Supply

Historically, before San Clemente Dam and Los Padres Dam, the Carmel River was a transport-limited system. River geomorphology was metastable, exhibiting characteristics of both meandering and braided river systems. Slope and discharge characteristics of the historic Carmel River place it in a potentially unstable zone where changes between meandering and braided river morphologies are prone to occur (**Figure 4-20**). Due to its greater slope, the middle Carmel River exhibited more braided planform characteristics than the river downstream (Kondolf and Curry 1986). The water table was high and the river exhibited a dense riparian corridor.

The 1911 flood, the largest on record, provides a historical context for geomorphic response to large flood events prior to San Clemente Dam and Los Padres Dam. The 1911 flood had a peak flow in excess of 20,000 cfs, roughly comparable to the 100-year flood event, and resulted in widespread flooding, sedimentation, and lateral migration of the river channel. Kondolf and Curry (1986) identified a 'fill terrace' deposited by the 1911 flood that varied from 500 ft to 2,000 ft in width along the lower 5.6

miles of the river and floodplain. The volume of material deposited by the 1911 flood was not identified. However, the extent of the 'fill terrace' from the 1911 event suggests massive sedimentation in the lower Carmel Valley. Assuming an average width of 1000 ft and depth of 1 ft for the 'fill terrace' would yield approximately 680 AF of deposited material along the 5.6 mile affected length. The 1911 flood also resulted in significant bank erosion and channel migration of as much as 1,600 ft, significantly widening the active channel footprint. Vertical aggradation processes associated with the 1911 flood caused parts of the Carmel River to transition from a meandering to a braided channel planform, resulting in a wide unvegetated channel on the lower Carmel for the next several years (Kondolf and Curry, 1986).



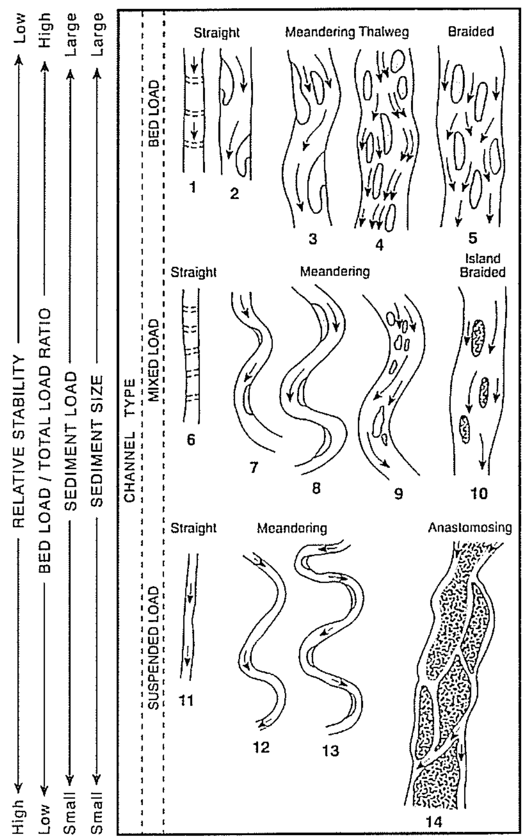
Source: Kondolf and Curry (1986)

Figure 4-20
Lower (L) and Middle (M) Carmel River slope and bankfull discharge plotted within zones of typical planform configurations.

Figure 4-21 provides a generalized overview of channel planform response to decreased sediment load. Changes in any of the variables shown in Figure 4-21, namely relative stability, bedload vs. total load ratio, sediment load and sediment size, will tend to produce a morphologic response as shown. Since the historic Carmel River exhibited higher sediment load and bed load characteristics than the contemporary channel, a broader, less stable and more braided channel configuration was observed.

In the decades following the 1911 flood, the lower and middle sections of the Carmel River narrowed to a single thread channel and incised. Many braided channel sections changed to a meandering planform, due mainly to reductions in sediment supply following the closure of San Clemente Dam in 1921. Kondolf and Curry (1986) measured about 13 ft of channel incision on the lower Carmel from 1911 to 1939. The extent to which incision was the result of the channel restoring its equilibrium profile and cross-section after the 1911 flood versus response to the closure of San Clemente Dam in 1921 is not known; channel responses to these events were similar and occurred concurrently. Hampson (1997) summarizes available survey data showing changes in channel invert elevation over time. Overall, the Carmel River has incised by several meters and continues to incise (Smith et al., 2004), due to declines in sediment supply resulting primarily from upstream dams but also from other factors listed in the *General Setting* subsection.

Riparian vegetation is an important contributor to lateral stability on the Carmel River. By the late 1970s, severe drought and groundwater pumping in the Carmel Valley had lowered the water table resulting in a significant loss of riparian vegetation, primarily in the middle Carmel River and upper half of the lower Carmel River between RM 5.0 and RM 15.5. This increased the risk of bank erosion from lower magnitude flood events due to reduced bank strength, particularly in the draw-down areas around pumping wells. Consequently, moderate floods from 1978 to 1980 produced severe bank erosion in these areas. Hampson (1997) noted that, in addition to severe bank erosion and channel shift, large gravel bars formed and the river became more unstable due to increased sediment loads.



Source: Knighton (1998)

Figure 4-21
Channel pattern characteristics

In contrast, the lower half of the lower Carmel River remained laterally stable through this period and during the 1982-83 flood events, despite much larger rates of sediment transport and bed aggradation in parts of the Carmel River. It is thought that bank erosion did not occur in this part of the lower Carmel River because, unlike upstream reaches, it maintained a relatively healthy riparian corridor that improved bank resistance to erosion (Kondolf and Curry, 1986). Groundwater pumping was reduced in the 1980s to ensure sufficient water for the riparian zone, which has since returned to occupy much of the river corridor. However, ongoing channel incision may pose a water supply risk to riparian vegetation if the water table declines in response to a lowered channel invert.

Following closure by dams, bank erosion has been the primary source of sediment for the Carmel River downstream of San Clemente Dam (Curry and Kondolf, 1983). However, beginning after the 1978 to 1980 bank erosion events, bank protection has been placed along approximately 40% of the river bank from the river mouth to RM 30 (Mussetter, 2002). Aggressive placement of bank protection, beginning around 1983, has reduced available sediment supply from bank erosion and promoted channel incision as an alternate source of bedload for supply-limited river flows.

Reductions in sediment supply and confinement by artificial bank protection have produced a modern day Carmel River that is narrower, deeper, and more stable than its historic predecessor. This provides both advantages and disadvantages to the community. For example, a deeper channel provides higher flow capacity and lower water surface elevations for a given discharge, decreasing flood risk. Also, the narrower channel of today is more stable due to decreased sediment loads and bank revetment, resulting in fewer problems related to bank avulsion that could threaten infrastructure or private property. In contrast, adverse impacts include ongoing channel incision, loss of sand available for beach replenishment, consequences related to sediment availability for aquatic habitat, and the potential for lowered ground water tables resulting from channel incision.

4.8.3 Extreme Events

Large, infrequent fires are the largest single source of extreme sediment yield events in the Carmel River watershed (Matthews, 1989a; Smith et al., 2004, 2009; Cal-Am, 2013). Fire data are available from 1911 to present. Significant fires in the Los Padres Reservoir subwatershed occurred in 1977, 1999, and 2008. The 1977 Marble-Cone fire was the most severe in recorded history, causing moderate to severe burning in 90% of the subwatershed. Additional factors contributing to extreme sediment yield after the Marble-Cone fire include a severe drought that preceded the fire and above average precipitation and high flows on the Carmel River a year later. Despite massive sediment yield and river aggradation following the fire, the Carmel River upstream of Los Padres Reservoir had scoured the post-fire material and returned to within 10% or 20% of its pre-fire channel cross-section and thalweg elevation within three years (Hecht, 1984).

In 1999, the Kirk Complex fire burned 57% of the subwatershed. Sediment production from the Kirk Complex fire has not been quantified, but anecdotal evidence indicates the fire did not significantly affect the rate of reservoir infilling (Cal-Am, 2013). The 2008 Basin Complex fire burned 48% of the subwatershed but severe burning affected only 11% of the burned area. The effect of this fire on basin sediment yield has not been quantified, but anecdotal reports indicated rapid siltation and delta growth in the Los Padres Reservoir following the fire (Smith et al., 2009).

ENTRIX (2008) reported that 400 earthquakes of 4.0 or greater occurred within 60 miles of the San Clemente Dam site between 1800 and 1985. However, none of the documents reviewed for this Plan identified significant increases in Carmel River basin sediment production following seismic events.

4.8.4 Sediment Issues Associated with Dam Removal

From a long-term sediment management perspective, dam removal can be viewed as functionally equivalent to the 'no-action' alternative, because eventually the reservoir will fill such that sediment is no longer trapped.

Removal of Los Padres Dam would significantly increase sediment supply to the Carmel River. The Los Padres subwatershed is identified as producing ten to eighty times higher average annual bedload per unit area than other tributaries in the Carmel River watershed (see Table 4-11). Hampson (1997) computed a total sediment load of 69.7 AF at the Near Carmel gage (RM 3.6) for WY 1995 which included a large magnitude flood of about 16,000 cfs (USGS 2012). For comparison, assuming equivalent unit weights of sediment, the average annual sediment load stored in Los Padres Reservoir from 1949 to 2008 was 29.7 AFA, or about 40% of the total load passing the Near Carmel gage during WY 1995. Given that the 1995 flood was the highest peak flow at this gage since 1962 (USGS, 2012), the total sediment load stored in Los Padres Reservoir in 1995 would be expected to have exceeded its average annual rate, possibly by several times. Consequently, very significant increases in bedload transport would be likely if the dam is removed. If not removed, a sediment management program will likely become necessary. Note that it should not be assumed that all this sediment would be transported to the Near Carmel gage; however, these observations offer an order of magnitude comparison of potential changes in sediment load following dam removal.

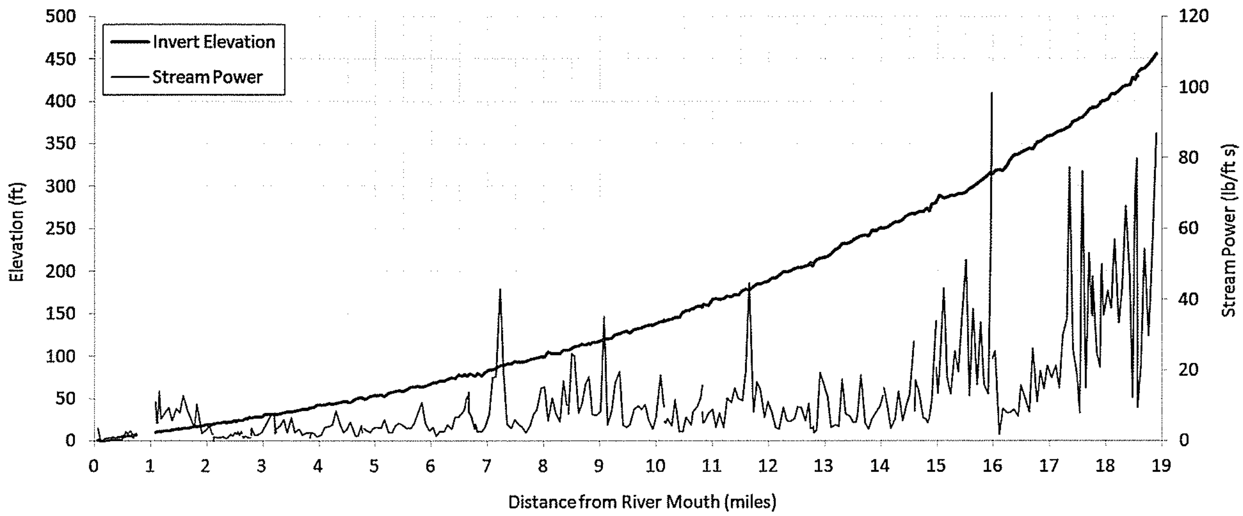
With increased sediment load, particularly bedload, the Carmel River would be expected to aggrade its channel bed and widen through increased bank erosion and lateral channel migration, developing a channel planform more characteristic of historical rather than present conditions (see Figure 4-21). As it did historically, channel braiding would be expected to occur more in the middle Carmel River due to its higher bed slope than on the lower Carmel River (see Figure 4-20). Existing bank protection and healthy riparian cover would be expected to reduce the amount of lateral channel migration that might otherwise occur; however, an increase in bank erosion and channel instability overall would be expected over the long-term on both the lower and middle Carmel River.

Restoration of historic sediment loads could result in widespread sedimentation, lateral channel shift, and bank erosion on the lower Carmel River like that in 1911. Since 1921, upstream dams have largely captured bedload contributions from the upstream watershed and provided downstream benefits by decreasing flood risk (through channel incision) and increasing lateral stability of the channel. Dam removal would increase the potential for dramatic sedimentation and channel avulsion events in the lower and middle Carmel River such as those observed during the 1911 flood.

The restoration of historic sediment loads would also result in beach replenishment, an increase in aquatic habitat due to channel widening, and the cessation of channel incision. Current gravel replenishment activities would no longer be required and a return to natural sediment loads in the river would prevent further channel incision. Potential channel aggradation, or at least the cessation of channel incision, would prevent any water table declines in response to a lowered channel invert. Thus, concerns of riparian vegetation loss due to channel incision would be removed, ensuring the long-term health and sustainability of the riparian corridor.

The extent of river aggradation and zones of sedimentation that may occur during intermediate or large floods cannot be identified in detail without numerical modeling and further analysis. However, preliminary examination of output from the FEMA HEC-RAS model of the 100-yr flood (FEMA 2007) shows a gradual decline in channel slope with distance toward the river mouth and a consequent decline in stream power (**Figure 4.-22**). Stream power is a measure of the energy available to transport sediment once a critical threshold for mobility is passed. Thus, declining stream power reflects the decline in sediment transport capacity with distance downstream, indicating the potential for sediment deposition along both the middle and lower Carmel River. Observations of 'fill terrace' deposits following the 1911 flood by Kondolf and Curry (1986) correlate well with low stream power values shown in the lower 5.6 miles (30,000 ft) of the river in Figure 4-22.

Much higher loads of large woody debris (LWD) would be expected following any dam removal. LWD provides benefits through the introduction of morphologic and hydraulic variability in the river channel, creating improved habitat conditions for refuge and foraging by aquatic species. Areas of concern include the numerous bridges cross the Carmel River downstream of the San Clemente Dam. Examination of the FEMA HEC-RAS model shows that the 100-year flood surface elevation is very close to the low chord of several of these bridges, creating the potential for extensive debris jams and consequent overtopping flows and property damage. The Watershed Institute (2013) identified between four and eight bridges that would be negatively impacted following San Clemente Dam removal. Given that the majority of the Los Padres Reservoir subwatershed is located in a national forest and not subject to development, woody debris loads similar to those that occurred historically are expected.



Source: FEMA (2007)

Figure 4-22
Invert profile and Total Stream Power for 100-yr flood

Recommended Next Steps

There is no standard methodology for assessing sediment-related costs, benefits and impacts of possible dam removal, although several organizations have published guidelines (ASCE, 1997, 2011; USACE, 2006;, EPA, 2007; Heinz Center, 2002; Randle, 2011; USSD 2012). Next steps recommended in this section are based on a preliminary review of available materials and should be included in future steps including those already initiated by MPWMD to characterize sediment management implications of a possible Los Padres Dam removal.

Develop a geomorphic baseline of existing conditions – Existing conditions must be documented in order to have a baseline from which to monitor and document future changes in channel morphology. This step would identify baseline geomorphic conditions upstream and downstream of Los Padres Dam. It is assumed that this has already been completed for the Carmel River downstream of San Clemente Dam but not upstream of the Los Padres Reservoir or downstream of the reservoir to San Clemente Dam.

Develop a predictive tool to screen options for sediment management – A feasibility-level assessment will require numerical modeling tools, such as HEC-RAS or HEC-6T, to quantify the sedimentation effects of dam removal alternatives. This modeling effort would provide a technical and defensible characterization of the hydraulic and sediment transport characteristics of the Carmel River following Los Padres Dam removal. Once developed, the HEC-RAS or HEC-6T model would be used to screen sediment management alternatives, such as the feasibility and effects of partial or total release of reservoir sediments downstream. Modeling activities would include the determination of channel profile adjustments, including vertical and lateral channel adjustment; identification of zones where sedimentation or scour is likely to occur; changes to flood risk and inundation limits, and the determination of flow turbidity, bed material composition, and sediment supply for beach nourishment. The development of these tools would require detailed sediment loading information, including grain size distributions. Thus, the collection of reservoir sediment samples and sediment load information may be needed.

4.8.5 Sediment Issues Associated with Reservoir Storage Enhancement

Reservoir storage enhancement options include those that increase reservoir capacity through sediment removal or increasing reservoir storage by increasing dam height. These activities, assuming the removed sediment does not re-enter the Carmel River downstream of the dam, do not significantly alter the effects of Los Padres Dam on the Carmel River. Dredging to restore the reservoir to its full capacity would increase trap efficiency from 71% to 79% (Cal-Am, 2013), and reduce the total sediment load that passes through the reservoir. Downstream effects would include a tendency toward continued rates of instream erosion due to sediment hungry flows than occur presently. Given that all inflowing bedload is currently trapped in the reservoir, a significant increase in channel incision due to this change in trap efficiency is not anticipated.

As noted previously, Cal-Am (2013) recently completed a study to examine the feasibility of removing approximately two million cubic yards of sediment from the Los Padres Reservoir. They identified three alternatives, ranging from the removal of 810,000 CY (500 AF) of material to 1.8 million CY (1,115 AF). Disposal sites for the removed material were identified either in the Los Padres Reservoir subwatershed or on a flat terrace just downstream of the dam. Sediment management issues related to reservoir sediment removal focus around the stabilization of sediment disposal sites to ensure material does not remobilize. This is particularly important for the disposal site downstream of the dam where an influx of sediment into the Carmel River could result in channel modifications similar to those discussed in Section 4.8.4.

Physical modifications at the dam to allow sediment by-pass represent an option, but again, there would be additional considerations; by-pass efficiency would have to be closely compared to costs.

Recommended Next Steps

Next steps for dam enhancement activities require the development of target reservoir storage capacities to meet water supply requirements. Sediment filling rates from Table 4-10 would then be used to develop the most cost-effective long-term approach for sediment removal to maintain reservoir capacity over the long-term. Details of such a removal plan are not discussed here because preliminary analyses of minimum storage capacities necessary to meet water supply needs greatly exceed the original reservoir capacity. Thus, even with total sediment removal, Los Padres Reservoir would provide limited storage benefits (e.g., perhaps meeting future instream flow needs, but not all water supply needs). Potential options to raise the dam crest elevation and/or add new reservoirs in the Carmel watershed are currently under consideration.

4.8.6 Watershed Management Implications

Based on historical rates of reservoir sedimentation, wildfires are the most important driver of sediment production in the Los Padres subwatershed, the majority of which is located in the Los Padres National Forest. A fire management or fuels reduction plan will be the most important component of any alternative for dam removal or enhancement. A Land Management Plan (USDA, 2011) provides details on fire management and fuels reduction for the national forest. It is unclear if additional steps are available to improve fire management for the purposes of sediment yield reduction in the subwatershed. It is recommended that discussions with the National Forest be held to identify opportunities in light of the importance of this issue to the Carmel River region.

Rehabilitation and erosion control options for natural erosion sites in the Los Padres Reservoir subwatershed are likely very limited, primarily because they are on steep slopes and lack road access, there are likely a very large number of erosion sites and erosion areas to treat, and new sections of the slope may begin to erode and contribute sediment during any particular flood. Bank erosion is also an important source of erosion. In general, treatment methods are constrained by the steep slopes and lack of access. As an initial strategy, we recommend developing a detailed assessment of erosion sources in the subwatershed. Once developed, the most feasible erosion control options can be identified and used to develop specific plans for erosion control and sediment management for roads, slopes, and the stream corridor.

Roads have been identified as the main anthropogenic source of sediment in the Los Padres Reservoir subwatershed (Smith et al., 2004) and, given their accessibility, may offer the best opportunity for future sediment management activities. Generally, erosion control treatments are developed after a watershed road management plan has been completed. These plans typically review access requirements, inventory the road system, and identify actions needed for environmental protection and mitigation. The plans also establish the requirements and standards for road use during wet weather, re-construction or improvement, maintenance and abandonment. The California Code of Regulations (Title 14 Chapter 4 California Forest Practice Rules) describes the general requirements for such a plan.

It is recommended that a road management plan for the Los Padres Dam subwatershed be developed that is a cooperative effort between the Los Padres National Forest, the MPWMD, Cal-Am, and other interested parties. Such a plan would consider whether any roads are to remain open to traffic, whether they are to be removed or abandoned or converted to trail, and the timing of closure to allow for restoration works, if access along the road network is needed for their construction. Such a plan would direct appropriate road rehabilitation measures, inspection and maintenance and, if necessary, the development of road improvements that meet current standards, accepting the fact that there are very few roads (permanent or temporary) within the watershed.

5. Water Supply and Demands

Cal-Am's Monterey District, serves most of the Monterey Peninsula, including the cities ofCarmel-by-the-Sea, Del Rey Oaks, Monterey, Pacific Grove, Sand City, and Seaside, and the unincorporated areas of Carmel Highlands, Carmel Valley, Pebble Beach, and the Del Monte Forest. This part of Cal-Am's service area is supplied by surface water and groundwater from the Carmel River system and the coastal subarea of the Seaside Groundwater Basin (Seaside Basin). Cal-Am's service area boundaries generally correspond to those of MPWMD.

5.1 Current Supplies

The principal existing supply sources are the Carmel River sources (groundwater andsurface water) and the Seaside Basin. Existing annual supplies from these sources are shown in **Table 5-1**.

Table 5-1 Current Water Supplies in the Monterey Peninsula, Acre-Feet Annually	
Carmel River System	3,376
Seaside Groundwater Basin	1,474
Sand City Desalination	94
ASR	1,300
Total Current Supplies	6,244

Source: Monterey County Planning Department, Pebble Beach Company Project, Draft Environmental Impact Report (2011) and updated unpublished MPWMD data.

It should be noted that actual "existing supplies" are a moving target that change each year due to the required reductions to both the Seaside Groundwater Basin and Carmel River withdrawals from the SWRCB Cease & Desist order.

5.2 Current Demands

Recent estimates by MPWMD, based on Cal-Am monthly production reports for its Carmel River and Seaside Basin Coastal Subarea sources, indicates the annual average quantity of water currently produced for Cal-Am customers within the Cal-Am Monterey District varies between just over 12,000 AFA to just over 14,000 AFA (5-year average is 13,290 AF). The annual production and estimated future supply gap are shown in **Figure 5-1**.

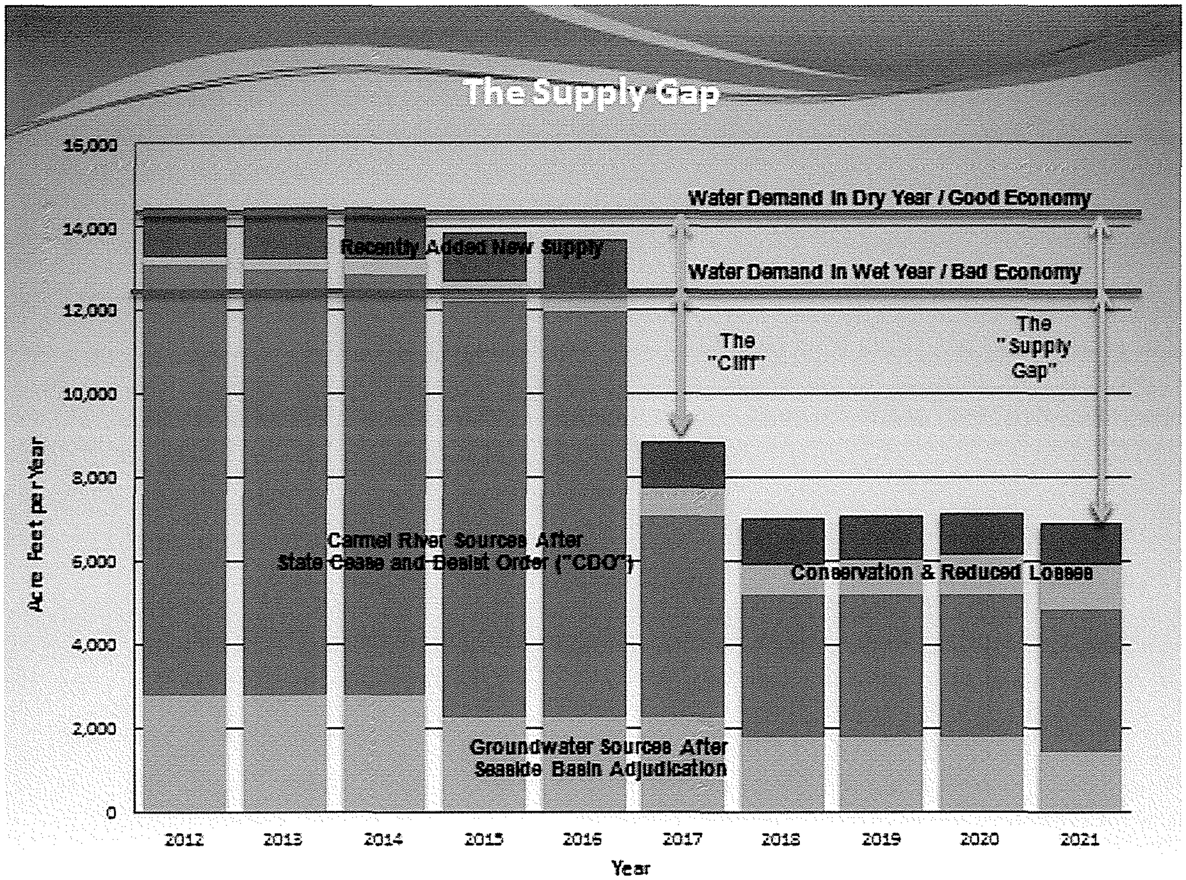


Figure 5-1
The Supply Gap

In 2013, California-American Water's application to the California Public Utilities Commission for the Monterey Peninsula Water Supply Project (A12-04-016) included an estimated total production need of about 15,300 AFA, which includes replacement supplies for the Carmel River Basin and Seaside Groundwater Basin, an increase in future demand due to an upturn in business activity, and water for lots of record. In addition, because a proposed desalination plant would rely on brackish water from the Salinas Valley Groundwater Basin, a portion of the desalinated water (875 AFA) would be returned to the Salinas Valley. Thus, Cal-Am's estimate of the short-term replacement water supply need is about 9,720 AFA for a desal-only supply.

Cal-Am's Monterey District Urban Water Management and Water Shortage Contingency Plan (UWMP) also include information on Cal-Am's near-term demands. According to water production information presented in the UWMP, Cal-Am's Monterey District produced 15,184.7 AF in 2005, all of which was from wells. Demand projections included in the UWMP also include an estimate of 15,550 AF for 2005.

5.3 Future Supplies

There are other potential supplies of water being considered to provide water to the Monterey Peninsula including a desalination project, expansion of the Pebble Beach recycled water project, and unaccounted for water recovery. These potential water supplies are provided here as information since these projects have not been approved and it is not certain that they would beimplemented. Potential future water supplies are shown in **Table 5-2**.

Table 5-2 Potential Future Water Supplies Compared Against Demands in the Monterey Peninsula, MPWMD's Official Position on Supply and Demand	
Demand	**Supply**
13,290 AFA (5-year average)	3,376 AFA legally from Carmel River (2017)
500 AFA for economic recovery	1,474 AFA legally from Seaside Basin (2021)
325 AFA for Pebble Beach Buildout	700 AFA Cal-Am intends to leave in the Seaside Basin for recharge for 25-years
1,181 AFA for legal lots of record	94 AFA available from Sand City long-term
	1,300 AFA assumed available from ASR
	3,500 AFA assumed from GWR
	9,044 AFA Total
	6.252 from small Desal
15,296 Total Demand	**15,296 AFA Total Supply**

Source: MPWMD official position on supply and demand.

5.4 Future Demands

Cal-Am's UWMP cites several sources and several estimates of future demand, including:

1) a projection that a total of 26,450 AFA would be needed in 2025 (an addition ofapproximately 10,000 AFA above current demand), from an evaluation of potential maximum buildout prepared by MPWMD in the 1990s and based on planning and zoning designations in effect in 1988;
2) a more recent study conducted in conjunction with the EIR prepared for the New Los Padres Dam and Reservoir project, which Cal-Am proposed in the 1990s following issuance of Order 95-10, which indicated an increase of 3,570 AFA would be needed by 2020;
3) a 2001 MPWMD analysis based on a review of vacant legal lots of record, which indicated additional demand of 1,181 AFA; and,
4) The UWMP notes that, although estimates may vary depending on the assumptions used, there is demand for additional water above that needed to replace Carmel River supply pursuant to Order 95-10.

A 2006 MPWMD survey of jurisdictions estimated a need of 4,545 AFA to satisfy 20-year General Plan build-out requirements of the Monterey Peninsula cities and unincorporated portions of Monterey County within the MPWMD boundary. The estimates developed by MPWMD (MPWMD, 2006b) represent a refinement ofearlier estimates, developed in consultation with the cities in its jurisdiction, and supersede theearlier estimates that are cited in the UWMP.

5.5 Short- and Long-Term Water Needs

There is a clear short- and long-term water need on the Monterey Peninsula.The total existing water demand is estimated to be about 15,300 AFA. This illustrates a current need for additional water of about 9,752 AFA. Even if additional planned conservation measure reduces demand by up to about 1,000 AF, there is an immediate need of water production capability to meet full demands in all years.

Future water needs directly hinge on how demand growth will appear over time. A review of planning documents indicates a future demand of 9,752 AFA.

6. Water Rights and Entitlements

This section summarizes estimates of the appropriate and riparian water rights to the surface and subsurface waters in the Carmel River and underlying Carmel Valley Alluvial Aquifer. These water right estimates are shown in **Table 6-1.** The estimates are grouped by water right holder or claimant and include Cal-Am, MPWMD and others.

Table 6-1
Appropriative and Riparian Water Rights to Surface and Subsurface Waters in the Carmel River and Underlying Carmel Valley Alluvial Aquifer, Acre-Feet Annually

California American Water (CalAm)	
Appropriative Right (Pre-1914)	1,137
Appropriative Right (Los Padres Reservoir, 1984)[1]	3,030
Riparian Right	60
Appropriative Right (Decision 1632, Table 13)	1,482
Monterey Peninsula Water Management District	
Appropriative Right (New Los Padres Reservoir, 2007) Amended November 30, 2011	18,674
Appropriative Right (Phase 1 ASR Project, 2007)[2]	2,426
Appropriative Right (Phase 2 ASR Project, 2011)[2]	2,900
Others	
Appropriative Right (Galante, surface water)	40
Appropriative Reservations (Decision 1632, Table 13)[3]	1,811
Riparian Rights (Presumed, Water Year 2002)	722
Total	32,282

Source: MPWMD Memorandum to the Board of Directors, Appropriative and Riparian Water Rights to the Surface and Subsurface Water in the Carmel River and Underlying Carmel Valley Alluvial Aquifer, August 18, 2008, and unpublished MPWMD estimates.

As shown in Table 6-1, appropriative and riparian water rights claims total over 32,000 AFA from the Carmel River and underlying alluvial aquifer. The information presented here does not distinguish between quantities of water for "direct diversion" or quantities for "diversion to storage" or between annual and the seasonal availability of water.

Also, the quantities shown here are focused on the water in the Carmel River mainstem and underlying Carmel Valley Alluvial Aquifer and do not include rights to groundwater stored in the non-alluvial

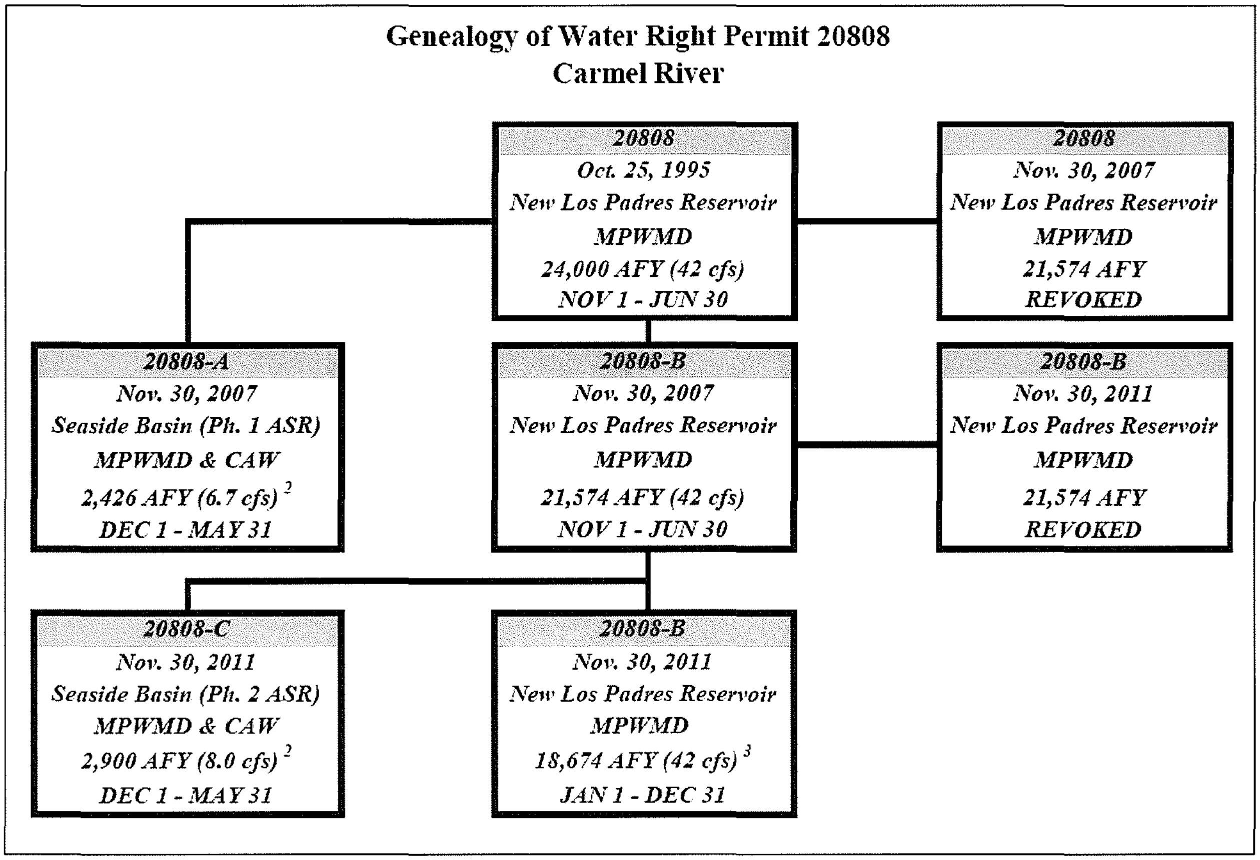
[1] Cal-Am's appropriative right at Los Padres Reservoir (License 11866) allows diversion of 3,030 acre-feet per year from October 1 through May 31. This quantity was reduced to 2,179 acre-feet in SWRCB Order 95-10 due to reservoir siltation and Cal-Am's ability to divert to storage.

[2] The appropriative rights for the Phase 1 and 2 ASR Projects are jointly held by Cal-Am and the MPWMD.

[3] This represents the amount of pending or confirmed non-Cal-Am rights.

formations in the Carmel River Basin or surface water in the tributaries to the Carmel River. The water rights priority year (i.e., year granted by the SWRCB) is included for appropriative rights in Table 6-1.

Permit 20808 is MPWMD's primary permit for the New Los Padres Reservoir authorized on October 25, 1995. Its provisions since then have evolved as elements of the MPWSP, particularly, the Seaside Basin Phases 1 and 2 ASR have emerged. The schematic below shows the genealogy of water right permit 20808.



Source: L. Hampson, MPWMD, September 14, 2012.

6.1 New Los Padres Water Right Opportunity

This Plan considered alternative ways to utilize the unused approved water right associated with the New Los Padres Reservoir, 18,674 AF. The unused water right represents a unique opportunity to perfect this entitlement with new, long-term water supply infrastructure that holds the potential to put a large part of the right to maximum beneficial use. Amendments to this right would be required depending on which long-term water supply alternative is chosen. Points of diversion/re-diversion, diversion rates, season of diversion, and storage limits would all be open to re-consideration depending on which option is selected for implementation.

7. Constraints and Opportunities

7.1 Technical Rationale Statements

7.1.1 Dam Facility

Dam Removal

Removal of reservoir sediment and its disposal is the most significant component of a dam removal plan from an instream resources perspective. Sediment disposal options include identifying suitable disposal sites and treatments for long-term stabilization within the Carmel watershed, allowing some or all of the reservoir sediment to be released downstream, or stabilizing some of the reservoir sediments in place as part of the river restoration design.

Wildfires are the most important driver of sediment production in the Los Padres Reservoir subwatershed, and have historically produced annual sediment yields up to 30 times the historical average (Matthews 1989a; Smith et al. 2004, 2009; Cal-Am2013). While catastrophic fires are episodic, a fire management and fuels reduction plan will be an important component of any watershed sediment management plan.

Reservoir Storage Enhancement

Reservoir storage enhancement options are those that increase reservoir capacity through sediment removal or by increasing dam height. Since dam completion in 1949 (Matthews 1989a), sediment eroded from the Los Padres Reservoir subwatershed has reduced reservoir capacity from the original 3,030 AF in 1949 to 1,785 AF in 2008, a decline of about 41%.

Salient Issues:

- *Finalizing the decision for the ultimate disposition of Los Padres Dam and Reservoir is critical in order to begin concerted efforts at developing and implementing the long-term physical solution – keep it or remove it?*
- *Without a final decision on the ultimate disposition of the facility, no long-term sediment management plan can be effectively developed.*
- *While sediment removal plans have been prepared, options for downstream sediment releases following dam removal have not been examined in detail and, if it is determined to proceed with dam removal, such plans would be revisited.*
- *How much of the accumulated sediment should be released downstream and under what flow regimes if it is determined that dam removal proceed – in order to effectively target sediment starved river/riparian reaches for both habitat restoration and floodplain accretion.*

- *If reservoir storage enhancement proceeds, long-term sediment removal and upstream sediment retention (sedimentation avoidance) plans will be necessary.*

- *If reservoir storage enhancement proceeds, target reservoir storage capacities for future projected instream flow and water supply requirements must take into account sediment filling rates in order to develop the most cost-effective sediment removal approach and maintain reservoir capacity over the long-term.*

7.1.2 Dam Operations / Sediment Management

Dam Removal

The Los Padres Reservoir subwatershed is a very high sediment producer relative to other parts of the Carmel River watershed. Geomorphic changes to the Carmel River are anticipated if the dam is removed and natural sediment loads are restored. The restoration of historic sediment loads can be also expected to result in beach replenishment, and the cessation of ongoing channel incision. Current gravel replenishment activities would not likely be required and potential channel aggradation, or at least the cessation of channel incision, would prevent future water table declines in response to a lowered channel invert. Thus, concerns of riparian vegetation loss due to channel incision and consequent water table declines would be diminished.

Reservoir Storage Enhancement

Assuming that removed sediment does not re-enter the Carmel River downstream of the dam, a long-term sediment removal program would not significantly alter the effects of Los Padres Dam on the Carmel River. Given that all inflowing bedload is currently trapped in the reservoir, increases in reservoir trap efficiency resulting from dam enhancement are not expected to alter existing rates of instream erosion that presently occur due to sediment hungry flows.

The narrower channel of today is more stable due to decreased sediment loads and bank revetment, resulting in fewer problems related to bank erosion or channel avulsion that could threaten infrastructure or private property.

Salient Issues:

- *With increased sediment load, particularly bedload which would follow dam removal, the Carmel River may aggrade its channel bed and widen through increased bank erosion and lateral channel migration.*

- *Future modeling studies are required to determine the potential for future channel aggradation that would follow dam removal. If significant, flood risk may increase due to higher water surface elevations during high flows.*

- *Higher large woody debris (LWD) loads would be expected during flood events following a potential dam removal. LWD provides benefits through creating improved habitat conditions for refuge and foraging by aquatic species, however, higher LWD loads may result in debris* *accumulation at bridge crossings during floods, potentially causing flooding, scour, and structural damage.*

- *Reductions in sediment supply and confinement by artificial bank protection has produced a modern day Carmel River that is narrower, deeper, and more stable than its historic predecessor. A deeper channel provides higher flow capacity and lower water surface elevations for a given discharge, decreasing flood risk. Dam removal would change these conditions.*

7.1.3 Instream Habitat Conditions

Dam Removal

Increased bedload transport following a potential dam removal would resupply and restore substrate for juvenile rearing of steelhead trout and higher LWD loads would improve habitat complexity, offering refuge and foraging areas for fish. Higher sediment loads may also initiate a trend toward historical channel conditions which exhibited a wider bed and higher rates of lateral erosion, a trend that could improve the overall extent and diversity of aquatic habitat. Dam removal would also eliminate marsh sediments that rim the Los Padres Reservoir and provide potential habitat for threatened California red-legged frogs.

Due to high natural sediment loads in the Carmel River above the dam, its removal may increase flow turbidity particularly for moderate to high flows. Large sediment yield events, such as those following basin wildfires, may overwhelm parts of the channel bed with fine sediment, temporarily reducing habitat availability for spawning and rearing until subsequent flows flush out the fine sediment.

Temperature data from upstream and downstream of Los Padres Reservoir indicate that flows downstream of the reservoir are generally warmer than those upstream throughout the year, with average daily water temperatures in summer months exceeding the 50-60°F optimal for steelhead growth both upstream and downstream of the reservoir. Historically, flow releases at Los Padres Dam when the reservoir is nearly full reduce the risk of thermal stress on salmonid populations; however, flow releases later in the dry season, when the reservoir is normally drawn down, often exacerbate thermal stress on downstream steelhead populations, including fish reared at the Sleepy Hollow steelhead rearing facility.

Removal of the dam would eliminate the benefits of thermal cooling by the reservoir early in the dry season; but this may be offset by the restoration of riparian cover along the stream and elimination of the reservoir surface area exposed to solar heating.

Salient Issues:

- *The CDFW, MPWMD, and others have expressed concerns over the loss of flow augmentation should the dam be removed. Flow augmentation provided by Los Padres Reservoir, or any upstream storage facility, is crucial to maintaining or achieving recovery success in the Carmel River as defined by NMFS in the Final Steelhead Recovery Plan – without flow augmentation recovery would likely continue to be significantly inhibited.*

- *CDFW has questioned whether aquatic habitat in the river above the dam is more suitable for spawning and nursery areas than that currently wetted by flow augmentation downstream of the reservoir.*

Reservoir Storage Enhancement

Gravel augmentation downstream of Los Padres Dam would likely need to be continued due to the loss of bedload material deposited in the reservoir.

- *Preserving Los Padres Dam would maintain existing reductions in sediment load downstream of the dam, reducing overall substrate quality and complexity as well as upstream accessibility for anadromous steelhead trout.*
- *Existing fish passage accessibility could be improved through established methods of fish passage infrastructure.*

7.1.4 Water Demand/Supply

Dam Removal

If Los Padres Dam is removed, there will be insufficient flows in the main stem of the Carmel River to meet water supply, fish passage, and environmental instream flow needs. In order to maintain these desired flows, additional water storage would be necessary. The upper Carmel River basin has the highest annual rainfall and therefore highest water supply potential in the watershed. Consequently, the available water yield generated within this part of the Carmel watershed must be utilized in any plan to achieve 'maximum beneficial use' of watershed runoff.

Reservoir Storage Enhancement

Even with complete sediment removal and restoration of the reservoir to its original capacity, there is insufficient storage to meet future water supply shortfalls from the watershed. Consequently, alternate sources of water supply through the MPWSP have been identified. New potential supply sources withinthe watershed include opportunities for new dams and tributary reservoir storage on Pine Creek, San Clemente Creek, Cachagua Creek, and Boronda Creek. Except Cachagua Creek, all of these options involve diverting flows from the Carmel River upstream of Los Padres Dam through a tunnel to the tributary reservoir; thus taking advantage of upstream hydrology, current point of diversion authorization, and gravity flow.

Salient Issues:

- *The extent to which Carmel River hydrology is to be relied upon in the future as an environmental and consumptive water resource asset must be determined; this inevitably involves a decision regarding Los Padres Dam and whether additional storage is to be pursued as part of the watershed's long-term strategy.*

- *Uncaptured and as yet unallocated yield within the watershed provide the opportunity to enhance and augment water resource management flexibility – newly established yield can enhance (and influence) existing and future anticipated requirements (e.g., GWR, instream flows,* *MPWSP sizing, Seaside Basin adjudication, updated prognosis for yield availability within the Carmel River aquifer units, etc.).*

- *Any future water supply plan involving watershed hydrology in the Carmel River basin must recognize and address the hydrologic effects of anticipatedongoing climate change – these should be incorporated as boundary conditions where the planning focus is concentrated on the extremes.*

7.1.5 Summarize Impacts / Benefits

The following bullets summarize impacts and benefits of dam removal and enhancement options for Los Padres Reservoir:

Dam Removal – Impacts / Constraints

- *A restored sediment regime may initiate a trend toward a more historic channel configuration on the Carmel River, which was wider and more laterally unstable. This might result in increased flood risk from channel aggradation and a higher incidence of bank erosion and property damage from increased lateral instability.*
- *Large, severe wildfires in the Los Padres subwatershed will continue to generate massive sediment yield events. Adverse downstream impacts may include flooding due to channel aggradation; property damage due to sedimentation and bank erosion; and, temporary burial of spawning and rearing habitat by fine-sediments.*
- *Higher large woody debris loads may result in debris accumulation at bridge crossings during floods, potentially causing flooding, scour, and structural damage.*
- *Juvenile steelhead will need to be relocated from the river to the fish rearing facility earlier in the year due to the loss of flow augmentation – in fact, the rearing facility may be made inoperable without flow augmentation.*
- *Removal of reservoir sediments will require disposal and storage within the watershed, allowing some or all of the reservoir sediment to be released downstream, or stabilizing some of it in place as part of the river restoration design.*

Dam Removal – Benefits / Opportunities

- *Removal of the most significant obstruction to fish passage on the Carmel River.*
- *A restored sediment regime, including large woody debris loads, is likely to improve aquatic habitat for steelhead trout through increased hydraulic and morphologic complexity as well as restoration of substrate for spawning and rearing.*
- *Ongoing trends of channel incision will likely slow or cease, with some areas potentially experiencing channel aggradation.*
- *Restoration of historic sediment loads will likely reduce and eventually remove the need for gravel augmentation and also support beach replenishment.*

Dam Enhancement – Impacts / Constraints

- *Ongoing trends of channel incision and loss of sand available for beach replenishment would continue.*

- *Existing reductions in sediment load downstream of the dam would be maintained, reducing overall substrate quality and complexity and upstream accessibility for anadromous steelhead trout.*
- *Restoration of the original reservoir volume provides only limited improvements to water supply.*

Dam Enhancement – Benefits / Opportunities

- *Preserving the dam under an enhancement scheme would maintain existing conditions in the Carmel River, which include decreased flood risk (although the limited capacity of the reservoir cannot provide significant flood attenuation), instream flow augmentation downstream, some thermal benefit, as well as consumptive withdrawals (though this has been significantly reduced through Order 95-10 and the current CDO.*
- *A watershed sediment management plan, assuming one is permitted within the Wilderness Area could help reduce reservoir sediment loadings.*

Regardless of which dam removal and/or enhancement option is ultimately selected, contemporary and future planning considerations must acknowledge the changing nature of the watershed's incident precipitation and resulting hydrology. Without a dam in place, dry periods and the potential increase in both frequency and magnitude of these dry periods into the future will represent growing challenges to the beneficial uses currently within the Carmel River. Protecting the supply entitlements of non-Cal-Am water right holders that rely on storage offered by the current dam will be an important consideration in any decision of the dam's future.

7.2 Institutional Rationale Statements

7.2.1 Water Rights

Water rights for MPWMD, split between Los Padres Reservoir, the then considered "New" Los Padres Reservoir, and its ASR Phases 1 and 2 for the Seaside Groundwater Basin are set out in water right permit 20808 and more specifically, its amended permits, 20808A through 20808C. The ASR Phases 1 and 2 permits (Permit 20808C) for 2,426 AFA and 2,900 AFA, respectively, are limited to wet season diversions (i.e., December 1 – May 31). See Chapter 5 – Water Rights and Entitlements and the genealogy schematic.

The original New Los Padres Reservoir water right (Permit 20808) was for 24,000 AFA and has since been amended (often referred to as the "remainder" permit) to 18,674 AFA (Permit 20808B). This permit has an open diversion season of January 1 – December 31. As a new permit, the water right is junior to the appropriative reservations under Table 13 of D-1632 (e.g., Cal-Am, Carmel Valley Ranch, Rancho Canada, Quail Lodge, etc.), all riparian, overlying, and pre- and post-1914 water right holders. Permits 20808A, 20808B, and 20808C must finalize their application for water by December 1, 2020.

These water rights are additional to the original Cal-Am Los Padres Reservoir rights for 19,000 AFA which, under amended Permit 7130B in 1984 were split 15,970 AFA for MPWMD and 3,030 AFA (reduced to 2,179 AFA by SWRCB Order 95-10) to Cal-Am. The 15,970 AFA portion was revoked by SWRCB in 2011 after MWPMD abandoned the permit.

Salient Issues:

- *MPWMD's current permit for the then "New" Los Padres Reservoir is 18,674 AFA; can this be preserved, perfected, and ultimately transferred to a new storage facility in the watershed?*

- *Resolution of Los Padres Dam's future will determine if, and how, MPWMD chooses to perfect their 20808B rights by December 1, 2020; this is time and expense that could be avoided unless a new storage opportunity is identified.*

- *Mean unimpaired runoff to Los Padres Reservoir over the past century has averaged around 39,000 AFA, more recent trends of flow show a slight increase to about 43,000 AFA – the SWRCB's Water Availability Analysis (as part of 20808) has already demonstrated that water was available in most, if not many years, during the November – March periods. The hydrology supports completing the water rights process if MPWMD desires.*

- *A Pine Creek Reservoir (see Chapter 8.6 – Tributary Dams and Reservoirs) or a reinitiated "New" Los Padres Reservoir would store up to 20,000 AF and 24,000 AF, respectively.*

7.2.2 Steelhead Recovery Plan Implementation

The NMFS South Central California Coast Steelhead Recovery Plan ("Recovery Plan") has identified a number of Recovery Actions. The Recovery Plan itself includes several broad general characterizations of in-basin conditions based on incomplete knowledge of current watershed management practices, past surveys, and ongoing monitoring. Indeed many of the recommended Recovery Actions include information that has already, in some form, been collected, analyzed, and made available in ongoing MPWMD reporting documents in collaboration with the primary resource agencies and Cal-Am. It appears that the lack of complete knowledge of the watershed has led to certain Recovery Actions that are either unclear, contradictory to others, or would result in significant economic impact (without the benefit of rationalizing those costs/benefits).

Salient Issues:

- *The Recovery Plan focus including initial discussions with Cal-Am regarding the ultimate fate of Los Padres Dam has focused narrowly on fish passage; improved passage for all life stages or dam removal – neither embrace the broader edict of integrated watershed management and the cumulative strategies necessary to ensure species recovery.*

- *Permanent removal of any upper Carmel River watershed storage facility would severely limit the ability to meet even current minimum downstream flow needs – the watershed, simply due to its inherent hydroclimatic characteristics, requires man-made intervention (i.e., storage) if it wishes to alter the natural seasonal hydrograph to meet current needs for environmental and non-Cal-Am water rights holders.*

- *Innovative proposals as those presented in this MPWMD Strategic Plan can provide the release hydrology necessary, from available runoff, to both meet downstream instream flow requirements as well as open up the entire upper watershed and mainstem Carmel River to fish migration – when combined with a dam removal project.*

- *MPWMD's unused permitted water right of 18,674 AFA represents a tangible and effective water resource to help meet a variety of downstream fisheries and water quality needs. How would NMFS recommend MPWMD put that recognized water right to maximum beneficial use?*

- *Could this same water right be used as a negotiative tool for new storage development? Such storage, as these current analyses have shown, could increase minimum flows at Sleepy Hollow to perhaps 8-10 cfs over a wider range of water year types (based on new upstream storage retention).*

- *For any proposed off-mainstem reservoir, consideration should be made of the loss in potential habitat on that tributary. With the proposed Pine Creek Dam (on the Pine Creek watershed) for example, the potential adverse effects to 5 miles of designated critical habitat in that watershed could be superseded by the additional 1.4 miles of Carmel River mainstem currently inundated by Los Padres Reservoir that could be restored and 6.8 miles of upper basin streams that could be opened up under a new hybrid alternative.*

- *NMFS appears fixated on fish passage; placing less importance or emphasis on the suite of other factors that are important to fisheries recovery. Passage without guaranteed instream flows is not likely to be successful in the long-term.*

7.2.3 Implementation of the Physical Solution for the Seaside Groundwater Basin

An effective long-term physical solution for the Seaside Groundwater Basin will be determined by a number of commitments, hydrogeological limitations, and successful integration with major water management initiatives across the region, not the least of which is the pending MPWSP.

The Seaside Basin Adjudication has reduced Cal-Am pumping from the basin aquifer on a continuous and aggressive reduction schedule until, as defined by the Watermaster, the natural safe yield of the basin is attained (identified no later than 2021). Cal-Am's right to withdraw from the basin is being reduced from approximately 4,000 AFA to 1,474 AFA. Cal-Am has also agreed with the Watermaster to further reduce withdrawals to 774 AFA for 30-years in order to replenish the basin for current annual extraction in excess of Cal-Am's adjudicated right.

Groundwater replenishment, natural and artificial, will continue to be a vital component of the MPWSP. Early commitments and successes are optimistic. Since the beginning of MPWMD's ASR feasibility testing program through WY 2012, a total of 4,477 AF has been injected into the basin.

A current constraint on the Seaside Basin aquifer is its available usable capacity. Relative to the riparian aquifer of the Carmel River (e.g., lower aquifer only), the Seaside Basin aquifer has a current *usable capacity* (7,512 AF) about one-third that of the lower Carmel River aquifer (21,927 AF). Is the final solution for the Seaside Basin constrained by available remaining and usable capacity? No. Total storage capacity within the combined subareas of the various coastal aquifers exceeds 123,000 AF. Usable capacity, however, is currently limited by the extent and accessibility of the subsurface phreatic stores from existing extraction wells with currently unusable storage estimated at 115,800 AF.

At present (through 2012), recent groundwater storage tracking estimates reveal that usable capacities are about 32-34% utilized in the Seaside Groundwater Basin. Accordingly, there is room to enhance utilization with existing infrastructure. Moreover, the large potential yet undeveloped storage capacity (i.e., 115,800 AF) suggests that expanded groundwater management facilities could provide improved water supply development in the future.

Salient Issues:

- *What is the cost of delivered water over time from the Seaside Groundwater Basin, relative to a new upper Carmel River Basin source? When risk coefficients are applied; does that change the results?*

- *While it can be said that the MPWSP is largely the result of the CDO, it is interesting that the overall hydrologic effectiveness (and ultimate potential) of the ASR element will be derived from a final solution to the upper Carmel River basin yield determinations and, therefore, flow availability in the river.*

- *Two issues are relevant - the first is related to the supply sources for the GWR Project (Salinas Valley) and ASR element (Carmel River supply); the second is related to the actual available and usable storage capacity in the aquifer. Both issues, while benefitting from existing information, should be updated in terms of their supporting data/models.*

- *How can MPWMD's existing water rights be used to assist the GWR/ASR if Los Padres Reservoir and any upper basin storage/diversion opportunities are no longer seen as viable?*

7.2.4 MPWSP Implementation

The MPWSP is a duly recognized project by virtually all interested stakeholders on the Peninsula. It represents the culmination of significant effort including water supply planning, design engineering, environmental constraints, legal, and various institutional issues. An important element of the MPWSP involves the Groundwater Replenishment Project (or "GWR") and its vital ASR projects which, in many ways, are being used as the *sliding scale* for final desalination sizing. This is a dynamic process made all the more challenging as the CDO schedule allows little room for typical *"confirm and adjust"* tactics.

A Los Padres Dam or upper basin "solution" is inextricably linked to the MPWSP and particularly, the GWR and ASR elements. To the extent the current MPWSP desalination sizing is contingent upon the assumptions of the GWR (and the Water Purchase Agreement), upstream water availability will be an important facet to maximize the quantities and periods of Carmel River water availability. MPWMD's watershed management responsibilities include arguably, the most vital region of the basin, its *headwaters.*

The demand projections, currently at 15,296 AFA, while continually fluctuating (e.g., Seaside Basin payback schedule, Pebble Beach buildout, LORs variability, etc.) can be accommodated by a conservative application of anticipated ultimate demands. This should not represent an unavoidable hindrance.

It is recognized by MPWMD that the combined effects of the CDO and Seaside Basin Adjudication would have a disastrous effect on the Peninsula's communities without a new firm and major replacement water source. In addition to the MPWSP, all other potential options are being considered. Indeed, MPWMD this past July approved a local water project funding program that is intended to encourage independent water supply development within the watershed that could help MPWMD improve overall water supply management flexibility. The City of Pacific Grove's recent local non-potable water supply project is an example. Should this motivation be limited to only small local agency independent projects?

Salient Issues:

- *Can MPWMD and Cal-Am resolve the Los Padres Dam or upper basin "solution" in a timely manner so as to bring final closure to what the ultimate storage and upper watershed management scenario looks like for the future? Such clarity would go a long way in adding assurance to the effectiveness of the GWR/ASR initiatives.*

- *If, for example, a new storage facility (as was considered with New Los Padres Dam and Reservoir) is implemented, capable of providing upwards of 20,000 AFA of storage, what implications would that have on the possible operational preferences of the GWR/ASR?*

- *Does the SWRCB recognize the interconnectivity between the MPWSP and the final solution for the upper watershed and Los Padres Dam? What information from this Plan can we use to help assuage any concerns they may have?*

8. District Alternatives

Fundamentally, alternatives should meet most if not all of the key planning principles outlined earlier (see Chapter 3 – Key Planning Principles). As noted previously, these principles define the primary and overall objectives of MPWMD and should serve as the guiding standards in developing the suite of alternative categories and sub-categories.

When viewing the options available to MPWMD to meet these objectives, several distinct categories emerge. One category involves potential new physical facilities or modifications to existing facilities. A second category includes the various locations of any new facilities. A third category includes the ownership, institutional governance, and operational agreement(s) associated with those facilities. A final category involves permitted water entitlements (e.g., surface or subsurface adjudicated water rights) that either exist currently or, could be additionally secured through separate SWRCB petitioning.

A number of permutations are possible between and among categories (the latter represented by sub-categories). **Figure 8.1** shows a very simplistic conceptualization of how the various sub-category alternatives can be combined with other sub-category alternatives in developing the *operative alternative*. The operative alternatives would be developed at the far right of the diagram.

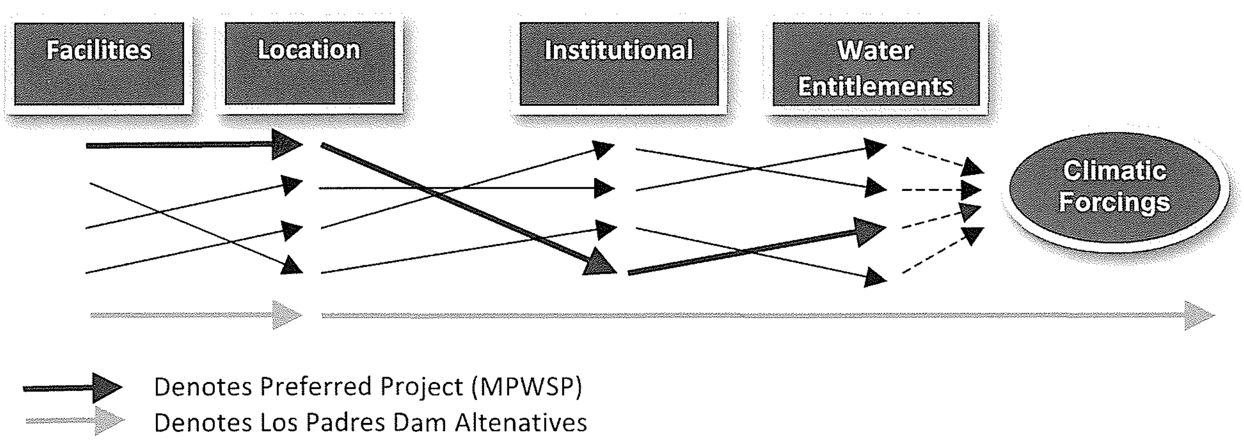


Figure 8.1
Simplistic Conceptual Diagram of Alternative Sub-Category Permutations

The operative alternatives are then put through a two-tiered screening process for initial concept-level screening (see Chapter 9 – Alternatives Screening Process). The categories focus on facilities, location, institutional/regulatory variation, water entitlements/available supplies, and the hydrologic adjustment factors associated with anticipated climate change. Other possible categories emerge as one considers these various elements, but on closer inspection many of these other categories really represent screening criteria and not genuine alternative categories (e.g., environmental sensitivity, public perception, timing/efficiency of process, regulatory agency support, etc. – see Chapter 9).

A key category, costs is not included in this depiction. A separate and independent economic evaluation could, however, use the results of this operative alternatives assessment to generate option-specific costing estimates. Cost analyses would likely represent the final key determinant in the selection of the operative alternative.

Hydrology, as one would expect, represents a key component in any of the alternatives and as such is not considered as an alternative component; there is no alternative to adequate or sufficient hydrology – it represents an *a priori* requirement. The variability, both spatial and temporal, the infrastructural limitations, and overall watershed hydrologic functionality has been previously discussed in detail in Chapter 4 – Watershed Hydrology.

As noted earlier, known global climatic forcings and their influence on significant hemispheric atmosphere-ocean circulation (e.g., ENSO) will play some role in long-term yield generation in the Carmel River watershed. Knowing how this hydrometeorologic driver ultimately affects watershed yield functionality will be an important consideration in the advancement of any operative alternative if it proceeds to the feasibility stage. At a minimum it (i.e., climate change effects) should be incorporated into a robust evaluation of the long-term viability of watershed yield within the basin. This can occur within or outside of this current Plan process.

Climate Change as a Negotiative Tool

As a sidebar, for MPWMD, delineating the range of potential effects to basin hydrology brought about by continued (and anticipated future) climatic forcings will represent a strong negotiative tool in pending consultations with various resource agencies (i.e., most resource agencies have yet to fully incorporate climate change into their permitting review processes and have not established precedents on how to offset, ameliorate, or institute allowable variances when presented with climate-adjusted information).

While Figure 8.1 is illustrative in terms of demonstrating the breadth of possibilities available with these permutations, tracking every possible operative alternative (i.e., there are several more sub-category permutations than what is shown here) is beyond the scope and relevance of this investigation. Rather, the depiction is intended to convey the two-dimensional complexity of both the alternative categories and sub-categories. Choosing any one option under a single category (i.e., one dimensionally) without the broader context of the other categories (and sub-categories) limits the utility and efficacy of the alternatives identification and selection process.

It is recognized that numerous alternatives for the Monterey Peninsula have been studied over the years; both by MPWMD and Cal-Am. In fact, the process can be viewed as a dynamic one as the water resource experts at MPWMD and Cal-Am, who commit to the daily operation, planning, and implementation of various water programs within the basin know better than anyone the needs, limitations, regulatory challenges, costs, and public sentiment associated with future water supply activities.

8.1 Current Project – MPWSP

The priority project for MPWMD is the current Monterey Peninsula Water Supply Project (the "MPWSP"). This current Plan and its focus on the long- and short-term strategies associated with Los Padres Dam and Reservoir does not detract from or impart any conclusions regarding the MPWSP.

Much information exists regarding the MPSWP and its numerous multi-faceted components are not repeated here. Of relevance to the long-term disposition of Los Padres Dam and Reservoir and its role as a continuing water supply facility to meet the water demands of the Peninsula, some background is appropriate.

On April 23, 2012, California American Water Company filed an application for a Certificate of Public Convenience and Necessity (CPCN) for the MPWSP and authorization to recover all present and future costs in rates. The purpose of the MPWSP is to replace a significant portion of the existing water supply from the Carmel River, as directed by the State Water Resources Control Board ("SWRCB"). Acquisition of an alternative water supply is necessary for Cal-Am to comply with SWRCB Order No. WR 95-10 ("Order 95-10"), which directed Cal-Am to develop and implement a plan to replace what the SWRCB determined to be unlawful diversions from the Carmel River. On October 20, 2009, the SWRCB issued a Cease and Desist Order ("CDO") (Order No. WR 2009-0060), which requires Cal-Am to undertake additional measures to reduce its unpermitted diversions from the Carmel River and to terminate all diversions in excess of 3,376 AFA.

The current MPWSP is described in detail in the Cal-Am application to the CPUC, Application A.12-04-019 on April 23, 2012 for the MPWSP. This was an amended application following Cal-Am's withdrawal of its previous support of the Regional Water Project, originally filed in 2004 (under Application A.04-09-019) and referred to as the Coastal Water Project (or "Regional Project"). The CPUC certified the Regional Project Final EIR (SCH No. 2006101004) in December 2009 (under Decision D.09-12-017). The following year, the CPUC approved implementation of the Regional Project Alternative (under Decision D.10-12-016).

Both projects, the CWP and the current MPWSP, were and are intended to replace existing water supplies within the watershed that have been constrained by legal decisions affecting water supply in the Carmel River and Seaside Groundwater Basin. Many of the same elements in the CWP were retained in the MPWSP, but several key elements have been modified and/or relocated including the ocean water intake system and desalination plant.

Cal-Am's current proposal, now under a Settlement Agreement between many of the original parties, is to size the proposed desalination plant to 9.6 millions of gallons perday (mgd) also requesting authorization to reduce the plant size to 6.4 mgd and supplement water supplies of 3,500 AFA of water purchased from the Groundwater Replenishment Project ("GWR"), a separate joint project of the Monterey Regional Water Pollution Control Agency ("MRWPCA") and MPWMD. Through the Sizing Settlement, the Settling Parties agreed to a third sizing option of a potential 6.9 mgd plant to be combined with 3,000 AFA of water from the GWR.The agencies sponsoring the GWR Project are not under Commission jurisdiction, however, the Commission must approve any Water Purchase Agreement thatmay be proposed by Cal-Am. In addition to the GWR, other key components (public elements) of the MPWSP include the Aquifer Storage and Recovery (ASR) and Pacific Grove Small Projects; each of these elements are a critical component to the long-term water supply solution on the Peninsula.

Of relevance to Los Padres Dam and Reservoir and upper watershed supplies in general is the pending Commission decision on whether to authorize Cal-Am to build a smaller desalination plant that includes a Water Purchase Agreement for water producedfrom the GWR. MPWMD's intended GWR source water originates in the Salinas Valley. Source water for a future expansion of the ASR project in the Seaside Groundwater Basin originates in the Carmel River watershed uplands and the ultimate disposition of the water right associated with a New Los Padres Dam and Reservoir will have an effect on the long-term yield of the ASR Project in the Seaside Groundwater Basin.

8.2 Los Padres – Storage Enhanced

It is well established that the active storage within Los Padres Reservoir has been significantly reduced since its construction over 60-years ago. Approximately 2.1 million cubic yards of sediment has accumulated behind the dam. For any reservoir, storage can be gained by one of two possible means; 1) dredging out accumulated sediment, or 2) raising the dam face. The reasons for the current reduced storage in Los Padres Reservoir have been described in numerous documents (e.g., Cal-Am, 2013, 2003; MPWMD, 2011, 1995, 1989, 1981) and previously in Subchapter 4.8 – Sediment Budget).

Both approaches are, by and large, temporary in their effectiveness unless efficient long-term sediment management prescriptions are implemented. This is because sedimentation in all reservoirs is a natural process that cannot be avoided without deliberate management action. Impounding a river, by its very nature, impedes the natural migration of bedload and suspended sediments that are carried downstream with river flow. Reservoir bed accretion begins as soon as the river is closed.

Massive volumes of hillslope detrital material can enter reservoirs through mass wasting events. These can include a variety of slump types and catastrophic landslides. They are infrequent events, but can lead to significant amounts of material entering a reservoir in a single event; a more frequent though less instantaneous process results from large scale wildfires. Following large scale wildfire, denuded slopes, left exposed to high intensity rainfall events can result in the entrainment and mobilization of large quantities of detrital material (e.g., top soil, organics, leaf litter, small to medium sized clasts, etc.). This material enters waterways and become trapped in downstream reservoirs. Such conditions have long been acknowledged in industry practices such as logging and road construction in forested areas and are most prodigious in steeply sloping terrain. Subchapter 4.8 – Sediment Budget describes the mechanisms and processes associated with sedimentation in Los Padres Reservoir.

As discussed in detail in Subchapter 4.8 – Sediment Budget, past fires in the Carmel River watershed together with the annual ensuing rainy seasons, have resulted in a range of erosion and reservoir sedimentation conditions. While several wildfires have occurred in the watershed in recent times (e.g., 1999 Kirk Complex, 2008 Basin Complex), it was the 1977 Marble-Cone fire that produced the most notable sediment depositional event. A U.S. Geological Survey (USGS) 1977-1979 study found a loss of 590 AF in reservoir capacity in 1978 following the 1977 fire and 1978 intense rainfall sequence. This storage loss is equivalent to approximately 952,000 cubic yards of sediment deposition from this singleepisode (Cal-Am, 2013; USGS, 1979).

Any storage enhancement of Los Padres Reservoir must fully acknowledge both the inevitable sedimentation from natural erosion and sediment transport processes and the likelihood of future large scale mass wasting events. The larger the upstream source area, the greater the potential for wildfire to trigger mass wasting events that can have major effects on the downstream reservoir. While such large and periodic fires are unavoidable, care must be exercised to ensure that any storage enhancement alternative implement prescriptions that are highly sensitive to these environmental constraints.

Sediment management as an efficient and cost effective prescription should be ongoing. Technology has advanced such that several commercial options and innovative methods are indeed emerging and now available. A close examination of the available methods and benefits to Los Padres Reservoir with a carefully selected annual program would be necessary with any commitment to retaining the reservoir as a long-term water reliability fixture within the watershed.

8.2.1 In-Situ Dredging Only

Under this alternative, Los Padres Reservoir storage capacity would be increased by dredging only. To facilitate dredging, during the active construction seasons, the Carmel River would be diverted along the reservoir and dam site, and the reservoir would be drawn down to elevation 1,000 ft msl by August 1. Potential techniques include mechanical excavation using conventional earthmoving equipment; hydraulic dredging using a suction dredge, and barge-mounted clamshell or long-arm excavator.

A recent Cal-Am investigation looked into various dredging options including complete sediment removal (90% or 1.8 million cubic yards) with upstream disposal; partial sediment removal (40% or 0.81 million cubic yards) with upstream disposal; and partial sediment removal (44% or 0.9 million cubic yards) with downstream disposal (Cal-Am, 2013). Each of the dredging options would require between 4-5 years for sediment removal with total project construction ranging from 6-7 years. Similarities among the options also include river by-passes, upstream coffer dam, accommodation for minimum instream flow maintenance, improved reservoir access, and disposal area site preparation and erosion control measures. Detailed schematics of the key elements within the various project options are provided in the recent Cal-Am report (Cal-Am, 2013).

A significant issue is the disposal areas. Upstream disposal is proposed under two of the options. While detailed discussion of the various sorting, layering, compaction, re-vegetation, drainage, and erosion control measures are set out in Cal-Am (2013), the proximity of the upstream disposal area to the Carmel River is cause for concern. **Stockpiled sediment from dredging should wherever possible be located *downstream* of the reservoir or, ideally, outside of the watershed altogether**. Otherwise, mass wasting events, particularly the catastrophic episodes described previously under a combination of wildfire, high intensity rainfall, and slope failures, could mobilize stockpiled sediment and reintroduce back into the reservoir.

As noted previously, without a permanent sediment management plan, any benefits accrued from this alternative would ultimately be only temporary.

8.2.2 Dam Raise

Under this alternative, the Los Padres Dam crest would be raised in elevation with the aim of capturing additional winter runoff from the upper watershed. A dam raise by itself would also represent only a temporary solution since again, it would not address the primary cause for storage capacity decline; reservoir sedimentation.

To be sure, dam raises are a regularly part of the contemporary California water supply vernacular. Numerous studies of dam raises on such large CVP facilities as Shasta Dam (the State's largest reservoir), Folsom Dam, Los Vaqueros Dam, and most recently San Luis Dam have occurred in recent years. With such facilities, where the range of issues such as Statewide yield forecasting, CVP/SWP water contractor obligations ranging in the millions of AF, coordinated CVP hydropower generation, Central Valley flood control, reservoir thermal management, and highly regulated downstream Delta water quality control make such projects highly complex, there exists today robust interest in expanding these facilities via dam raises.

Dam raises often represent a viable, regulatory supported, and effective alternative to building new impoundments at undisturbed locations. However, where the existing infrastructure has aged, needs replacement of component elements, or requires modifications to address conditions (not originally conceived), retrofit and improvement work can be just as complex, time consuming, and costly.

At Los Padres Dam, any dam raise would need to consider a variety of factors including; proposed yield enhancement volume, spillway modification (and/or completely new outlet designs), footprint expansion, earthen slope and abutment stability, the ongoing need to integrate improved fish passage, and ongoing reservoir sedimentation issues, to name but a few. Expansion of storage at Los Padres Reservoir through a dam raise would likely encounter institutional limitations from the resulting inundation of its upstream boundary which would submerge a larger portion of the Ventana Wilderness. **To develop the additional storage that would make such a project worthwhile, it seems that a lower river impoundment capable of submerging a larger portion of the existing facility and watershed without impinging on the Ventana Wilderness would be more appropriate (see Subchapter 8.4 - New Lower Los Padres Dam and Reservoir)**

Based on the 2008 bathymetry and contour profile of the impoundment, storage could be increased with the implementation of various dam raises.

Existing storage – 1,786 AF
5 foot raise – 2,028 AF
10 foot raise – 2,270 AF
20 foot raise – 2,754 AF

These are total storage values.

Temporary, annual storage enhancements are possible with such means as inflatable dams. MPWMD has estimated that with such temporary structures and, given the constraints of the "up-reservoir" boundary (i.e., Ventana Wilderness), increases in storage might be on the order of 60 AFA per vertical foot.

The minimum annual inflow to Los Padres Reservoir is over 3,000 AF, so even with a 20-foot dam raise, the reservoir would be expected to fill *every* year. The median inflow to the reservoir is about 36,800 AF. A 20-foot dam raise would only generate an additional 968 AF of storage and represent about 3% of the median inflow. A 10-foot and 5-foot dam raise would capture about 1% and 0.7% of the median inflow, respectively.

8.2.3 Ownership Variation

Institutionally, an ownership change in the reservoir would unlikely affect the ultimate physical solution for the facility. Accordingly, this is not a true alternative to the long-term disposition of Los Padres Dam and Reservoir. All of the natural watershed hydrological, environmental, and physical engineering facets associated with the facility remain largely unaffected regardless of who claims ownership.

Nevertheless, while the physical options available may not change, the overall governance, responsibilities, and priorities may reflect large or subtle differences; as MPWMD and Cal-Am are two very different organizations. Their inherent priorities, watershed management obligations, and financing structures differ markedly. Institutionally, issues involving regulatory compliance (e.g., public versus private lead agency status), contract issuance, bond/financing procurement, stakeholder collaboration and, indeed, even public perception (as seen in recent public sentiments regarding MPWMD takeover of the facility) are tangible concerns.

With the removal of San Clemente Dam, Los Padres Dam and Reservoir will become the primary infrastructural facility on the Carmel River and its position within the watershed will remain as the primary surface storage impoundment capable of meeting a variety of downstream flow, recharge, and direct water supply needs. This attribute has been long recognized by both MPWMD and Cal-Am and is the reason why so much effort has gone into determining the dam's long-term solution.

While the ultimate ownership of Los Padres Dam remains speculative, the current relevancy of the issue can be seen in how both Cal-Am and MPWMD view differently the manner with which certain regulatory agencies are requesting the issue be addressed. MPWMD, for example, has made it clear to both the CPUC and NMFS that its position regarding Los Padres Dam should be one that takes into account a broader suite of factors and concerns. In fact, part of the rationale and objective in preparing this current Plan was to delineate the complexity associated with many of the interrelated and interdependent factors related to the dam.

Whether Los Padres Dam remains under Cal-Am management, cedes to MPWMD, remains to be seen, but the implications cannot be ignored.

8.3 Los Padres Dam – Removal

This alternative has arguably received the greatest interest and discussion in recent years. It represents one extreme boundary condition and would result in an array of new considerations. Like many other dams across the U.S., numerous factors influence the decision to remove a dam; structural obsolescence; safety and security considerations; economic obsolescence; lost recreational opportunities; water quality and supplyissues; and ecosystem restoration, to name but a few. Careful consideration of each issue must be made both within the existing and future contexts.

For Los Padres Dam, the ongoing fisheries passage and aquatic habitat issues have represented a significant influential factor in promoting the call for removal. For example, in a recent letter dated April 22, 2013, NOAA Fisheries "... *strongly encourages California American Water to resolvethe fish passage and other potential take issues at Los Padres Dam by completing athorough feasibility study on the merits of either: 1) entirely removing the dam andrestoring the reservoir area to its original environs; or 2) improving the dam withappropriate permanent fish passage modifications that allow for unimpeded, safe andeffective, upstream and downstream migration of all life stages of S-CCC steelhead."*

Dam removal would involve mechanical dismantling of the structure and physical removal of the debris. This usually begins with a dam breach to drain water stored behind the dam. For small, run-of-river structures, demolition of the remaining structure then can proceed while dealing with relatively shallow water conditions. For larger dams with significant storage, a systematic process of creating increasingly large notches in the structure is necessary. Los Padres Dam is really a medium-sized facility (i.e., between 1,000 and 10,000 AF of initial active storage). Attaining shallow water conditions would not be as significant an issue with Los Padres Dam as it would with other larger facilities.

To many, the recovery of a river following dam removal implies that the physical and biological components of the watercourse will return to the same level that existed before the building of the dam. Rarely, however, is this possible, because of the other impacts and changes that have taken place in the watershed since the dam was constructed. The Heinz Center (2002) spells out many of these perceptions and realities. The removal of a dam will not automatically result in the full recovery of the river or the species that it once supported. It is essential to evaluate each dam removal in the context of other community issues andthe location of the dam within the watershed.

For the Carmel River, fish listings and their related requirements (e.g., passage, rearing refugia, habitat maintenance, etc.), diversions, established recreational values, and flooding risks, all represent current challenges in the river's management that did not exist prior to, or following dam construction.

Removal of the dam will affect each of these established instream or flow-related issues in some manner. From a riparian and fluvial geomorphological perspective, removal of Los Padres Dam and its implied sediment management issues have been discussed earlier (see Subchapter 4.8 – Sediment Budget).

Following dam removal, the discharge in restored streams may be small in magnitude, but its continuous nature has important implications for the hydrologic underpinnings of the aquatic and riparian ecosystems connected with the stream (Malanson, 1993). The most common downstream hydrologic effects following dam removal are generally increased peak flows, altered low flows, increased range of discharges, altered timing of flows, and changes in flow ramping rates. Without the moderating effect of dams and their controlled releases, river flow regimes return to their natural variability. Within the riverine corridor, all rivers exist in a state of quasi-equilibrium as they respond to natural hydroclimatic (e.g., inter-annual rainfall-runoff) and geomorphic processes (e.g. downcutting, bank scour, sediment deposition, and corresponding hydraulic gradient adjustments).

Los Padres Dam, however, as a run-of-the-river facility *above the spillway* provides defined downstream flow management (e.g., it is limited in its operational range, typically between 1,000 ft msl and 1,040 ft msl). While dead pool is lower, at 980 ft msl, the reservoir is not typically operated to this level in order to avoid sedimentation of the lower outlets. The ratio of storage over yield for the reservoiris quite high (e.g., over 20). Even for large dams, while the ratio is often greater than 10, they do not typically exceed 20. Dams that have storage capacities that approach one year's water yield of the stream are likely to have large upstream reservoirs and their removal will likely result in substantial effects on downstream hydrology and instream geomorphologic response. With the very high storage to yield ratio, removal of Los Padres Dam would not appear to hold that same potential.

What makes the decision to remove Los Padres Dam more complex can be attributed to two primary factors. **First, it will remain the only impoundment on the Carmel River (after removal of San Clemente Dam) and, therefore, provide the only means of managed flow control from headwater annual yield. Second, given the river's episodic, temporal, and highly variable inter-annual flow regime and downstream minimum flow requirements, sustaining the ability to mete out appropriate releases over the summer season (i.e., extending the unimpaired hydrograph) is an essential function.** From these reasons, maintaining some kind of upstream flow release control would appear vital. Such hydrologic benefit or proposed advantage offers a solid foundation upon which MPWMD, through several possible venues (e.g., Cal-Am CPUC rate hearing; SWRCB CDO negotiations; discussions with NMFS regarding the Final Steelhead Recovery Plan, etc.) to begin to establish a prescriptive strategy for long-term regulatory compliance in the watershed; essentially, moving towards a permanent regulatory "solution" for the watershed.

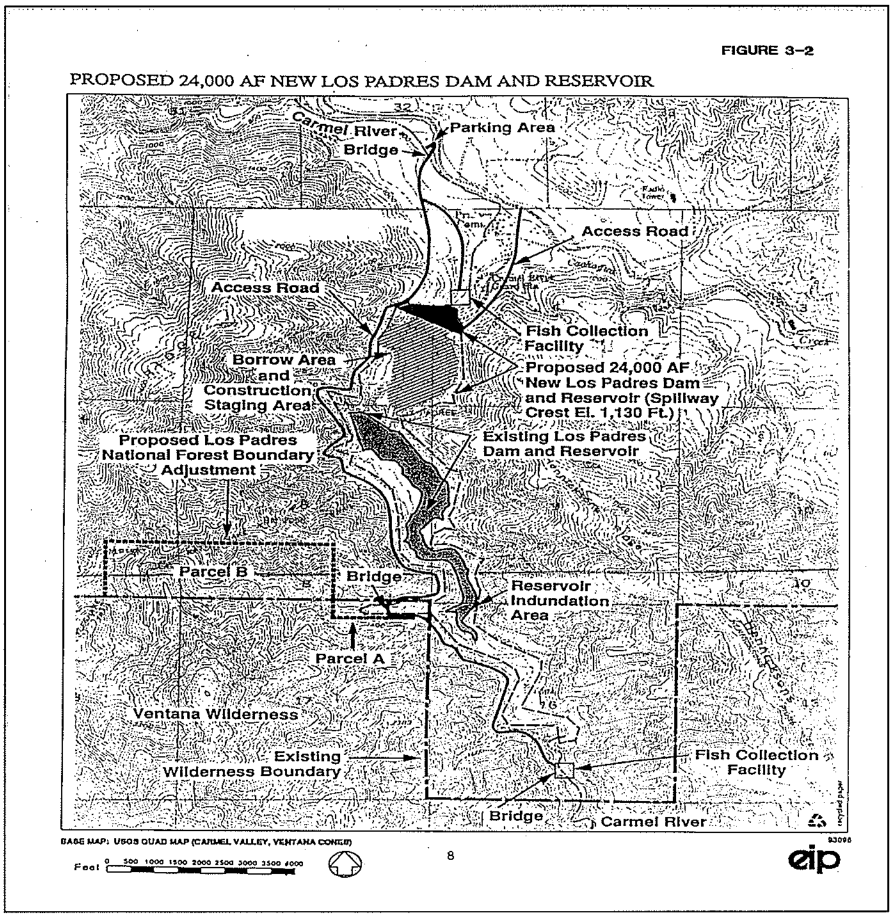
Recharging groundwater supply in the near stream areas along downstream channels represents an important benefit to water supply (Dingman, 1994). Given the unique nature of the lower Carmel River to changing hydraulic gradients between the river and groundwater, maintaining the ability to recharge this vital subsurface storage reservoir over as long a period as possible is essential. Los Padres Dam, like any other storage impoundment in the upper watershed provides the continuous instream flow necessary to recharge the various subsurface aquifer units along the Carmel River riparian recharge zones.

Finally, dam removal also may release accumulated sediment. This sediment, whether toxic or not, can reduce the quality of downstream water for human consumption, but may also restore stream habitat through deposition. Downstream sediment redistribution following dam removal and its various implications was discussed previously in Subchapter 4.8 – Sediment Budget.

8.4 New Lower Los Padres Dam and Reservoir

This alternative exists as an option previously investigated by MPWMD. In the early 1990s, MPWMD developed plans for a New Los Padres Dam and Reservoir, designed to replace the existing facility with a larger downstream dam (**Figure 8-2**). The project received necessary Stateand federal permits, but 57% of the voters on the Peninsula rejected the necessary bonds to finance construction of the projectin 1995. Cal-Am subsequently attempted to build the project privately, but in September 2003, the CPUC dismissed their application for theproposed new Carmel River Dam without prejudice and directed Cal-Am to file anew application to seek CPUC authorization to pursue the proposed Coastal Water Project instead (see Current Project – MPWSP above).

The project had acquired a SWRCB permit for MPWMD to obtain up to 42 cfs by direct diversion and up to 24,000 AFA by storage from November 1 through June 30. This was a significant milestone at the time.



Source: MPWMD, 1995

Figure 8.2
New Los Padres Dam and Reservoir

Cal-Am filed an application with the CPUC to build the proposed dam, with a modification providing that the project would not supply any water for new development. Environmental studies were commissioned and a Draft Supplemental EIR was released in December 1998. However, it was not certified, due to water allocation questions and additional environmental issues raised by the listing of the California red-legged frog and Central Coast steelhead trout as threatened species under the Endangered Species Act. In May 2001, the National Marine Fisheries Service (NMFS) indicated that federal approval of the reservoir would be unlikely, and Cal-Am stopped work on the project.

MPWMD (1995) provides detailed descriptions of the project's features. Of particular note, the project proposed a multi-level vertical intake tower to access water different depths within the reservoir. This was a proposed temperature control device (TCD); the first of its kind on the Carmel River dams. It was proposed that the new reservoir would extend 2.7 miles upstream, essentially inundating the current dam and reservoir and extending a short distance up Danish Creek and into a small portion of the Ventana Wilderness. Overall size of the water surface area would increase to 266 acres, relative to the 55 acres of the current Los Padres Reservoir. Proposed construction staging over the identified 20-month construction period would be within the area between the new and old dams, thus significantly reducing the potential environmental effects from this element of the project.

Hydrologically, this new reservoir would provide additional water storage of 23,600 AF in a normal year to about 5,500 AF in a critically dry year. With such storage, drought protection would be significantly improved as the project would generate between 16,000 and 20,000 AF of additional storage at the beginning of the five multi-year drought periods since 1902 based on simulation modeling (MPWMD, 1995).

Under the proposed project, Cal-Am's production limit would increase from 17,619 AFA to 21,000 AFA, an increase of 3,381 AFA. At the time, this increase in production was considered appropriate to meet Cal-Am's growth projections for at least 20-30 years.

As noted previously, development of a new on-stream storage facility on the Carmel River would need to carefully balance a number of beneficial uses and competing needs. Not the least of which for this highly sensitive watercourse was the need to ensure adequate flows for the various life cycle stages of the federally listed anadromous *O. mykiss* as part of the South Central California Coast (SCCC) Distinct Population Segment (DPS).

As an example, the operational schedule for releases from the dam to meet various downstream fisheries needs was developed (see **Table 8-1**). These were established after consultation and agreement with NMFS. Minimum required flow releases are based on water year type and the periods of the year where the various life cycle needs (e.g., egg incubation, smoltification, juvenile rearing, adult emigration, and spawning) are known to occur.

Table 8-1. Proposed Operating Rules for New Los Padres Dam Minimum Instream Flows Below Dam		
January-March	**April-May**	**June-December**
Normal or Better Years	Normal or Better Years	Normal or Better Years
Maintain 20 cfs below Dam for juvenile rearing until an attraction event occurs. Once an attraction event occurs, maintain 50 cfs below dam for migration, spawning, and incubation.	Maintain 40 cfs below dam for smolt emigration.	Maintain 20 cfs below dam for juvenile rearing.
Below Normal Years	**Below Normal Years**	**Below Normal Years**
Same as Normal Years	Same as Normal Years	Same as Normal Years
Dry Years	**Dry Years**	**Dry Years**
Same as Normal Years except that once an attraction event occurs, maintain 35 cfs below dam for migration, spawning and incubation.	Maintain 30 cfs below dam for smolt emigration.	If usable storage in new reservoir is greater than 5,500 AF, maintain 20 cfs below dam for juvenile rearing. If usable storage in new reservoir is less than 5,500 AF, maintain 10 cfs below new dam for juvenile rearing.
Critically Dry Years	**Critically Dry Years**	**Critically Dry Years**
Same as Normal Years except that once an attraction event occurs, maintain 20 cfs below dam for migration, spawning, and incubation.	Maintain 20 cfs below dam for smolt emigration.	Maintain 10 cfs below dam for juvenile rearing.
Critically Low Storage	**Critically Low Storage**	**Critically Low Storage**
Maintain 5 cfs below dam and San Clemente Dam.	Maintain 5 cfs below dam and San Clemente Dam.	Maintain 5 cfs below dam and San Clemente Dam.

It was projected that with the allowable Cal-Am production from this facility, river flow would be continuous in three out of four years and that flows to the lower Carmel River Lagoon would occur in 87% of the years (MPWMD, 1995). This project had developed, refined, and considered many of the vital requirements needed for implementation including, most notably, SWRCB water rights approval.

Statements from NMFS that such a project would not likely succeed in securing the necessary federal approvals under the federal ESA would need to be revisited. While acknowledging the traditional position of NMFS regarding the adverse effects of passage blockage, this can be accommodated with new state-of-the-art passage facilities. What cannot be accommodated, however, were all dams to be removed from the Carmel River would be the capability of meeting downstream flow needs (as illustrated in Table 8-1) for the various life cycles of listed steelhead. Major elements of the NMFS Recovery Plan not the least of which is the *management of surface and groundwater*, could not be achieved, even to the state of existing conditions, were all impoundments removed. **With the new NOAA (and NMFS) re-organization now complete, MPWMD should immediately seek an audience with the NMFS head office (in Seattle) to express these views and update their executive level staff.**

8.5 Other Carmel River Sites

Similar to previous alternatives, a fundamental basis for many of the water supply alternatives is the desire to capture excess winter flows in the Carmel River watershed and "store" that yield for later season use. Whether that "storage" occurs above ground in surface storage impoundments or within the phreatic water-bearing zones of defined aquifers is a matter of both technical advantage and institutional preference. Both can provide an additional available water supply that can be used for a variety of beneficial uses.

An effective solution to this constraint is to develop storage off the Carmel River in one of the many tributary watersheds that exists *"off-mainstem"*. These are discussed in greater detail in the next Subchapter.

8.6 Tributary Dams and Reservoirs

As part of the development of this Plan, numerous storage alternatives related to the existing tributaries within the Carmel River watershed were investigated and, where appropriate, developed into the following discussions. **Figure 8.3** shows the locations of the various tributary reservoir alternatives described in the following section. Additionally, an evaluation was conducted to estimate the volume of storage in the basin that would be required to supply certain flow requirements of the Carmel River at the Sleepy Hollow Weir. **Table 8-2** shows the estimated usable storage that would be required to meet 5, 10, 20, and 40 cfs flow year around at Sleepy Hollow.

Table 8-2
Estimated Usable Storage Requirements to meet Flow at Sleepy Hollow (Acre-Feet)

	5 CFS	10 CFS	20 CFS	40 CFS
Storage Requirement to meet Minimum Streamflow	4,200	8,000	15,000	30,000
Storage Requirement with Meeting Water Supply Demands.	22,000	29,000	44,000	73,000
Storage Requirement (with GWR)	15,000	22,000	37,000	66,000

The storage required to meet a 5 cfs continuous flow in all water year types at Sleepy Hollow is about 4,200 AF. This is larger than the amount of storage currently developed in the basin. A usable storage of 30,000 AF would be required to meet a continuous flow of 40 cfs at the Sleepy Hollow Weir. These values would dedicate all of the storage to meeting instream flow requirements at Sleepy Hollow. In order to develop a supplemental consumptive water supply, 7,000 AFA in this evaluation, usable storage of about 22,000 AF would be required. This would allow the additional demand of 7,000 AF to be met in all years while also maintaining 5 cfs flow at Sleepy Hollow. A storage requirement of about 73,000 AF would be required to meet consumptive water demands and a 40 cfs continuous flow at Sleepy Hollow. If the consumptive water supply required were reduced by half to 3,500 AFA, then the storage required to meet consumptive demands while providing 5 cfs at Sleepy Hollow Weir would be about 15,000 AF.

It should be noted that this analysis is intended as a potential future augmentation to the MPWSP and not an alternative to it.

8.6.1 Pine Creek Dam and Reservoir

The Pine Creek Dam and Reservoir alternative consists of constructing a new dam and reservoir on Pine Creek near the confluence with Carmel River upstream of the existing San Clemente Reservoir. The additional storage would benefit the watershed by providing additional water to meet both instream flows on the main-stem of the Carmel River during the low flow months, and additional water to meet consumptive demands. This alternative includes a new water diversion on the Carmel River located about 1 ¾ miles upstream of the existing Los Padres Reservoir high water mark near Carmel River Camp. Water would be diverted from the Carmel River at this location and conveyed via a tunnel to Danish Creek where water originating from Danish Creek would be diverted and continue via tunnel to the Pine Creek Reservoir. See **Figure 8.4**"Los Padres Dam and Reservoir Long-Term Strategic and Short-Term

Tactical Plan, Pine Creek Reservoir Conceptual Map" for a conceptual map of the Pine Creek Dam and Reservoir alternative.

A. Development of Alternative

Development of this alternative included evaluation of the two major components of the project, the Carmel River Camp Diversion located on the Carmel River and the Pine Creek Reservoir. The Pine Creek Reservoir was evaluated to determine the appropriate size and location to maximize water supply development.

The diversion on the Carmel River (Carmel River Camp Diversion) is locatedto allow water to flow by gravity into Pine Creek Reservoir while locating the diversions below the Miller Fork Confluence to maximize tributary drainage area and resulting water supply availability. The Pine Creek Dam height was selected to maximize the available storage capacity while allowing available runoff in the watershed to support the developed storage capacity.

B. Preliminary Alternative Description

The Pine Creek Dam alternative consists of constructing a new dam and reservoir on Pine Creek near the confluence with Carmel River upstream of the existing San Clemente Reservoir. The alternative consists of about a 20,000 AF reservoir impounded by a new Pine Creek Dam. The reservoir would have a surface area of about 158 acres. The dam would be an approximately 390-foot high embankment or concrete-faced rock-fill dam with a crest length of about 900 feet and top elevation of about 1,220 feet. The normal maximum water surface elevation of the reservoir would be about 1,200 feet. The dam would include a concrete intake and outlet control facilities and a concrete overflow spillway.

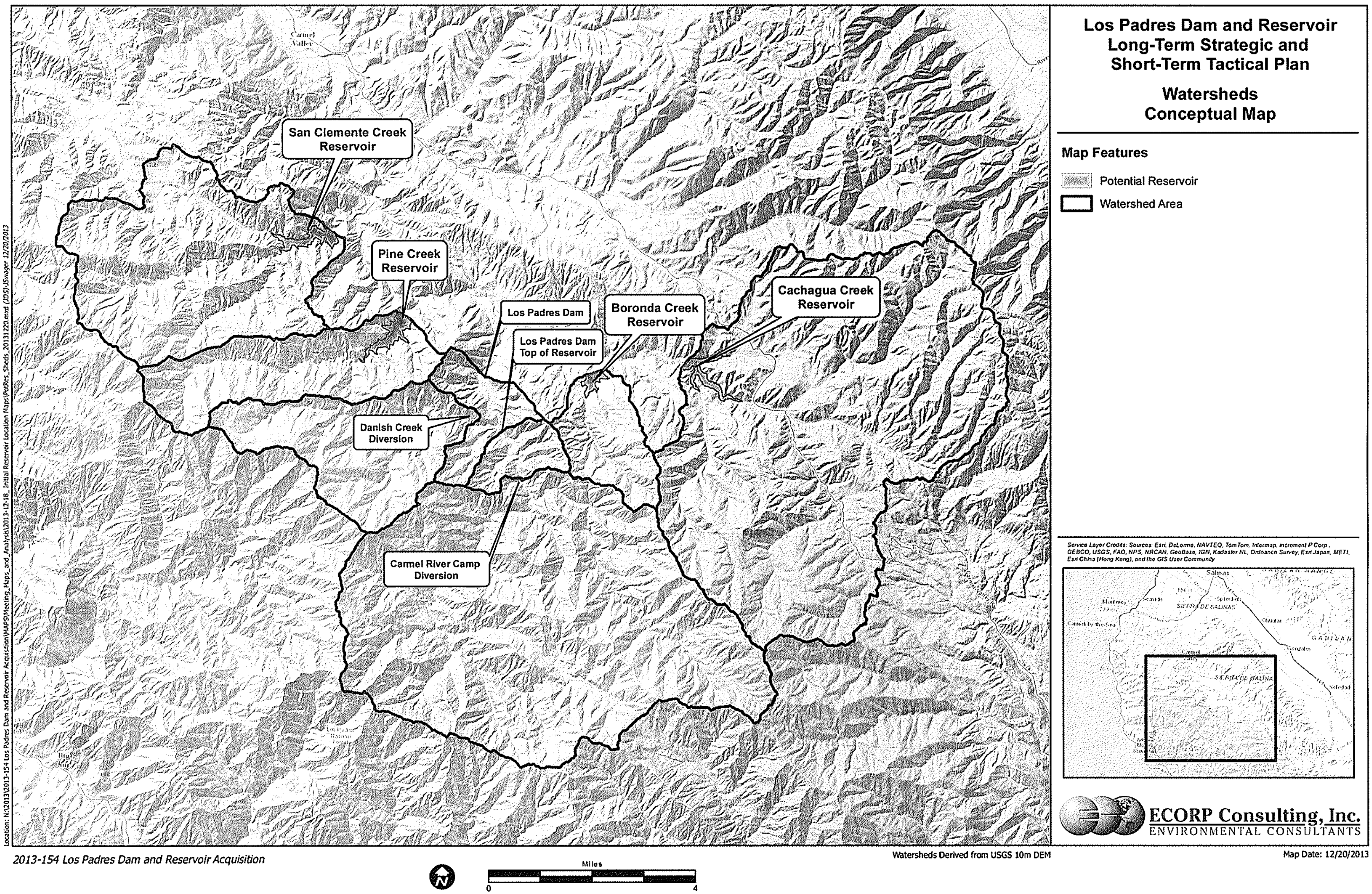

Los Padres Dam and Reservoir
Long-Term Strategic and
Short-Term Tactical Plan
Watersheds
Conceptual Map
Map Features
Potential Reservoir
Watershed Area
San Clemente Creek Reservoir
Pine Creek Reservoir
Los Padres Dam
Los Padres Dam Top of Reservoir
Boronda Creek Reservoir
Cachagua Creek Reservoir
Danish Creek Diversion
Carmel River Camp Diversion
Carmel Valley
ECORP Consulting, Inc.
ENVIRONMENTAL CONSULTANTS
2013-154 Los Padres Dam and Reservoir Acquisition
Watersheds Derived from USGS 10m DEM
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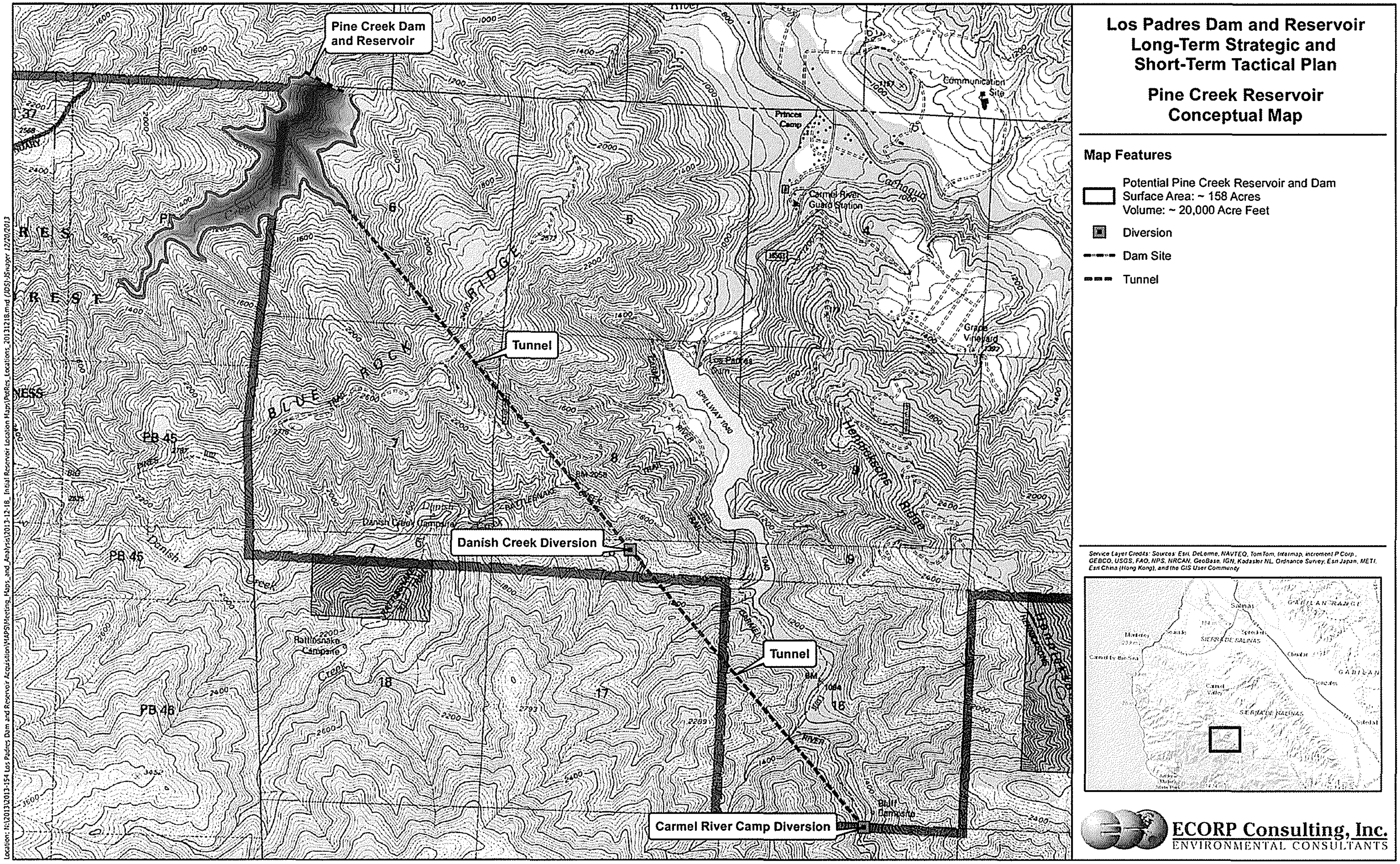
Figure 8.3



2013-154 Los Padres Dam and Reservoir Acquisition

USGS 7.5' Quadrangles: Carmel Valley (1995) and Ventana Cones (1995)

Map Date: 12/20/2013

Scale in Feet

0 4,000

Figure 8.4

A diversion facility on the Carmel River would divert water into the first tunnel of about 1.9 miles in length. Preliminary estimates suggest that a concrete lined tunnel of about 8 feet in diameter could convey up to about 300 cfs of water. The Carmel River Camp Diversion is limited to 275 cfs for this evaluation. It is anticipated that the Carmel River Camp Diversion structure would be configured to allow free flowing sediment passage as well as include fully functional upstream and downstream fish passage. An additional diversion structure would be located on Danish Creek to divert flows to the second tunnel of about 1.5 miles in length into Pine Creek Reservoir. A maximum diversion rate of 25 cfs is considered at the Danish Creek Diversion.

A hydroelectric generation facility at the Pine Creek Dam was not included in this alternative. However, the potential for adding generation should be considered if this alternative is selected for future study.

C. Operation

The Pine Creek Reservoir would be operated to store inflow from Pine Creek during the runoff period and deliver water to meet downstream water supply demands throughout the year. Additionally, water would be diverted from the Carmel River at the Carmel River Camp Diversion and conveyed via a tunnel to Danish Creek and the Danish Creek Diversion. Water originating from Danish Creek would be diverted into the tunnel and conveyed to Pine Creek Reservoir. Draw down of the reservoir was assumed to occur to a minimum level equal to 1,500 AF of storage. Flows will be passed through the outlet works, which could include power generation if it is later determined to be economical. Flows in excess of the reservoir capacity would be passed through the project overflow spillway.

D. Hydrology

The Carmel River Camp Diversion would import water from the Carmel River to the off main-stem Pine Creek Reservoir. The watershed tributary to the Carmel River Camp Diversion is significantly larger than the Pine Creek watershed producing significantly more water annually (the median annual flow at the Carmel River Camp Diversion and the Danish Creek Diversion is about 27,000 and 6,500 AF, respectively).

A water yield analysis was performed for the Pine Creek Reservoir. Natural inflow from the Pine Creek watershed directly tributary to the reservoir and the diversion anticipated from the Carmel River and Danish Creek were considered in the analysis. Both firm yield and safe yields were investigated. Water supply system safe and firm yield definitions used in this evaluation are defined as follows:

Safe Yield: The annual maximum quantity of consumptive water that can be made available in any year, including the driest year of record.

Firm Yield: The annual quantity of water that can be made available with deficiencies up to a 50% in Critically Dry Year types. Critically Dry Years for the study period include 1961, 1968, 1972, 1976, 1977, 1988, 1989, 1990, 1994, and 2007.

The historic monthly inflow directly tributary to the reservoir was approximated using a paired basin analysis of the estimate of the unimpaired flow in the Carmel River at the existing Los Padres Dam site for water years 1958 through 2012 (except for years 2003-2006 which were not available). The drainage area of Los Padres Reservoir is 44.8 square miles and the local drainage area of Pine Creek Reservoir is about 7.2 square miles. The inflow into the new reservoir was estimated based on the ratio of the tributary area at the proposed dam site to the tributary area corresponding to the Los Padres flow values (7.2 to 44.8 square miles).

The historic monthly flow in the Carmel River at the Carmel River Camp Diversion and in Danish Creek at the Danish Creek Diversion were also estimated based on the ratio of the tributary area at the proposed diversionsites to the tributary area of Los Padres Reservoir. The tributary area of the Carmel River at the Carmel River Camp Diversion is about 32.9 square miles. The tributary area of Danish Creek at the Danish Creek Diversion is about 7.9 square miles.

Minimum instream flows from the Carmel River Camp Diversion were assumed to be 5 cfs year around. Minimum releases from Pine Creek Dam and the Danish Creek Diversion were assumed to be 0.5 cfs year around or the natural flow, whichever is less.

The water yield of the Pine Creek Reservoir was evaluated using flow information developed for water years 1958 through 2012 (except for years 2003-2006 which were not available). A custom spreadsheet computer model was developed and used to simulate operation of the reservoir, diversion and tunnel system. Various water supply demand levels were tested until the reservoir was drawn down to the assumed minimum storage of 1,500 AF. Reservoir evaporation losses were estimated at 600 AFA based on the evaporation losses typical for the location.

The firm yield of Pine Creek Reservoir was estimated to be about 7,600 AF. This amount of consumptive water supply would be available in all years except Critically Dry Years. The safe yield was estimated to be about 4,200 AF. This is the minimum amount of water that would be available in Critically Dry Year types. The project yield is directly influenced by its operational parameters. For example, this analysis assumes that the Pine Creek Reservoir would be operated to meet a minimum flow requirement of 5 cfs at the Sleepy Hollow Weir. No allowance for releases from Los Padres Reservoir were assumed to meet the flow requirement at Sleepy Hollow. If this flow requirement were increased, it would have the resulting effect of lessoning the consumptive water yield. Conversely, if this flow requirement were lessoned, even in certain months of the year, storage at Pine Creek would be preserved and the consumptive water yield would increase.

Hydrology and flow information for the Pine Creek Reservoir alternative is included in Appendix A.

E. Water Rights

Development of the Pine Creek Reservoir alternative will require the appropriate entity to secure additional rights to allow new diversion of water. This alternative would require the following new rights to divert water.

- Right to divert consumptive water from the Carmel River at the Carmel River Camp Diversion into Pine Creek Reservoir.
- Right to divert consumptive water from Danish Creek at the Danish Creek Diversion into Pine Creek Reservoir.
- Right to divert consumptive water from Pine Creek into the Pine Creek Reservoir.
- Right to redivert consumptive water released from Pine Creek Reservoir to its place of use in the demand service area.

Existing water rights, project facilities, operation, and hydrology of the Carmel River were reviewed. Securing the right to divert consumptive water under this alternative could potentially occur through a change in point of diversion under MPWMD's existing rights associated with the New Los Padres Reservoir. Additionally, a water right would be required to allow water diversion from Danish Creek and Pine Creek.

8.6.2 Boronda Creek Dam and Reservoir

The Boronda Creek Dam and Reservoir alternative consists of constructing a new dam and reservoir on Boronda Creek near the confluence with Cachagua Creek. The additional storage will benefit the watershed by providing additional water to meet instream flows on the main-stem of the Carmel River during the low flow months. This alternative includes a new water diversion on the Carmel River located about 1 ¾ miles upstream of the existing Los Padres Reservoir high water mark near Carmel River Camp. Water would be diverted from the Carmel River at this location and conveyed via a tunnel to the Boronda Creek Reservoir. See **Figure 8.5**"Los Padres Dam and Reservoir Long-Term Strategic and Short-Term Tactical Plan, BorondaCreek Reservoir Conceptual Map"for a conceptual map of the Boronda Creek Dam and Reservoir alternative.

A. Development of Alternative

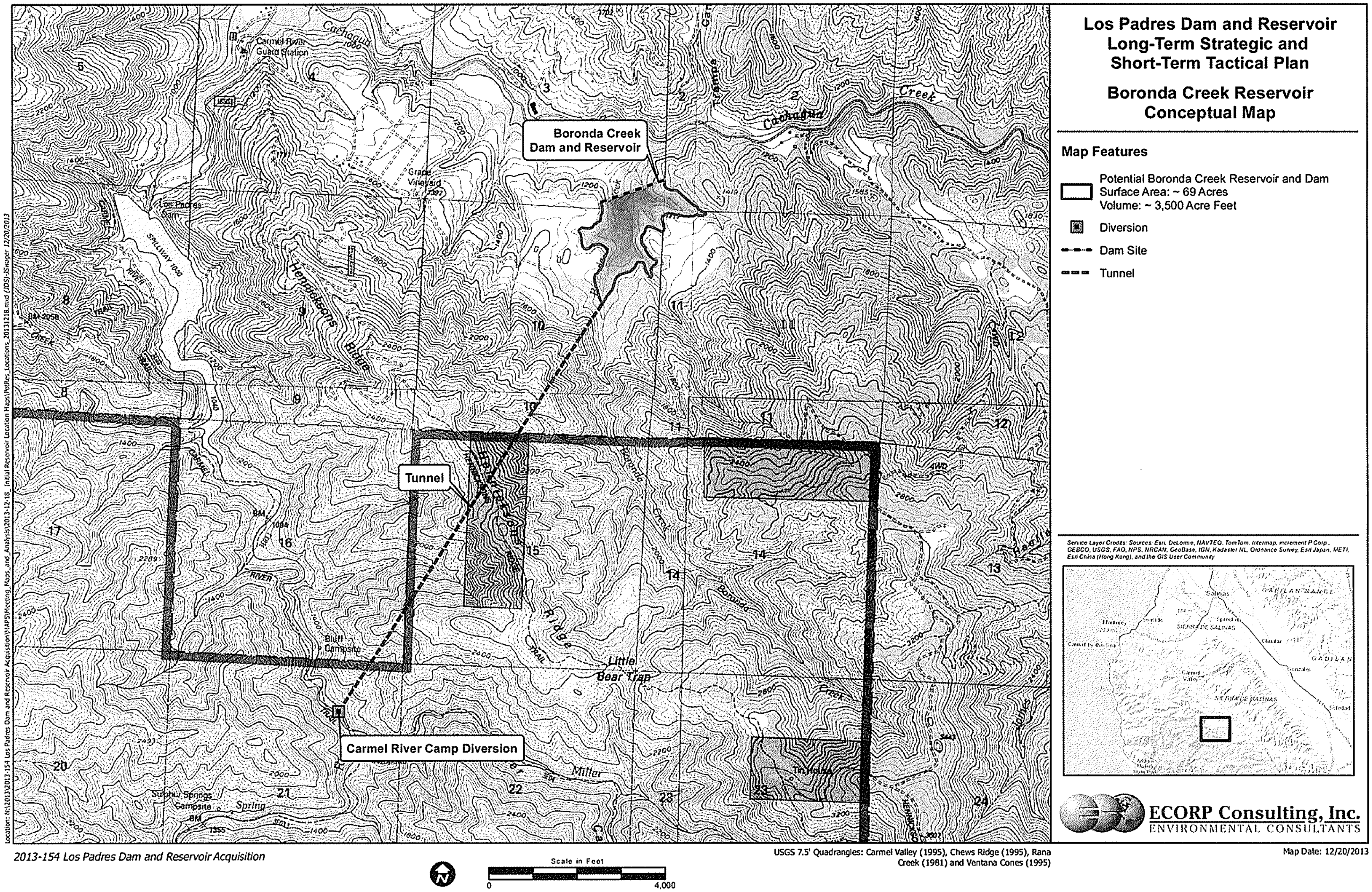
Development of this alternative included evaluation of the two major components of the project, the Carmel River Camp Diversion located on the Carmel River and the Boronda Creek Reservoir. The Boronda Creek Reservoir was evaluated to determine the maximum appropriate size and location to maximize water supply development.

The diversion on the Carmel River (Carmel River Camp Diversion) is located to allow water to flow by gravity into Boronda Creek Reservoir while locating the diversions below the Miller Fork Confluence to maximize tributary drainage area and resulting water supply availability. The Boronda Creek Dam height was selected to maximize the available storage capacity while allowing runoff from the Carmel River Camp Diversion to flow by gravity to the Boronda Creek Reservoir.

B. Preliminary Alternative Description

The Boronda Creek Dam alternative consists of constructing a new dam and reservoir on Boronda Creek near the confluence with Carmel River upstream of its confluence with Cachagua Creek. The alternative consists of about a 3,500 AF reservoir impounded by a new Boronda Creek Dam. The reservoir would have a surface area of about 69 acres. The dam would be an approximately 180-foot high embankment or concrete-faced rock-fill dam with a crest length of about 1,700 feet and top elevation of about 1,300 feet. The normal maximum water surface elevation of the reservoir would be about 1,280 feet. The dam would include a concrete intake and outlet control facilities and a concrete overflow spillway.

A Diversion on the Carmel River would divert water into a tunnel of about 2.1 miles in length. The diversion facility would function to divert water into the tunnel. Preliminary estimates



2013-154 Los Padres Dam and Reservoir Acquisition

USGS 7.5' Quadrangles: Carmel Valley (1995), Chews Ridge (1995), Rana Creek (1981) and Ventana Cones (1995)

Map Date: 12/20/2013

Figure 8.5

suggest that a concrete lined tunnel of about 4 feet in diameter could convey up to about 50 cfs of water. The Carmel River Camp Diversion is limited to 50 cfs for this evaluation. It is anticipated that the Carmel River Camp Diversion structure would be configured to allow free flowing sediment passage as well as include fully functional upstream and downstream fish passage.

A hydroelectric generation facility at the Boronda Creek Dam was not included in this alternative. However, the potential for adding generation should be considered if this alternative is selected for future study.

C. Operation

The Boronda Creek Reservoir would be operated to store inflow from Boronda Creek during the runoff period and deliver water to meet downstream water supply demands throughout the year. Additionally, water would be diverted from the Carmel River at the Carmel River Camp Diversion and conveyed via a tunnel to Boronda Creek Reservoir. Normal operational draw down of the reservoir was assumed to occur to a minimum level equal to 500 AF of storage. Flows will be passed through the outlet works, which could include power generation if it is later determined to be economical. Flows in excess of the reservoir capacity will be passed through the project overflow spillway.

D. Hydrology

The Carmel River Camp Diversion imports water from the Carmel River to the off main-stem Boronda Creek Reservoir. The watershed tributary the Carmel River Camp Diversion is significantly larger than the Boronda Creek watershed producing significantly more water annually (the average annual flow at the Carmel River Camp Diversion and Boronda Creek is about 27,000 and 2,800 AF, respectively).

A water yield analysis was performed for the Boronda Creek Reservoir. Natural inflow from the Boronda Creek watershed directly tributary to the reservoir and the diversion anticipated from the Carmel River were considered in the analysis.

The historic monthly inflow directly tributary to the reservoir was approximated using a paired basin analysis of the estimate of the unimpaired flow in the Carmel River at the existing Los Padres Dam site for water years 1958 through 2012 (except for years 2003-2006 which were not available). The drainage area of Los Padres Reservoir is 44.8 square miles and the local drainage area of Boronda Creek Reservoir is about 3.5 square miles. The inflow into the new reservoir was estimated based on the ratio of the tributary area at the proposed dam site to the tributary area corresponding to the Los Padres flow values (3.5 to 44.8 square miles). The Boronda Creek subwatershed is located in a much lower rainfall producing area than the Los Padres Reservoir subwatershed.

The historic monthly flow in the Carmel River at the Carmel River Camp Diversion was estimated based on the ratio for the tributary area at the proposed Diversion sites to the tributary are corresponding to the Los Padres flow values. The tributary area of the Carmel River at the Carmel River Camp Diversion is about 32.9 square miles.

Minimum instream flows from the Carmel River Camp Diversion were assumed to be 5 cfs year around. Minimum releases from Boronda Creek Dam isassumed to be 0.5 cfs year around or the natural flow, whichever is less.

The water yield of the Boronda Creek Reservoir was evaluated using flow information developed for water years 1958 through 2012 (except for years 2003-2006 which were not available). A custom spreadsheet computer model was developed and used to simulate operation of the reservoir, diversion and tunnel system. Since the size of the reservoir impoundment and the available water is relatively small, the water made available under this alternative is not sufficient to meet even the 5 cfs flow requirement assumed at the Sleepy Hollow Weir. Therefore, there would be no water supply yield to meet consumptive demands under the Boronda Creek Reservoir alternative.

Hydrology and flow information for the Boronda Creek Reservoir alternative is included in Appendix A.

E. Water Rights

Development of the Boronda Creek Reservoir alternative will require the appropriate entity to secure additional rights to allow new diversion of water. This alternative would require the following new rights to divert water.

- Right to divert consumptive water from the Carmel River at the Carmel River Camp Diversion into Boronda Creek Reservoir.
- Right to divert consumptive water from Boronda Creek into the Boronda Creek Reservoir.
- Right to redivert consumptive water released from Boronda Creek Reservoir to its place of use in the demand service area.

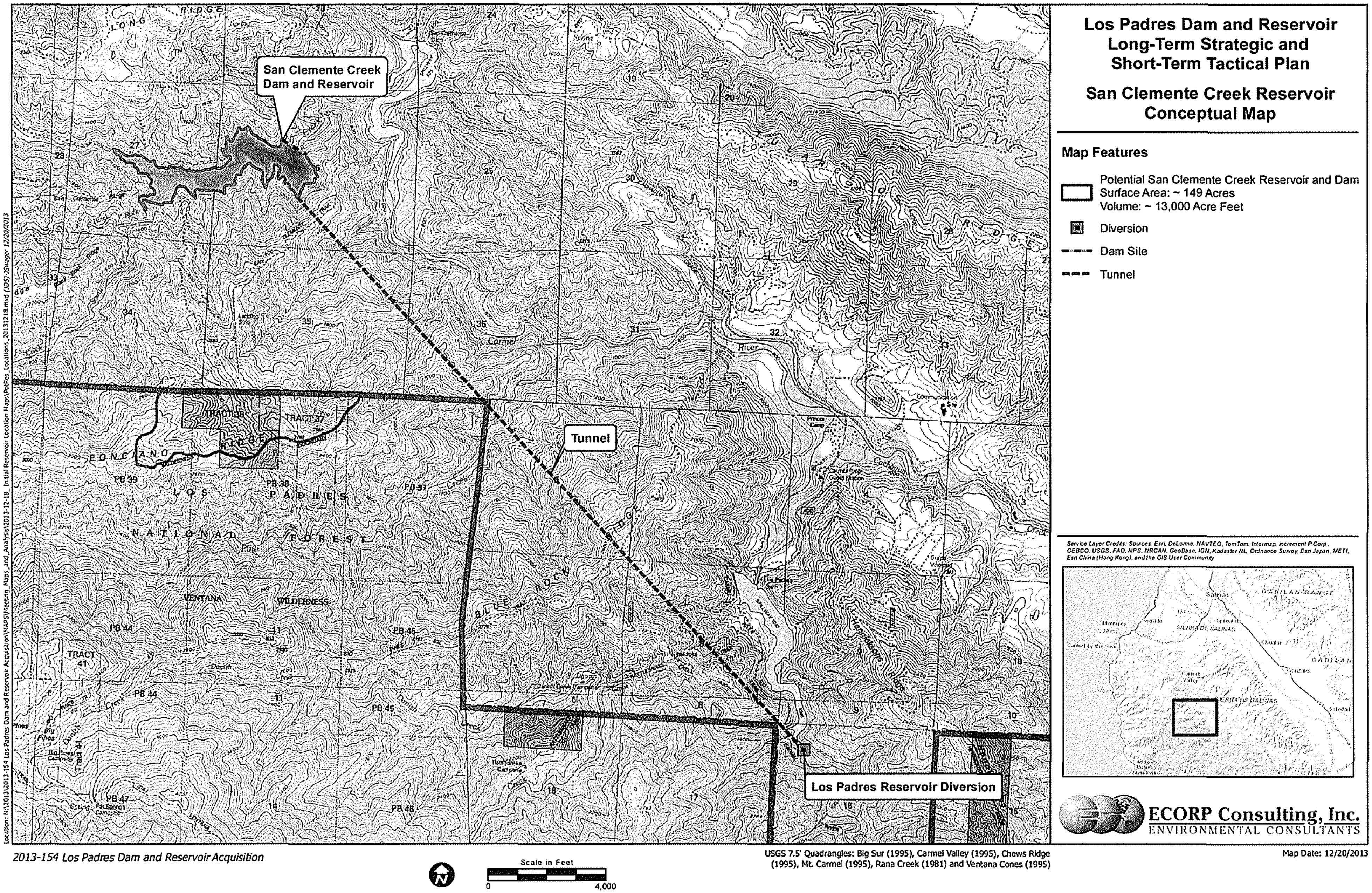
Existing water rights, project facilities, operation, and hydrology of the Carmel River were reviewed. Securing the right to divert consumptive water under this alternative could potentially occur through a change in point of diversion under MPWMD's existing rights associated with the New Los Padres Reservoir. Additionally, a water right would be required to allow water diversion from Boronda Creek.

8.6.3 San Clemente Creek Off-Mainstem Dam and Reservoir

The San Clemente Creek Dam and Reservoir alternative consists of constructing a new dam and reservoir on San Clemente Creek near the confluence with the Carmel River located just upstream of the existing San Clemente Reservoir. The additional storage would benefit the watershed by providing additional water to meet both instream flows on the main-stem of the Carmel River during the low flow months, and additional water to meet consumptive demands. This alternative includes a new water diversion on the Carmel River located near the existing Los Padres Reservoir high water mark at the tail of the reservoir impoundment. Water would be diverted from the Carmel River at this location and conveyed via a tunnel to the San Clemente Creek Reservoir. See **Figure 8.6** "Los Padres Dam and Reservoir Long-Term Strategic and Short-Term Tactical Plan, San Clemente Creek Reservoir Conceptual Map" for a conceptual map of the San Clemente Creek Dam and Reservoir alternative.

A. Development of Alternative

Development of this alternative included evaluation of the two major components of the project, the Carmel River Camp Diversion located on the Carmel River and the San Clemente Creek Reservoir. The San Clemente Creek Reservoir was evaluated to determine the maximum appropriate size and location to maximize water supply development.



Los Padres Dam and Reservoir Long-Term Strategic and Short-Term Tactical Plan
San Clemente Creek Reservoir Conceptual Map
Map Features
Potential San Clemente Creek Reservoir and Dam
Surface Area: ~ 149 Acres
Volume: ~ 13,000 Acre Feet
Diversion
Dam Site
Tunnel
San Clemente Creek Dam and Reservoir
Tunnel
Los Padres Reservoir Diversion
LOS PADRES NATIONAL FOREST
VENTANA WILDERNESS
PONCIANO RIDGE
BLUE ROCK RIDGE
Carmel River
ECORP Consulting, Inc.
ENVIRONMENTAL CONSULTANTS
2013-154 Los Padres Dam and Reservoir Acquisition
Scale in Feet
0
4,000
USGS 7.5' Quadrangles: Big Sur (1995), Carmel Valley (1995), Chews Ridge (1995), Mt. Carmel (1995), Rana Creek (1981) and Ventana Cones (1995)
Map Date: 12/20/2013

Figure 8.6

The diversion on the Carmel River (Carmel River Camp Diversion) is located to allow water to flow by gravity into San Clemente Creek Reservoir while locating the diversion as low as possible in the watershed to minimize tunnel length. The San Clemente Creek Dam height was selected to maximize the available storage capacity while allowing runoff from the Carmel River Camp Diversion to flow by gravity to the San Clemente Creek Reservoir.

B. Preliminary Alternative Description

The San Clemente Creek Dam alternative consists of constructing a new dam and reservoir on San Clemente Creek near the confluence with Carmel River upstream of its confluence with Carmel River. The alternative consists of about a 13,000 AF reservoir impounded by a new San Clemente Creek Dam. The reservoir would have a surface area of about 149 acres. The dam would be an approximately 245-foot high embankment or concrete-faced rock-fill dam with a crest length of about 950 feet and top elevation of about 1,120 feet. The normal maximum water surface elevation of the reservoir would be about 1,100 feet. The dam would include a concrete intake and outlet control facilities and a concrete overflow spillway.

A diversion on the Carmel River would divert water into a tunnel of about 4.8 miles in length. The diversion facility would function to divert water into the tunnel. Preliminary estimates suggest that a concrete lined tunnel of about 8 feet in diameter could convey up to about 300 cfs of water. The Carmel River Camp Diversion is limited to 275 cfs for this evaluation. It is anticipated that the Carmel River Camp Diversion structure would be configured to allow free flowing sediment passage as well as include fully functional upstream and downstream fish passage.

A hydroelectric generation facility at the San Clemente Creek Dam was not included in this alternative. However, the potential for adding generation should be considered if this alternative is selected for future study.

C. Operation

The San Clemente Creek Reservoir would be operated to store inflow from San Clemente Creek during the runoff period and deliver water to meet downstream water supply demands throughout the year. Additionally, water would be diverted from the Carmel River at the Carmel River Camp Diversion and conveyed via a tunnel to San Clemente Creek Reservoir. Draw down of the reservoir was assumed to occur to a minimum level equal to 1,000 AF of storage. Flows would be passed through the outlet works, which could include power generation if it is later determined to be economical. Flows in excess of the reservoir capacity will be passed through the project overflow spillway.

D. Hydrology

The Carmel River Camp Diversion imports water from the Carmel River to the off main-stem San Clemente Creek Reservoir.The watershed tributary the Carmel River Camp Diversion is significantly larger than the San Clemente Creek watershed producing significantly more water annually (the average annual flow at the Carmel River Camp Diversion and San Clemente Creek is about 27,000 and 17,400 AF, respectively).

A safe water yield analysis was performed for the San Clemente Creek Reservoir. Natural inflow from the San Clemente Creek watershed directly tributary to the reservoir and the diversion anticipated from the Carmel River were considered in the analysis.

The historic monthly inflow directly tributary to the reservoir was approximated using a paired basin analysis of the estimate of the unimpaired flow in the Carmel River at the existing Los Padres Dam site for water years 1958 through 2012 (except for years 2003-2006 which were not available). The drainage area of Los Padres Reservoir is 44.8 square miles and the local drainage area of San Clemente Creek Reservoir is about 15.0 square miles. The inflow into the new reservoir was estimated based on the ratio of the tributary area at the proposed dam site to the tributary area corresponding to the Los Padres flow values (15.0 to 44.8 square miles).

The historic monthly flow in the Carmel River at the Carmel River Camp Diversion was estimated based on the ratio for the tributary area at the proposed Diversion sites to the tributary are corresponding to the Los Padres flow values. The tributary area of the Carmel River at the Carmel River Camp Diversion is about 32.9 square miles.

Minimum instream flows from the Carmel River Camp Diversion were assumed to be 5 cfs year around. A minimum release from San Clemente Creek Dam is assumed to be 0.5 cfs year around or the natural flow, whichever is less.

The water yield of the San Clemente Creek Reservoir was evaluated using flow information developed for water years 1958 through 2012 (except for years 2003-2006 which were not available). A custom spreadsheet computer model was developed and used to simulate operation of the reservoir, diversion and tunnel system. Various water supply demand levels were tested until the reservoir was drawn down to the assumed minimum storage of 1,000 AF.Reservoir evaporation losses were estimated at 550 AF per year based on the evaporation losses typical for the location.

The firm yield of San Clemente Creek Reservoir was estimated to be about 5,500 AF. This amount of consumptive water supply would be available in all years except Critically Dry Years. The safe yield was estimated to be about 2,000 AF. This is the minimum amount of water that would be available in Critically Dry Year types.

Hydrology and flow information for the San Clemente Creek Reservoir alternative is included in Appendix A.

E. Water Rights

Development of the San Clemente Creek Reservoir alternative will require the appropriate entity to secure additional rights to allow new diversion of water. This alternative would require the following new or amended rights to divert water.

- Right to divert consumptive water from the Carmel River at the Carmel River Camp Diversion into San Clemente Creek Reservoir.
- Right to divert consumptive water from San Clemente Creek into the San Clemente Creek Reservoir.

- Right to redivert consumptive water released from San Clemente Creek Reservoir to its place of use in the demand service area.

Existing water rights, project facilities, operation, and hydrology of the Carmel River were reviewed. Securing the right to divert consumptive water under this alternative could potentially occur through a change in point of diversion under MPWMD's existing rights associated with the New Los Padres Reservoir. Additionally, a water right would be required to allow water diversion from San Clemente Creek.

8.6.4 Cachagua Creek Dam and Reservoir

The Cachagua Creek Dam and Reservoir alternative was previously investigated in the early 1990's and consists of constructing a new dam and reservoir on Cachagua Creek near the confluence with the Carmel River located just downstream of the confluence of Finch Creek and Conjeo Creek. The additional storage will benefit the watershed by providing additional water to meet instream flows on the main-stem of the Carmel River during the low flow months. See **Figure 8.7**"Los Padres Dam and Reservoir Long-Term Strategic and Short-Term Tactical Plan, Cachagua Creek Reservoir Conceptual Map" for a conceptual map of the Cachagua Creek Dam and Reservoir alternative.

A. Development of Alternative

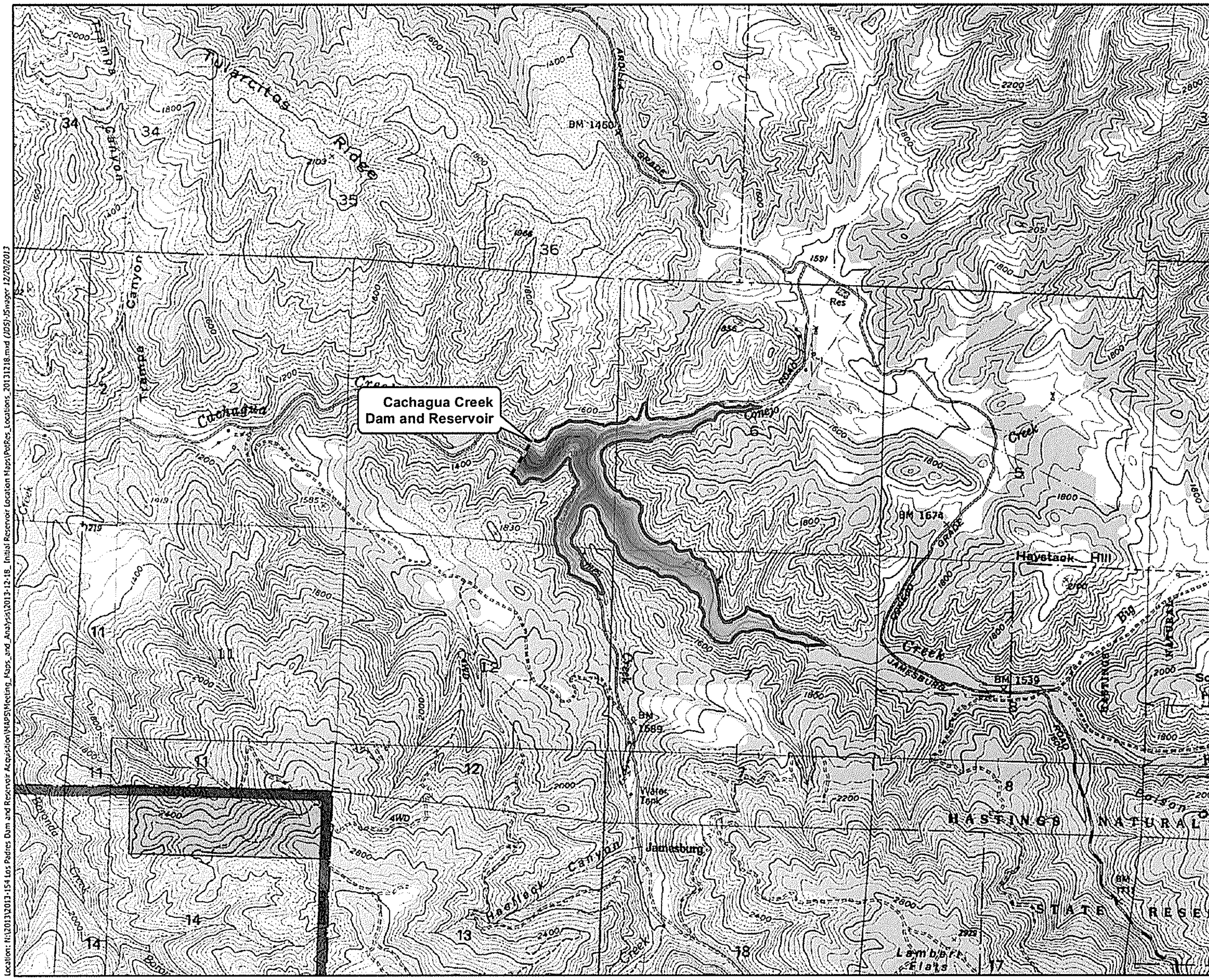
The Cachagua Creek Dam and Reservoir was previously developed and is presented as an option to develop new storage that would provide a benefit to the Carmel watershed.

B. Preliminary Alternative Description

The Cachagua Creek Dam alternative consists of constructing a new dam and reservoir on Cachagua Creeklocated just downstream of the confluence of Finch Creek and Conjeo Creek. The alternative consists of a 6,000 AF reservoir impounded by a new Cachagua Creek Dam. The reservoir would have a surface area of about 109 acres. The dam would be 199-foot high embankment or concrete-faced rock-fill dam with a crest length of about 850 feet and top elevation of about 1,459 feet. The normal maximum water surface elevation of the reservoir would be about 1,434 feet. The dam would include a concrete intake and outlet control facilities and a concrete overflow spillway.

C. Operation

The Cachagua Creek Reservoir would be operated to store inflow from Cachagua Creek during the runoff period and deliver water to meet downstream water supply demands throughout the year. Draw down of the reservoir was assumed to occur to a minimum level equal to 1,000 AF of storage. Flows would be passed through the outlet works. Flows in excess of the reservoir capacity would be passed through the project overflow spillway.



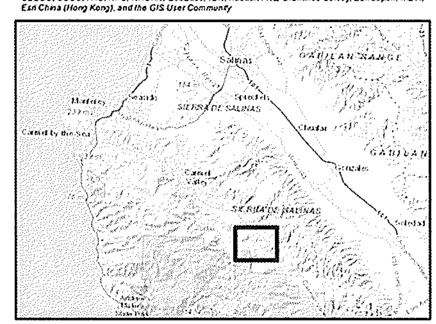
Los Padres Dam and Reservoir Long-Term Strategic and Short-Term Tactical Plan

Cachagua Creek Reservoir Conceptual Map

Map Features

- Potential Cachagua Creek Reservoir and Dam
  Surface Area: ~ 138 Acres
  Volume: ~ 6,000 Acre Feet
- Diversion
- Dam Site

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community



ECORP Consulting, Inc.
ENVIRONMENTAL CONSULTANTS

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Scale in Feet 0 4,000

USGS 7.5' Quadrangles: Carmel Valley (1995), Chews Ridge (1995), Rana Creek (1981) and Ventana Cones (1995)

Map Date: 12/20/2013

Figure 8.7

D. Hydrology

The tributary drainage area of the Cachagua Creek basin would drain directly into the Cachagua Creek Reservoir. A yield analysis was not performed for this alternative. The water yield of the Cachagua Creek Reservoir alternative would likely not provide significant consumptive water supply yield because the storage would be reserved to primarily meet the 5 cfs flow requirement assumed at the Sleepy Hollow Weir. Therefore, there would be no water supply yield to meet consumptive demands under the Cachagua Creek Reservoir alternative.

E. Water Rights

Development of the Cachagua Creek Reservoir alternative will require the appropriate entity to secure additional rights to allow new diversion of water. This alternative would require the following new rights to divert water.

- Right to divert consumptive water from Cachagua Creek into the Cachagua Creek Reservoir.
- Right to redivert consumptive water released from Cachagua Creek Reservoir to its place of use in the demand service area.

A new water right appropriation would be required to allow water diversion from Cachagua Creek.

8.7 Imported Transfer Water

At present, the Monterey Peninsula does not import water from external outside sources. As an example, no federal or State water project water (e.g., Central Valley Project or State Water Project) is used anywhere in the watershed. Additionally, no water rights are transferred into the watershed from adjoining or proximal basins under existing agreements with willing water purveyors.

Regarding CVP and/or SWP supplies, three issues are paramount. First, is the issue associated with the availability of the supply allocation. No *new* CVP federal water service contracts for M&I use have been authorized since 1990 with the passage of P.L.101-514 (Section 206). This supply was for 50,000 AFA for Sacramento and El Dorado counties to meet the immediate needs of those rapidly growing counties during the late 1980s. While Sacramento County has secured its portion (e.g., 35,000 AFA), El Dorado County is still awaiting final approval; their contract being held up by the Delta litigation in the continuing jurisdiction of Judge Oliver Wanger in *The Consolidated Salmonid Cases; Findings of Fact and Conclusions of Law re: Plaintiffs' Request for Preliminary Injunction* (Docs. 161 & 230), Case 1:09-cv-01053-OWW-DLB Document 347 Filed 05/18/2010 related to USBR's proposed *Long-Term Operation of the Central Valley Project and State Water Project in the Central Valley, California* ("OCAP"). MPWMD could apply for a new CVP water contract (i.e., become a CVP contractor) or negotiate a long-term transfer with an existing CVP contractor(s) **but would likely face the same in-Delta issues that would significantly reduce the firm yield of the contract.**

A significant issue associated with either State or federal water allocations are the established shortage provisions that are applied equally across all contractor categories (e.g., M&I and Ag) within the South of Delta and North of Delta CVP service areas. Over the years, these apportionments have been notably reduced and the current CVP shortage policy consider reductions to M&I contractors up to 50%

(lowered from 75% since 1992). South of Delta contractors have experienced the largest imposed shortages owing to their need to pump from the Delta. If new CVP water is conveyed to Monterey Peninsula it would be considered a South of Delta source.

Similarly, for State Water Project contractors, the primary storage reservoir is Oroville (North of the Delta) and deliveries require pumping through the Delta (with possible storage in San Luis Reservoir) for conveyance to the State Water Contractors identified in Table A; known as the "Table A" contractors. **Again, for MPWMD, any new contract would be considered South of Delta.**

Table A contractors are subject to some of the most egregious imposed shortage provisions in California water resources; deliveries rarely, if ever, approach contracted amounts. The Department of Water Resources' (DWR's) initial delivery projections for the 2013-2014 WY, based on near- and longer-term precipitation forecasts and system operational requirements, put the Table allocations at only 5% for the upcoming year. With the declaration of drought by the Governor earlier this year, State Water Contractors have been severely curtailed with Ag contractors, especially in the San Joaquin and south San Joaquin Valley, hit particularly hard. This has been elevated to an issue of national concern.

The second issue relates to the whether CVP water is permitted to be used on the Monterey Peninsula. All federal water must be used exclusively with the authorized CVP Consolidated Place of Use (CVPOU). The current CVPOU would have to be amended to include the service areas identified by MPWMD as potentially receiving this new supply. From an environmental permitting perspective both the new CVP contract and the amendment to CVPOU could be included as part of the suite of federal actions required for analysis under NEPA and the federal ESA.

The third issue is related to conveyance. Any CVP water would likely come from the San Felipe Unit of the CVP which allocates water out of San Luis Reservoir, a jointly operated CVP/SWP facility for delivery to Santa Clara County and northern portion of San Benito County. Water from San Luis Reservoir is diverted through the 1.8 miles of the Pacheco Tunnel 1 to the Pacheco Pumping Plant and then lifted into the Pacheco Tunnel flowing through the 29 mile Santa Clara Conduit terminating at the Coyote Pumping Plant. The Hollister Conduit branches off the Pacheco Conduit about 8 miles from the outlet of the Pacheco Tunnel and delivers water to the San Justo Reservoir.

A long-term plan that would include either State or federal water supplies could be developed similar to the San Justo Reservoir about 3 miles southwest of the City of Hollister. San Justo Reservoir is a 9,906 AF capacity reservoir that regulates imported water supplies into San Benito County, provides pressure service to some agricultural lands, and storage for peaking of agricultural water. **Any viable alternative to acquire CVP/SWP water would require extensive new conveyance, pumping, and storage facilities; distances for conveyance alone would exceed 25 miles.**

8.8 Hybrid Alternatives – Combined with MPWSP

From a water supply perspective for the Monterey Peninsula, it is accepted that the MPWSP represents the most viable, supportable, and progressive means of securing additional and urgently needed new water supplies. Significant time and effort have gone into its evolution and development to its current form. The recent Settlement Agreement, ongoing activities associated with GWR, water purchase agreement, and pending rate hearings demonstrate the importance and urgency of this collaborative effort.

The MPWSP is intended to provide a long-term reliable water supply capable of meeting the current and future anticipated water demands and needs on the Peninsula. Arguably, under such conditions, any new developed water supply within the watershed may seem superfluous but instream flow requirements and water rights of non-Cal-Am purveyors must still be addressed. **The counter argument of course is that contemporary water management planning dictates that no one exclusive water supply option ever be relied upon.** In the water resources planning, due diligence always dictates that a broad portfolio of water supply entitlements, facilities, and integrated supply scenarios be established; an edict within the water industry that is now universally accepted. The inherent uncertainty and risk associated with much of today's water resource practices (e.g., natural – climate change; or man-made - regulatory volatility) obligates water resource agencies to embrace a broad, multi-faceted, and diverse platform of water supply, infrastructure, and delivery agreements. In the present case, any new yield development within the Carmel River watershed stands to provide benefits to existing and future requirements and needs (e.g., ASR and Table 13 water rights).

The upper Carmel River watershed, regardless of the MPWSP, will continue to naturally generate substantial water yield in every water year. While these quantities have, currently do, and will continue to vary, the long-established historical trends clearly establish the magnitude of this inter-annual water flux. **Overall single year runoff totals may be low and warrant classification as "dry" or "critically-dry" years, but at some point during the precipitation season, unimpaired runoff would have exceeded ecosystem minimums. It is *that* yield, regardless of its temporal duration, that storage projects should attempt to capture.**

Upper basin yield represents a vital *water asset* for MPWMD and the long-term resiliency of the watershed's hydrologic functionality. **A genuine long-term plan and implementation strategy for the upper watershed is essential to ensure that all of the existing (and anticipated continuing future) requirements can be met by the effective headwaters management**; minimum downstream flows, habitat protection, riverine/riparian quality enhancement, and of course assured water deliveries.

The discrete alternatives described in this Plan can, and should be part of the overall cooperative and coordinated implementation of the MPWSP. **They should not control or supplant the MPWSP, but they need to be considered together.**

8.9 New Water Rights

A variant of the imported transfer water alternative, there is also at least the theoretical possibility of obtaining a new appropriative water right from the SWRCB. Surface water within the Carmel River watershed is as yet unadjudicated. Moreover, hydrologically, it has been shown that surplus water exists within the river at certain times of certain water years; in many years in fact, it exists in significant quantities. Allowing such uncaptured surplus flows to run out to the Pacific Ocean due simply to a lack of storage seems counter to the SWRCB's fundamental premise of putting public trust resources to maximum beneficial use. Allowing water to leave a watershed as "surplus" does not do that.

Any new water right would have conditions attached to its permit that would be tied closely to instream fisheries needs and balanced against projected withdrawals from the various downstream subsurface flow units. Similar to MPWMD's current permits, periods of authorized diversion, minimum instream flow targets, and permitted locations would be included.

At this time, acquiring a new water right from the SWRCB may seem unlikely, especially given the recent focus of their CDO based on their claims of unauthorized takings by Cal-Am. Nevertheless, it should remain an option depending on the ultimate alternative selected and the ability to transfer by petition, current authorizations provided for the lower Los Padres Dam (see Subchapter 8.4 – New Los Padres Dam and Reservoir) to a new location.

Acquiring a new water right *per se* does not represent an alternative to Los Padres Dam, but it is part of the broader suite of actions that MPWMD should keenly retain.

A more likely scenario is to seek amendment of MPWMD's existing permits, if necessary, so that they fit into whatever future water supply option for the upper watershed is ultimately selected. As discussed in Subchapter 8.6 – Tributary Dams and Reservoirs, several potential new "off-mainstem" reservoirs are possible, each requiring a new water right or amendment to an existing one. From a water rights perspective, MPWMD is in a good position here. There are existing water right permits (e.g., 20808-B) that were issued under assumptions of developing additional in-basin storage that, for a variety of reasons, never occurred. **Making the claim to now put that authorized public trust resource to maximum beneficial use is a compelling argument.**

8.10 No-Action Alternative

While not necessary intuitive at first glance, the No-Action alternative in the context of this Plan is informative since it provides the rationalization for deliberate and ongoing action by MPWMD. Decision makers can reaffirm the risks associated with various constraints imposed upon it and thus, verify again that its chosen path of action is the correct one.

Unlike its legislative counterparts, the No-Action alternative for these purposes can be structured in whatever fashion best suits the sponsoring agency. Typically, some baseline condition represents the foundational threshold or starting point to assess the validity (or preference) of the action alternatives.

Accordingly, baseline conditions could represent a number of differing but important thresholds. For example, it could represent at a broad level, a *without* MPWSP condition. As noted previously, this Plan is not intended to refute, detract, or in any way obviate the MPWSP. It could also represent at various sub-levels, a *without* Carmel River surface supply condition, a *without* groundwater replenishment condition or, a *without* desalination condition, or a without Los Padres Dam (i.e., similar to the Los Padres Dam Removal alternative). Returning to the initial focus of this report, however, it could simply represent a *without* action taken on Los Padres Dam, essentially, a "do-nothing" alternative, leaving the ultimate disposition of the dam completely up to Cal-Am.

The complexity of the various intersecting and inter-dependent water resource issues on the Monterey Peninsula requires that MPWMD engage in and represent the wider water resource management interests of the watershed when addressing any water infrastructure in the basin. To be sure, MPWMD has a vested interest in Los Padres Dam and Reservoir for all of the reasons explained earlier. Whether Los Padres Dam is retained/removed or other storage facilities are developed within the watershed and on the Carmel River mainstem is of vital interest and importance to MPWMD.

From MPWMD's perspective, if the No-Action alternative represents the true "do-nothing" option, it would result in a concession of responsibilities, priorities, and the acceptance of uncontrolled risks within the watershed. All of these consequences would appear to go against its governing principles and the empowering statute that gave MPWMD management control over water resources in the basin in the first place.

Under the No-Action alternative, the scope of Cal-Am's pending feasibility study related to the NMFS South Central California Coast Steelhead Recovery Plan would be limited to its current scale; namely, removal of the Los Padres Dam and Reservoir. As MPWMD has continually stated on numerous occasions, the ultimate designed management of the Carmel River watershed must address all of the interwoven issues related to fisheries recovery as well as other beneficial uses (e.g., ASR, Table 13 water rights, other non-Cal-Am water right holders, riparian health, riverine corridor management, etc.) in a balanced co-equal manner. Public trust resources in the Carmel River watershed, as recognized by statute, must be balanced across numerous important, but often competing interests. **Any such designed management involving a decision over the fate of a critical facility within the watershed must be done so with the widest breadth of scope. Moreover, the process under which decisions are to be made must imbue multi-lateral governance, public transparency, and the full range of stakeholder priorities and interests.**

The No-Action alternative is risky for MPWMD in that it relegates and limits the decision of Los Padres Dam and Reservoir to two primary entities within the context of the South Central California Coast Steelhead Recovery Plan; NMFS and Cal-Am. These two parties have specific mandates that have helped define, at least to date, the potential scope of any forthcoming feasibility effort into the long-term future of Los Padres Dam. At this time, what is missing is the broader overview of what a Los Padres Dam removal might really mean to the many interwoven and interdependent factors that have made this facility such an essential fixture in helping manage the sensitive hydrologic response of the Carmel River watershed. Moreover, what is also missing is the discussion of whether new storage potential exists in the upper basin. **From MWMD's perspective, it need not matter how storage is retained (or developed) in the upper basin, only that some long-term storage capability exists. There is no special preference for Los Padres Dam *per se*, so long as MPWMD retains the ability to manage the instream resource needs of the watershed through some upper basin retention facility.**

9. Alternatives Screening Process

This chapter presents the process upon which the alternatives identified in the previous chapter were screened. The screening process involves a multiple step process applying a hierarchical evaluation. As noted earlier, the project objective is to prepare a **multi-faceted long-term strategic and short-term tactical plan** for the District. The Plan, through an evaluation of the various factors that have made Los Padres Dam and Reservoir such a critical facility to water resources management in the basin, will generate technical and institutional information that can be used as valuable guidance to:

A. *Support negotiations with Cal-Am, NMFS, other public trust resource agencies (e.g., SWRCB, CDFW, etc.), and vested watershed stakeholders, and,*
B. *Provide an immediate near-term and longer-term planning and options strategy in the form of a tactical "road-map".*

The alternatives identified in the Plan represent a wide range of potential options that can help MPWMD meet both the near- and long-term water supply and water resource needs in the Monterey Peninsula. The alternatives can serve as both a contingency to the MPWSP and act as the long-term **upper basin solution** to this vital area of natural water production (e.g., seasonal runoff).

As noted at the beginning of the Plan, MPWMD's current challenges are guided by several key planning principles. Each of these principles represents the primary standards upon which MPWMD desires to pursue any long-term water supply solution. These have been previously identified as:

A. Water Supply Security and Sustainability
B. Enhanced Fish Passage
C. Implementation of Effective Sediment Management
D. Maintenance of Target Instream Flows
E. Consideration of non-Cal-Am water rights holders

Accordingly, any potential alternative must be capable of meeting each of these key planning principles. Each of these planning principles, therefore, for the purposes of this screening process are converted into primary screening criteria and are briefly described below:

A. Water Supply Security and Sustainability

This primary screening criteria represents the focal point for water purveyors and those agencies having responsibility for water supply security. Any alternative must help MPWMD meet the current and anticipated future water supply needs on the Monterey Peninsula both the near- and long-term.

B. Enhanced Fish Passage

Improved fish passage in the Carmel River watershed has long been recognized as an essential requirement to help the listed South Central Coast steelhead *O. mykiss* fully utilize the existing habitats for their various life cycle stages. Any alternative must provide an effective means to improve fish passage within the watershed.

C. Implementation of Effective Sediment Management

The historic accumulation of naturally eroding riverine sediment in the two Carmel River mainstem impoundments has resulted in chronic operational issues both in the reservoirs and downstream. Any alternative must provide an effective means of addressing this long-standing issue.

D. Maintenance of Target Instream Flows

As a primary watercourse within the National Marine Fisheries Service (NMFS) South Central California Coast Steelhead Recovery Plan, maintaining appropriate target instream flows for various life cycle stages of listed anadromous *O. mykiss* is of paramount importance. Such flows must be fully integrated with projected and planned instream flow needs for consumptive use purposes. Any alternative must demonstrate the ability to meet established instream flow targets at select locations and across as many water year types as possible.

E. Consideration of Non-Cal-Am Water Rights Holders

Water rights holders within the Carmel River watershed other than Cal-Am hold important entitlements that are needed to meet existing and future beneficial uses. Their inclusion in any consideration of how the river system is ultimately managed in the long-term is essential.

The preceding primary screening criteria represent only the first tier. Additional screening criteria that cover the range of other issues, needs, and constraints are also applied.

9.1 Contextual Background

Similar to the CEQA Guidelines, it is appropriate to require that a reasonable range of alternatives feasibly attain *most* of the proposed project's basic objectives (see CEQA Guidelines § 15126.6). As noted previously, this Plan does not purport a distinct project and is outside the purview of CEQA. Nevertheless, it considers a *reasonable range* of alternatives in order to help encourage informed decision-making and public participation.

The alternatives identified and subject to this screening process shall be centered on those that would:

a. Attain most of the proposed project's basic objectives;
b. Avoid or substantially lessen one or more notable or significant environmental impacts; and
c. Be potentially feasible, technically, institutionally, and economically[1].

The following factors may be generally considered when evaluating feasibility: site suitability, economic viability, availability of infrastructure, general plan consistency, consistency with other plans or regulatory limitations, jurisdictional boundaries, and whether the proponent can reasonably acquire, control or otherwise have access to alternative site locations (see CEQA Guidelines § 15126.6(f)(1)).

[1] Economic criterion under a fully developed cost/benefit economic analysis was not part of this effort.

Unlike a NEPA or CEQA process, there is no "preferred alternative" or "proposed project". There is a current project defined for the previously as the MPWSP.

9.2 Screening Criteria

Various screening criteria have been identified for the initial listing of potential alternatives. These criteria are presented in **Table 9-1**.

Ideally, screening criteria should be developed prior to the identification and development of alternative upon which the screening criteria would be applied. This avoids preset bias in the identification of the screening criteria.

Table 9-1
Identification and Description of Screening Criteria

Criterion	Description
A. Technical and Engineering Feasibility	An alternative must be technically and physically feasible. An alternative must be based on existing and accepted state-of-the-art engineering concepts and cannot be based on experimental technologies. Also, an alternative must not be dependent upon either the availability or acquisition of site locations that cannot be reasonably assured.
B. Climate Change Adaptation	An alternative must provide the capability of adapting to, or provide a direct adaptation benefit to known factors associated with projected climatic changes.
C. Environmental Fatal Flaw	An alternative cannot have environmental impacts that are so significant as to negate the positive attributes of the alternative or, simply transfer potential environmental impacts from one location to another.
E. Long-term Reliability	An alternative must be capable of supplying water reliably year round and on a long-term basis.
F. Public Health and Safety	An alternative should be able to meet all existing and anticipated future State and federal health and safety requirements.
G. Timing	An alternative must be capable of being implemented within a reasonable timeframe such that the benefits and needs of the proposed project are not unduly delayed.
H. Institutional	An alternative cannot possess significant uncertainty that would prohibit the reasonable expectation that all permits, licenses, or other logistical requirements can be obtained.

9.3 Applied Screening

Each of the potential alternatives identified and described previously (Chapter 8 – District Alternatives) were evaluated against the screening criteria listed in Table 9-1, covering a range of standards (e.g., existing and emerging industry norms). Alternatives that met the various screening criteria also had to be able to attain *most* of the key planning principles identified earlier (e.g., Consideration of Non-Cal-Am water rights holders).

Results from the screening process are shown in **Table 9-2** and the notable conclusions discussed below. The discussions follow explanations of how the alternatives either met (or did not meet) the screening criteria presented from left to right in Table 9-2 (e.g., discussions start with the primary planning principles). The first tier screening criteria are discussed followed by the second tier screening criteria.

Most of the alternatives met the primary planning principles. **The Los Padres Dam Removal alternative, however, did not.** Removing the dam would not meet four of the five defined Primary Planning Principles. While it may have institutional support from some agencies (e.g., NMFS), it clearly cannot meet important planning principles including; the Water Supply Security and Sustainability; Implementation of Effective Sediment Management; the Maintenance of Target Instream Flows principles or, Consideration of Non-Cal-Am Water Rights Holders. More on the Los Padres Dam Removal alternative is discussed later.

The larger proposed new reservoirs were ranked higher than other alternatives for the Primary Planning Principles. This was based on the assumption that the larger the storage, the greater the ability to meet two important yet co-equal objectives; water supply security and sustainability and the maintenance of downstream target flows. With new structures, there is no removal, retrofit, or remediation work necessary to meet known operational criteria, whether it is fish passage or sediment management. The issues of fish passage and sediment management do not disappear; but there is no *recovery* element associated with new facility construction.

Table 9-2
Screening Results of Alternatives

Alternative	Planning Principles	T&E Feasibility	Climate Change	Environ. Fatal Flaw	Long-Term Reliability	Public H&S	Timing	Institut.
Los Padres – Storage Enhanced								
In Situ Dredging Only								
Dam Raise								
Ownership Variation								
Los Padres Dam – Removal								
New Los Padres Dam and Reservoir								
Tributary Dam and Reservoirs								
Pine Creek Dam								
Boronda Creek Dam								
San Clemente Creek – Off Mainstem								
Imported Water Transfer								
Hybrid Alternatives – Combined with MPWSP								
New Water Rights								
No-Action								

Notes:
Dark Green – Clearly met the screening criteria.
Light Green – Would meet the screening criteria under certain conditional requirements.
Red – This highlight is for the Environmental "Fatal Flaw" criterion only. See discussion for explanation. It is colored red to indicate that the Alternative failed this criterion.

The screening process made the assumption that all construction-related alternatives could meet the Technical and Engineering Feasibility criterion. All alternatives, through their design, are considered technically feasible. Even the Imported Water Transfer alternative, while likely requiring significant engineering innovation and design considerations to move CVP/SWP contract water from San Luis Reservoir, is technically feasible.

The Climate Change Adaptation criterion deserves explanation. The criterion is defined as; *"An alternative must provide the capability of adapting to, or provide a direct adaptation benefit to known factors associated with projected climatic changes."*It was intended that this criterion focus on the ability of alternatives to provide direct adaptation benefit to the watershed based on known changes brought about by climatic forcings. This meant, in other words, ***"Which alternative was capable of meeting the largest array of hydrologic (instream) requirements given that the Carmel River watershed is and will continue experience hydroclimatic shifting into the future?"*** Therefore, this came down to a matter of which alternative possessed the largest potential to store or retain annual runoff, as the best means to convert this naturally and annually available "asset" to beneficial use – water supply, instream flow/habitat, groundwater replenishment, and riparian aquatic needs.

Most of the new storage projects passed this criterion on the basis that they, by design, are intended to capture a larger portion of each year's annual runoff – a positive and direct adaptation to known hydroclimatic changes. The In-Situ Dredging Only alternative, while also generating "new" storage does so as a "recovery" project; it only offers to return storage to historical conditions.

The Environmental Fatal Flaw criterion was structured to depict a worst-case condition. Since none of the alternatives really possess a definitive environmental "fatal flaw", the criterion assumed that all alternatives would have some environmental issues requiring mitigation, but that they would differ in degree. The primary thresholds applied were 1) did the alternative return fish passage in the mainstem to its original state (a long-standing desire of NMFS), 2) did the alternative provide the capability for increased releases from storage (another NMFS requirement) and 3) did the alternative avoid the need to fully petition the SWRCB for a new water right.

The only alternatives that could realistically meet these requirements were the new off-mainstem storage reservoirs. By design, they avoid the Carmel River mainstem, they each generate additional storage significantly above what is current available at Los Padres Reservoir, and each capitalize on the existing authorized SWRCB points of diversion.

The Ownership Variation alternative reflects the differences in mandates between MPWMD and Cal-Am. As a "water management district", MPWMD adopts a broader responsibility, as codified in its enacting legislation, for *watershed management* activities in the Carmel River basin, relative to Cal-Am. These broader priorities include environmental protection and related stewardship commitments and priorities that may involve various environmental elements including instream flows, water quality, habitat protection/restoration, floodplain management, land use/access compatibilities, recreational corridor enhancement, etc. This distinction between MPWMD and Cal-Am is important to note and is intended to be reflected in this screening criterion.

Interestingly, typically a No-Action alternative can claim no net harm to the environment. That position was not taken for this analysis. The do-nothing option in this case poses very real risks, including those to the environment. The potential exists for dam removal at Los Padres to proceed forward under the No-Action alternative. **Without MPWMD collaboration and involvement in this process, including**

oversight as the watershed *management* agency for the basin, potential environmental effects associated with dam removal could be greater than they might be otherwise.

Both the dam storage enhancement alternatives (e.g., In-Situ Dredging Only and the Dam Raise) also were deemed to fail the Environmental Fatal Flaw criterion. This decision was partly based on the limited offsetting benefits that these alternatives would provide, relative to potential environmental damage that they would cause. **Moreover, the view was taken that any activity on the Carmel River mainstem should be avoided to the extent possible.** This was reflected in the suite of new storage alternatives that were developed for this Plan; <u>all new alternatives were proposed as "off-mainstem".</u>

From a Long-Term Reliability perspective, only the new major new storage reservoirs were deemed to clearly pass this criterion. Again, reliability was based on the ability to generate the maximum amount of additional storage – a key criterion to demonstrate reliability: ***The greater the supply; the greater the reliability.*** Since these would be new facilities, new sediment management strategies would likely be a project component. None of the existing storage enhancement alternatives claim a long-term permanent strategy to address sedimentation. The dredging alternative, for example, admits to a 20-30 year limitation of its proposed benefit. While an in situ dredging program together with an ongoing maintenance program may be technically feasible, it does not necessary address the fish passage issue and the magnitude of benefit (i.e., derived new yield) would be relatively small compared to the new off-mainstem storage options.

Like the Technical and Engineering Feasibility criterion, the Public Health & Safety criterion was also passed by all alternatives with the following caveat. Dam removal from the mainstem would result in the restoration of the natural sediment load to the lower 16 miles of the river. Such restored natural sediment transport could result in a higher risk to flooding over time due to aggradation of the stream profile in these downstream areas. Such effects, however, would likely be manageable as the inter-annual peak flow cycles would remove comparable amounts of sediment as it would deposit. Moreover, any chronic increase in flooding risk would be subtle, thus allowing ample opportunity for protection of community properties and structures that might find themselves in zones of higher potential flood risk.

All of these options are raw water supplies and there is no differential in the source area influence for water delivery to a range of differing water treatment facilities. Unlike an urban water development project or a project accessing multiple water sources from numerous disparate watersheds, the water supply contemplated in this Plan emanates largely from the headwaters of the Carmel River mainstem.

The Timing criterion also requires some explanation. This criterion was intended to illustrate which of the alternatives was most likely to be implemented the fastest. Ultimate project approvals depend on a whole host of factors, not the least of which include, technical complexity, institutional/financial constraints, environmental sensitivity (and related mitigation commitments), resource agency approval and support, public sentiment (represented by input, comment, and legal challenges within the review processes), and many more.

Most of the storage enhancement alternatives (e.g., In-Situ Dredging and Dam Raise) passed this criterion because, in relative comparison, they can be completed much quicker than the other alternatives, especially those involving new storage facilities.

The only reason why the New Los Padres Dam alternative did not fail this criterion when all other new storage alternatives did was that this project had undergone significant scrutiny, outreach, and development in the past. All resource agencies working in the watershed knew and know about the project. In fact, the SWRCB's progression of conditions associated with the original 20808 permit issued on October 25, 1995 was specifically granted for the New Los Padres Reservoir, originally for 24,000 AFA. This permit was modified recently on November 30, 2011, with the currently applicable Permit (20808-B) providing 18,674 AFA at a 42 cfs diversion rate between the period January 1-December 31 of each year. Granted, the right is junior to riparian, overlying, pre- and post-1914 rights, **but it nevertheless demonstrates that a significant hurdle, water rights, has been addressed, a major milestone from a timing perspective in any new water development project.** It was the intent to illustrate this advantage in the screening results for the New Los Padres Dam alternative.

Finally, the Institutional criterion was intended to show which of the various alternatives possessed at least tacit support from the regulatory agencies and in-basin stakeholders. Again, the Los Padres Dam Removal alternative was shown to have passed this criterion by virtue of NMFS' ongoing preference for this alternative (e.g., South Central California Coast Steelhead Recovery Plan). The New Los Padres Dam alternative also fit into this category owing again, to the SWRCB's acquiescence to a new water right permit for the project. Both the Hybrid Alternatives and the No-Action alternative also passed this criterion.

The Hybrid Alternatives – Combined with MPWSP passed all of the criteria. **This really represented the ability of the ultimately selected alternative, when combined with the existing MPWSP, to provide a workable, environmentally acceptable, and well supported project by the resource agencies and interested parties on the Peninsula.**

Interestingly, though not surprising, the Los Padres Dam Removal alternative ranked the lowest of all the in-basin alternatives. Based solely on a single purported advantage, *fish passage*, this alternative was not considered well suited as a long-term option or solution for the Carmel River watershed. All other alternatives offered some element of water development or yield enhancement. **The Los Padres Dam Removal alternative, however, is the only alternative (other than the No-Action alternative) that does not offer any ability to help meet the long-term sustainable water resource management objectives for the watershed. It is solely focused on only one aspect in a multi-aspect watershed.**

Most significantly, the Los Padres Dam Removal alternative ignores the hydrologic reality that characterizes the Carmel River watershed. Highly seasonal runoff, regardless of water year type, and the pressing need to retain vital storage to meet later season instream, consumptive, and groundwater replenishment needs are overlooked by this alternative. **By itself, this alternative provides the least benefit to the overall watershed and should be discarded as a stand alone solution for the basin.**

When combined, however, with other in-basin storage alternatives (e.g., Pine Creek Dam, San Clemente Off-Mainstem, Boronda Creek, etc.) the Los Padres Dam Removal alternative becomes acceptable. Why? Because it transfers its storage capabilities to another impoundment within the watershed and, therefore, preserves the ability to continue to meet seasonal instream, consumptive, and groundwater replenishment needs. Its removal also opens up the entire upper Carmel River watershed to fish passage.

Two alternatives were conspicuous in this process; the Ownership Variation and No-Action alternatives. As described in Chapter 8 – District Alternatives, these two options represent unique conditions from the more facility/operationally oriented alternatives. The No-Action alternative was clearly the easiest to implement since it requires doing nothing. Similarly, the Ownership Variation alternative, it is assumed, would meet all of the planning principles by whomever ultimately acquires ownership of Los Padres Dam in the long-term.

It should be noted that the application of the screening criteria and the rationale given were subjective in nature. A fully quantifiable, weighted analysis, was not performed. Such quantifiable metrics themselves, however, are also subject to bias and predispositions. In many ways, this process mimics those current efforts of the California Water Commission as it proceeds with development of its Guidelines for Public Benefits; a document whereby new water storage projects applicable for potential Water Bond monies under the Safe, Clean Drinking Water Act of 2009 (amended in 2012) can be evaluated against each other to determine relative value in the generation of public benefits.

This has been a complex process and emphasizes the difficulties in appropriately addressing all of the available public benefits associated with projects, their perceived weightings, how to avoid double-counting overlapping benefits, and ensuring that a common baseline for comparison is required between all project alternatives. The only criterion that requires and is set up to accommodate detailed quantification is an economic or cost criterion. Economics were not part of this *hydrological feasibility* investigative effort.

10. Discussion of High Ranking Priority Alternatives

From the alternatives screening process, several alternatives stand out, relative to the others. These were alternatives that were deemed applicable for further consideration by MPWMD.

From Table 9-2 in the preceding Chapter, the new storage projects emerged as possessing clear advantages over the others. In order of priority, based on the screening criteria results, the following projects are ranked in descending order.

1. **Pine Creek Dam**
2. **San Clemente Creek Off-Mainstem Dam**
3. **Boronda Creek Dam**

The Hybrid Alternatives with a fully implemented MPWSP provides the best means of achieving long-term water supply security, in-basin water resource protections, and establishes the flexibility to attend to the existing uncertainties surrounding the Water Purchase Agreement associated with the GWR. This Agreement will dictate the ultimate size of the desalination component of the MPWSP. Storage quantities proposed under these priority alternatives offer significant enhancement in the ability to meet a broad and growing array of downstream water needs. Capturing the seasonally plentiful Carmel River runoff, in larger, updated, and off-mainstem tributaries offers a solution to several contemporary issues not considered when the original facilities were built in 1921 and 1947.

Design storage of the existing impoundments on the river, 2,140 AF at San Clemente Dam and 3,030 AF at Los Padres Dam (both before sedimentation) clearly did not anticipate, at the time of their construction, the need for additional storage nor the reduction in active storage; both acting to make the two facilities obsolete by today's standards. **The Pine Creek Dam alone offers up to 20,000 AF of new storage that can be filled and spilled within existing carryover requirements and between water years such that significantly improved operational flexibility is afforded water managers within the Carmel River watershed.**

Paramount with these alternatives is the need to also proceed with the Los Padres Dam Removal. As discussed in Chapter 9 – Alternatives Screening Process, while the Los Padres Dam Removal alternative was not considered an <u>appropriate alternative by itself</u>, **when combined with other new storage development projects, it can provide significant benefits as part of a hybrid multi-element project**. As explained in the previous chapter, removing Los Padres Dam opens up the entire upper basin through Bruce Fork, Miller Fork, Ventana Mesa Creek, and Blue Creek up to the triple Ventana Cones at the watershed divide. With the pending removal of San Clemente Dam, unrestricted fish passage to these high elevation zones, barring any natural barriers (e.g., hydraulic steps, waterfalls, etc.) is possible with the removal of the existing Los Padres Dam.

When the removal of Los Padres Dam is combined with a new "off-mainstem" storage project; two vital needs of the resource agencies are provided. **First, as noted, is the opening up to fish passage of the entire upper Carmel River watershed. Second, is maintaining the ability to meet downstream flow and habitat needs, as well as water supply diversions, from new storage developed on a *tributary* to the Carmel River (hence, the "off-mainstem" label).** As explained earlier, even with storage fully returned to Los Padres Reservoir through costly dredging, the benefits to which themselves are only temporary (e.g., 20-30 years), the Carmel River cannot remain wetted along its entire river profile in all water years. Clearly, if continuous flow maintenance is desired, additional upstream storage is necessary.

The other new storage alternatives (e.g. Boronda Creek Dam) and Tularcitos Creek Dam, and Chupines Creek Dam (the latter two which were added later and did not have time to get into this Draft of the Plan) provide some notable advantages as well but are, for the latter two at least, limited to yield generation from the Tularcitos Creek watershed. The Tularcitos Creek watershed in the Sierra de Salinas highlands receives about half the precipitation as the high elevation slopes of the Santa Lucia Range; as the variation in orographic effects over short distances are particularly notable in this watershed.

The Boronda Creek Dam, while importing water from the Carmel River above Los Padres Dam is constrained by the topography of Boronda Creek to its confluence with Cachagua Creek. Accordingly, storage behind the Boronda Creek Dam would be about 3,500 AF. Based on the natural hydrology of the watershed, it is preferable to situate new impoundments downstream of the highest runoff generating areas (i.e., the upper Carmel River watershed from the Ventana Wilderness). **Storage at the Pine Creek and San Clemente Off-Mainstem reservoirs would be 20,000 and 13,000 AF, respectively.**

The further upstream storage is located in the watershed, the more valuable dry season releases become. For example, from an instream flow perspective, storage in the Boronda Creek subwatershed is probably worth more to main stem flow in the summer than storage in the Tularcitos Basin.

The enhancements at the existing Los Padres Dam and Reservoir site offer benefits, but as explained, do not provide the scale of storage enhancement generated by the other larger, new storage projects. Moreover, the Los Padres Dam enhancements do not directly address a key fisheries management issue; that is, to remove impoundments from the Carmel River mainstem. In that regard, these alternatives indirectly perpetuate a long-standing and chronic issue in the eyes of many public trust resource agencies (e.g., avoidable blockage of passage for listed anadromous fish and their habitat/flow sensitive life cycles).

For the dam raise option, limited storage gains are envisioned without dredging; a 20-foot dam raise for example, would only generate storage up to 2,754 AF (assuming no dredging operations). Again, this likely costly activity, combined with an equally costly dredging project, provides only marginal (and indeed temporary) storage increases, relative to the larger, and newer off-mainstem storage projects. **Moreover, under the new storage options, future hydropower (with pumped storage capabilities) in the steeper and more enclosed tributary valleys could prove highly opportunistic should MPWMD wish to explore such options as part of any water development initiative.**

In contemporary California and indeed western U.S. water resources management planning, *having the hydrology on your side* has become a credo that is manifesting itself into a growing interest in new storage development. The examples are credible;

- California Water Commission's new surface water storage Guidelines and facilitation of the pending Water Bond vote in November 2014;
- U.S. Bureau of Reclamation's fully developed Basin Studies program across the western States under the SECURE Water Act of 2009 where a key priority is developing new non-federal storage projects;

- California Department of Water Resources' ongoing CalFED Surface Storage Investigations;
- Delta Stewardship Council's recent foray into new storage development (as introduced by Vice Chair Fiorini) and their recognition of the importance of new storage in meeting whatever in-Delta standards ultimately are prescribed as part of the Delta Plan and BDCP;
- SWRCB's own interest in exploring whether (and how) new storage can help meet their mandated requirements to establish new water quality flow "objectives" across the 127 priority streams listed in California;
- ACWA's own recent Strategic Action Plan which includes new storage as an important priority.

No doubt, this current upcoming water year, once again will elevate the discussion of new storage when operators look back in hindsight at *what could have been*. They will remember the rule curve releases made in the immediate previous years and wonder if additional storage capabilities present at the time could mitigate or otherwise avoid what is generally accepted as California's third consecutive, and very likely, critically dry year.

As this Plan is being finalized, efforts are already underway to convince the U.S. Bureau of Reclamation to relax its reservoir release requirements over this winter in view of the low carryover in many CVP reservoirs across the Mid-Pacific Region and in light of the extremely low projected seasonal inflows that are anticipated. They are facing an immediate quandary; seek conference year status and relaxation on many of the NMFS imposed Biological Opinion or risk significantly greater cutbacks throughout the remainder of the year on contracted water deliveries.

Clearly, from these examples, times are changing when it comes to the acceptance of new storage. The need has always been there, but public perception has been sensitized. Despite the earlier NMFS position that the New Los Padres Dam project would unlikely receive necessary federal approvals, much has changed since then and continues to change. **What is often overlooked is that the NMFS statement was made in the context of a proposed new "on-stream" impoundment. This Plan, and the alternatives identified, developed, and presented herein offer a tangible and multi-beneficial alternative; *off-mainstem storage*.** It can meet the co-equal objectives of both the environment (i.e., restored fish passage to the mainstem and instream flow augmentation) and water supply demands. Public trust resource agencies, regulatory bodies, elected officials, and stakeholders, need to be fully educated on what this new opportunity represents and what it can provide.

For MPWMD to embrace a genuine *watershed-level solution*, it is felt that they must not be fixated by short-term solutions to existing facilities. These very same facilities have attracted the unnecessary attention of certain resource agencies. It makes little sense to spend time and effort on an interim temporary solution (e.g., dredging), when the long-term sustainable answer is simply deferred, the chronic environmental issue in eyes of the regulatory agencies is largely ignored (e.g., mainstem fish passage), and the benefits from the temporary solution are small, compared to other alternatives.

Rather, MPWMD should endeavor to seek innovative and <u>permanent</u> answers to the long storied challenges that continue to affect the Carmel River valley. Much like its commitment on the MPWSP, ASR, and GWR, where MPWMD has shown impressive leadership and unwavering dedication, **it must also look at its upstream watershed with similar aplomb.** For the Carmel River watershed, fortunately, hydrology is on its side. Any basin that experiences unattenuated and uncontrolled surplus flows at any time of the year is ripe to capitalize on that untapped resource asset. The only question that remains to be seen is how?

11. Tactical Decision Analysis ("If-Then" Sequencing)

11.1 Contextual Background

For MPWMD, the salient question(s) related to this Plan and the scope defined by its purpose are related to four key external players. They are Cal-Am, the CPUC, NMFS, and the SWRCB. Not surprisingly, three are regulatory bodies and the other is the primary water purveyor for the Peninsula. In addition, public input has been a critical factor in shaping MPWMD's decisions on both water supply projects and environmental restoration of the Carmel River.

The issues are complex and non-linear. Each issue is interwoven among a host of interrelated and interdependent factors, and each involving direct and indirect parties that are influenced by an active, informed, and passionate stakeholder base.

Before getting too deep into the "if-then" decision matrices, it is helpful to set out the general progression of steps that are involved in the decision making process and identify some of the typical issues that arise. The Heinz Center (2002) model provides a logical sequence of steps involved in an agency's decision regarding dam removal. At the outset is the identification of the various goals and objectives for either keeping or removing a dam; these can be also viewed as the advantages and disadvantages associated with the dam. The following listings are from the Heinz Center (2002).

Keeping the Dam	Removing the Dam
Water Supply	Safety & Security
Irrigation	Legal & Liability
Flood Control	Ecosystem restoration
Hydropower	Site Restoration
Navigation	Recreation
Flat Water Recreation	Water Quality
Waste Disposal	

For Los Padres Dam, most of these goals do not apply, primarily due to the relative small size of the reservoir. Distilled down to its two primary competing objectives – the conflicting objectives become one of water supply (in keeping the dam) versus ecosystem restoration (in removing the dam). The water supply objective really represents multiple objectives since it means (or should mean) basin water "assets". These additional "assets", held back or retained by Los Padres Dam or some other impoundment (see Chapter 8 – District Alternatives), can provide benefits to the watershed later in the year. These include water supply (including small irrigation), instream flows for various aquatic species and their flow sensitive life stages (an ecosystem benefit), water quality enhancement (through maintenance of a stream wetted perimeter), and recreational benefits (as an aesthetic condition of the riverine parkway). From a water supply perspective alone, consideration must also be given to non-Cal-Am water rights holders within the watershed as well as other institutional commitments (e.g., ASR).

So, strict application of those models that define what factors favor or disfavor dam removal must be looked at cautiously. Specific factors must be developed for the watershed in question.

All too often, it is assumed that dams provide only a water supply, hydropower, and flood control function. Regarding ecosystem function and restoration, dams have been labeled as environmentally damaging and wholly unsuited to meet these requirements. The truth, however, is quite different. In California, without dams, there would be little if any ability to manage for instream thermal conditions and virtually no way of managing for flow. All instream functions on impaired systems (i.e., those with dams) depend on the regulating effect of reservoir operations to meet their needs. Highly seasonal streamflows, as is characteristic in Mediterranean semi-arid climates, can only be moderated through dams which control releases so that the instream response is "smoothed" out; a condition unattainable in semi-arid unimpaired streams.

For the Carmel River watershed, with a current surface storage capacity that is a small fraction of the average flow to the ocean, it is less clear that increasing the water supply is necessarily in conflict with ecosystem restoration.

11.2 The NMFS Challenge

Climate change is placing NMFS in a challenging position. In many ways, they are in a quandary. As part of the National Oceanic and Atmospheric Administration (NOAA), they are part of a broader organization that is a leader in climate change science and applied water resources in the U.S. NOAA is one of the original five federal agencies making up the Climate Change and Western Water Group ("CCAWG"), an influential federal agency group working on climate change related adaptations for water resource management applications.

Recent studies are emerging that confirm the vital role of dams in offsetting the adverse hydrological shifting brought about by climate change (e.g., Hatcher and Jones, 2013). As noted by co-author Julia Jones at Oregon State University, "*....dams are doing what they are supposed to do, which is to use engineering – and management – to buffer us from climate variability and climate change.*" As the 2014 Columbia River Treaty undergoes formal review this year, studies such as these may continue to encourage regulatory agencies to view contemporary hydrology and its action-oriented regulatory provisions in a new light. Previous studies had already shared these same observations and there exists an expansive research base that illustrate the effects of dams on watershed response under a changing climate (e.g., Vicuna, 2006; Vicuna et al., 2007).

At the field level, however, this robust archive of new information is not always transferred down to NMFS staff. In past ESA consultations for example, NMFS staff were not necessarily apprised of or aware of what their broader NOAA colleagues were developing and advocating. Climate adjusted hydrologic simulation modeling, before any reservoir/instream water temperature or early life-stage salmon mortality models can be run, have not been consistently used by NMFS in their Biological Opinions. Moreover, for large system simulation models such as those used for the Central Valley, NMFS does not require or guide federal lead agencies to address upper basin hydrology changes due to climate change; a significant shortcoming in the effects analyses of their Biological Opinions since so much of what is evaluated depends on the upper reservoir inflows to these broad system wide models. Using historic data to "run" these mass balance system routing models without inflow refinements based on both climatic forcings and the empirical responses of the watershed to those new inputs, means that climate change is largely ignored.

The NMFS 2007 Biological Opinion on the Long-Term Operation of the Central Valley Project and State Water Project (also known as the "OCAP BiOp") is arguably the most comprehensive Opinion prepared by NMFS. It documents the potential effects on listed anadromous fish from the long-term continued operation of the two largest water projects in California. While the Delta pumps, invasive species, in-Delta water quality, ocean conditions, habitat flows, fish passage were all identified by NMFS as contributing factors to their threatened status, water temperature was one of the most significant adverse effects that they addressed. Without dams, and their proper operational integration into reservoir coldwater pool management, downstream temperature targets so necessary for certain fish life cycles could not be met under many natural flow situations.

A growing number of Statewide water initiatives have begun to discuss and explore what such changes in baseline hydrology really means to existing (and in many cases, entrenched) protocols for regulatory approval. Regulatory transitioning under climate change has emerged as a new prescient theme in the Bay-Delta debate, SWRCB water rights processes, California Water Commission new water storage interests, and throughout the water industry (Shibatani, 2013a; Shibatani, 2013b; Shibatani, 2012).

The NMFS "challenge" as noted in this sub-section will be to use contemporary climate change science, a more integrated view towards balancing multi-watershed beneficial uses, parallel support from other regulatory agencies (e.g., SWRCB), and the growing support for new storage across all segments of society to help redefine for NMFS what contemporary off-mainstem dams can provide. Across the world and indeed California and the western States, *the second era of dams is over*; there are negative perceptions tied to past environmental issues related to fish passage, downstream sediment starvation, riverine thermal management, etc. These long-standing issues can now be better addressed with new contemporary siting philosophies, improved technological advancements involving the dam facilities themselves (e.g., temperature control devices, fish ladders, improved spillway design, reconfigured power penstock shutters, etc.), as well as an updated appreciation for shifting hydrologic regimes and the need to re-address collective reservoir operations from both a flood control and water yield generation perspective.

11.3 Decision Making Considerations

Once the broad goals of the dam management effort are identified, the second step in the decision making process typically involves the identification of specific issues related to the dam and the collection and evaluation of the available information that can help support and/or refine any of the specific issues. For the Los Padres Dam discussion, these issues are well known and have been documented in numerous studies, reports, and raw data.

The decision to remove a dam or select an appropriate set of decommissioning prescriptions requires a complex evaluation involving numerous factors. Finding an effective and efficient means of analyzing the information and in a manner easily understood by decision makers has always been a challenge. Matrices are often used in this regard and have the advantage of summarizing data in a format that facilitates analysis (Loucksand Costa 1990). Matrices can accommodate the fact that all the possible combinations of events and strategies may not be realistic at the time of the decision-making and therefore must include a temporal view. Two common rubrics take the form of stoplight matrices and scaled matrices (Brauner et al, undated). For the spotlight matrix, which is the visually more discernible of the two, one can see how each of the evaluation criteria (rows) are projected over time (1-40 years) for each of the potential decommissioning options (columns) (**Figure 11-1**).

DECOMMISSIONING OPTIONS					
Dredge to Continue Operation	Cease Current Operations	Full Notch (no dredge)	Full Notch (dredge)	Partial Notch (no dredge, fish ladder)	Partial Notch (dredge, fish ladder)
Year 1 5 10 20 40	Year 1 5 10 20 40	Year 1 5 10 20 40	Year 1 5 10 20 40	Year 1 5 10 20 40	Year 0 5 10 20 40
● ● ● ● ●	● ● ● ● ●	● ● ● ● ●	● ● ● ● ●	● ● ● ● ●	● ● ● ● ●

Source: Excerpt from Brauner et al. (n.d.), Table 11-1, Summary of Spotlight Matrix 7, pg.168.

Figure 11-1.
Spotlight Matrix – For Environmental Criteria Showing Thresholds Achievement For Each Decommissioning Option Over Time

A stoplight matrix, while appropriate for dams under single entity governance and interest, may not be appropriate in this case. For Los Padres Dam, the issues are more complex. For one, both MPWMD and Cal-Am have vested and legitimate interests in the ultimate management option selected for this facility. Second, and not to be discounted, decommissioning or removal does not hold the same import with Los Padres as it does with other dams.

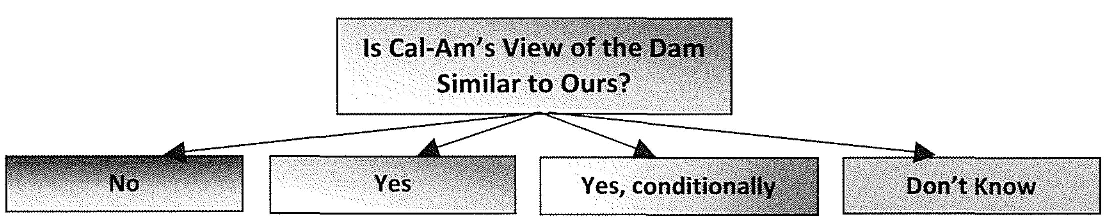
Fish passage is the primary reason behind the long time advocacy for removal of this facility. However, with state-of-the-art fish passage designed and incorporated into a new downstream facility, fish passage need not be a fatal flaw when designed at a new facility.

11.4 Los Padres Dam and MPWMD/Cal-Am

While the questions involving long-term water supply security and sustainability on the Peninsula are almost too numerous to list, this current Plan is the *Los Padres Dam and Reservoir – Long-Term Strategic and Short-Term Tactical Plan*. It is important to keep focused on that objective since it is easy to get overwhelmed by the larger suite of interconnecting issues and uncertainties. The overarching issue that is driving the need for this Plan focuses on the prescient question; ***What is to be the ultimate fate of Los Padres Dam?***

The answer to this represents the objective of the Long-Term *Strategic* Plan. The means to get there through the following series of discussions and schematics represents the Short-Term *Tactical* Plan. All of the preceding technical information supports these two Plan elements.

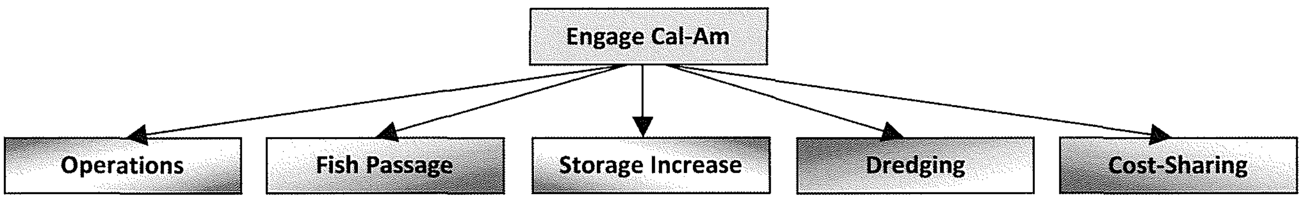
The answer to that question is influenced in part by the effectiveness of a number of unfolding processes and pathways. MPWMD is aware of each these processes and action pathways. Since Cal-Am is the owner of the facility, the decision tree for MPWMD must start there. The initial set of queries schematically presented might look something like this:



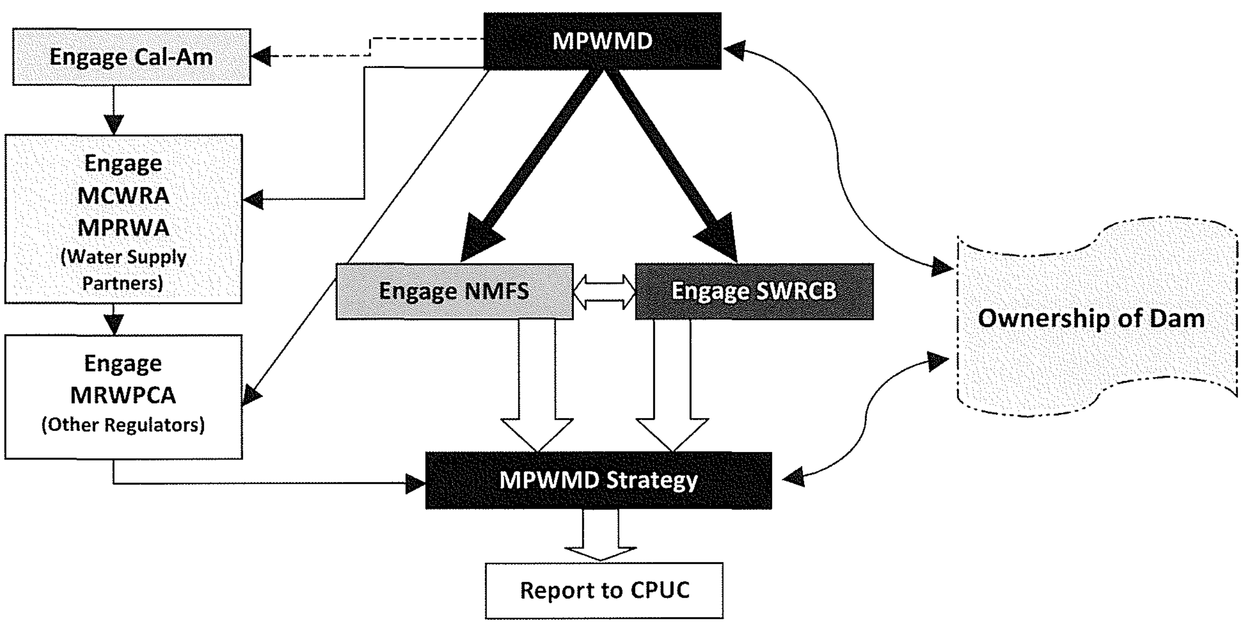
Each of these answers generates its own set of subsequent proposed actions. Assuming that MPWMD chooses to initiate some level of action depending on the above answer, the range of potential follow-ups set up the next tier of questions. For example, under the "Yes" answer, MPWMD could leave everything completely up to Cal-Am, choosing not to engage in any manner. However, the assumption is made that MPWMD would engage in some fashion even under the "Yes" answer.

The easiest of the above answers to follow through is the "Don't Know". Direct and immediate engagement with Cal-Am to get to the first step is straightforward (or should be).

With the "No" answer and assuming its unacceptability to MPWMD, the follow up reply by MPWMD comes in an escalating scale of responses. Two categories of response are relevant here, depending on the degree of disagreement. If the degree of disagreement is minor or low, then the actions for MPWMD would seem straightforward with the range of potential minor issues identified below:



If, alternatively, the degree of disagreement is high or, if it is apparent to MPWMD that Cal-Am is fixed on a current solution counter to MPWMD's vision, then a wider range of potential actions could ensue. **At some point, MPWMD would have to determine how willing, if at all, it is prepared to push its agenda and under what context.** Continual engagement with Cal-Am is a given, but the necessity for parallel engagements with other agencies/parties is also evident.



This process requires keeping genuine channels open with Cal-Am in the hopes of coming to a mutually acceptable understanding and agreement. The two primary public trust resource agencies of significant importance are NMFS and the SWRCB. Their influence, ultimately, will help frame the final solution for Los Padres Dam and Reservoir. Collateral issues concerning both agencies are relevant and ideally should be carefully aligned so that progress from discussions with one agency can be effectively used in deliberations with the other (**Figure 11-2**). Ultimately, from these discussions, MPWMD would craft a strategy that conveys an effective solution for Los Padres Dam including a range of technical and institutional/legal (and financial) prescriptions. It is *this* solution that would be presented to the CPUC in any of the upcoming formal and informal opportunities related to their continuing jurisdiction on this matter.

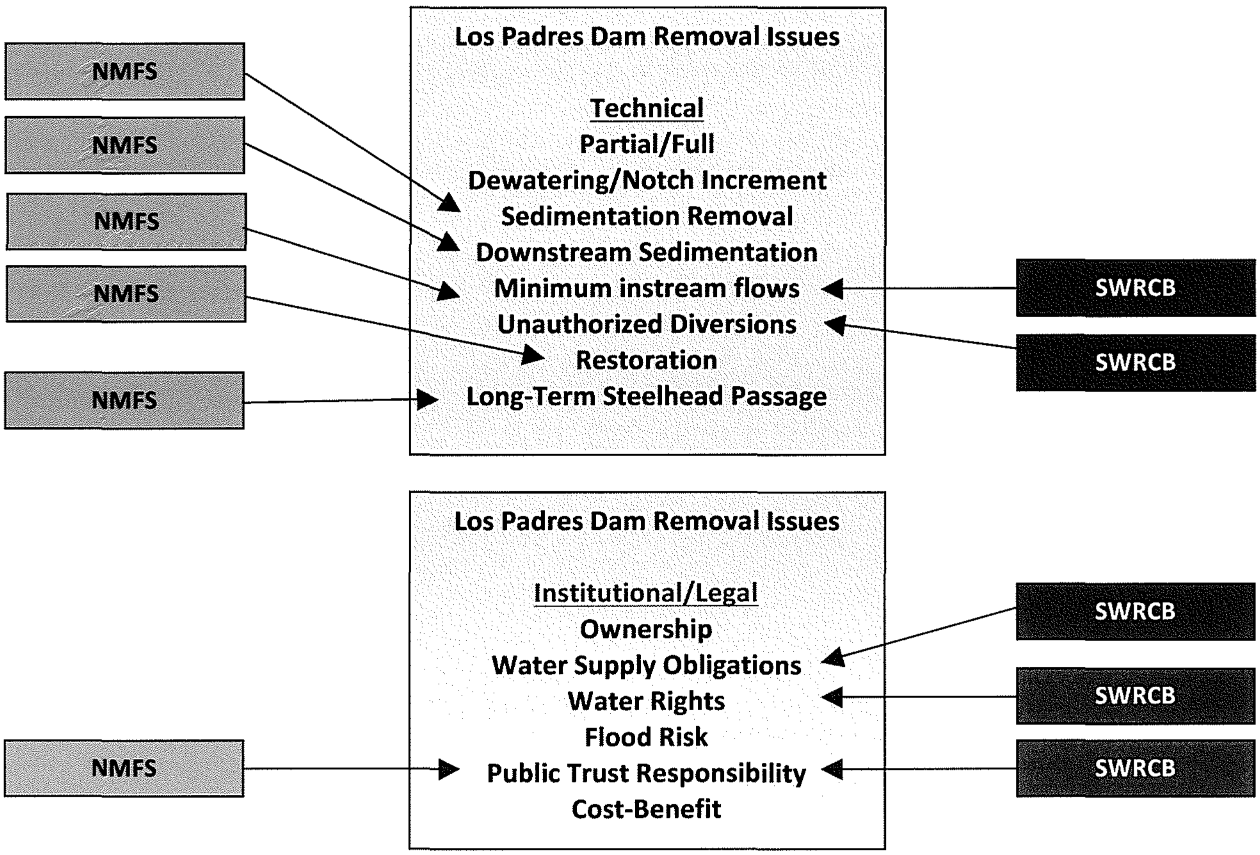


Figure 11-2.
Coincident Issues of the SWRCB and NMFS Regarding Los Padres Dam
Technical and Institutional/Legal Issues

As shown in Figure 11-2 above, some issues are germane to both the SWRCB and NMFS, while others hold mere tangential relevancy. Interestingly, based on this subjective pairing, it appears that the focus of NMFS' interests are on those issues identified under the Technical category whereas for the SWRCB, the focus seems to be more directed towards those under the Institutional/Legal category.

MPWMD's recognition of these issues, both those specific to one agency and those where collateral interest is present is important to help craft the initial consultation tactics. For example, both agencies have an interest in maintaining minimum instream flows. Yet, the reasons and objectives behind their interests differ.

From MPWMD's perspective, approaching either NMFS or the SWRCB on the issue of minimum instream flows really diverts back to the fundamental question as to what the district's ultimate objective is for this facility. ***What is MPWMD's preferred option regarding Los Padres Dam?*** If, as the previous discussions in this Plan have set out, Los Padres Dam represents but one element in a larger multi-faceted solution for the watershed, then the strategy for MPWMD would be cast in a certain light. If, however, Los Padres Dam represents the sole facility-solution for the watershed in the longer-term, then the options for MPWMD would differ. See **Figure 11-3** for a generalized schematic.

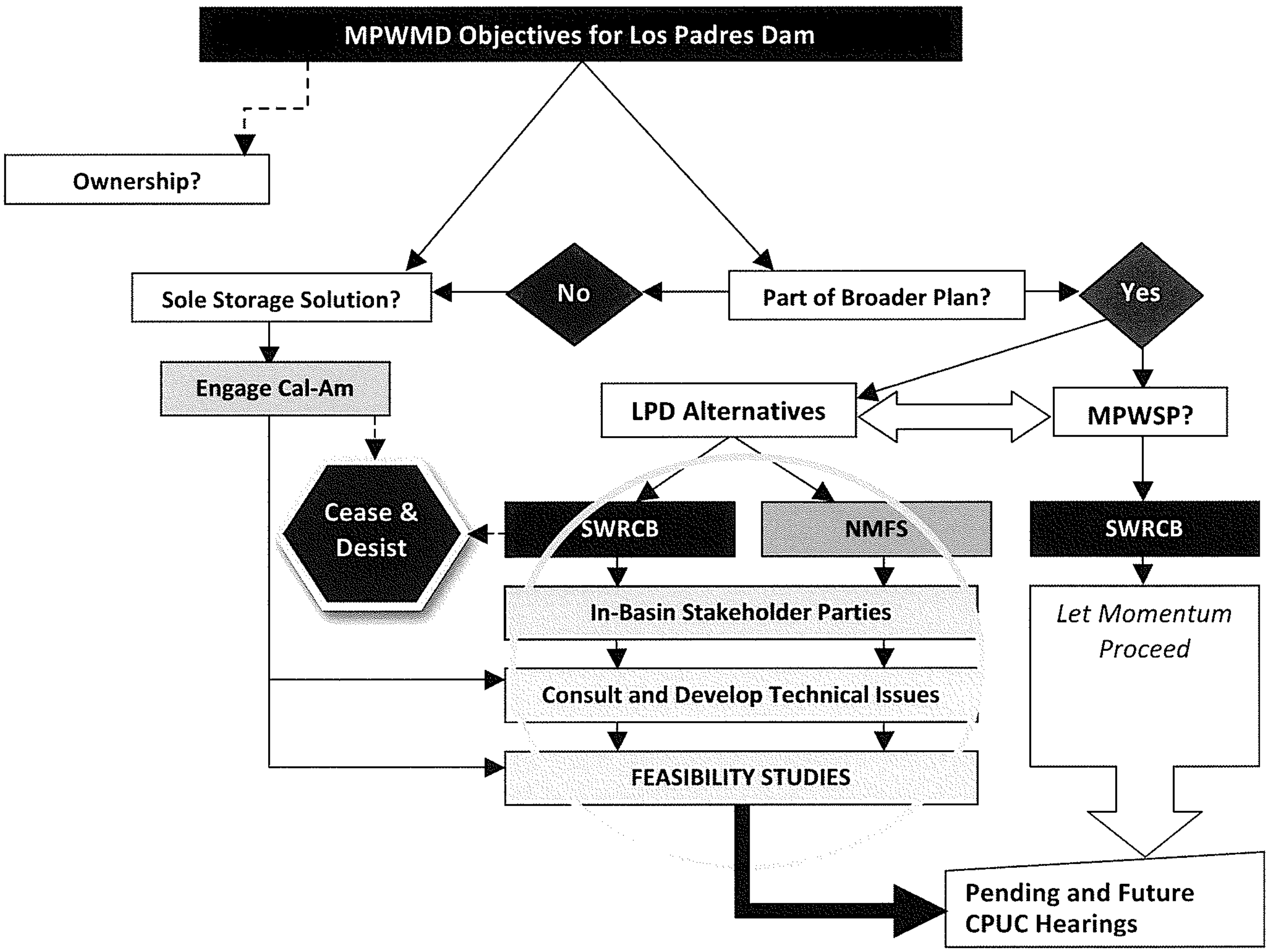


Figure 11-3.
Generalized Schematic of Decision Points Related to Los Padres Dam Objective
Sole Storage Solution or Part of Broader Plan

From Figure 11-3, in this simplistic visualization, depending on how MPWMD views Los Padres Dam within the longer term context of the Carmel River watershed solution framework, various steps and engagements would occur. While the Figure identifies two of the primary public trust resources agencies (i.e., NMFS and SWRCB) others would be involved including California Department of Fish & Wildlife, Regional Water Quality Control Board, U.S. Army Corps of Engineers, U.S. Forest Service, and others. **Notable in this illustration is the need to allow the MPWSP to proceed forward unaffected by the deliberations regarding Los Padres Dam.**

On this latter point, care must be exercised to ensure no inadvertent obstacles or unnecessary impediments are generated that would impair or otherwise delay full processing and approval of the

MPWSP. This is a delicate prerequisite since neither project (e.g., MPWSP or Los Padres Dam) can be exclusively isolated. To be sure, there is support, commitment, and optimism, albeit guarded, that the MPWSP can be effectively and successfully implemented within the time horizons necessary. As alluded to frequently in the previous discussions, it is incumbent upon any water purveyor and/or water resources management agency to ensure that the widest possible suite of water assets, facilities, and operational contingencies are available. Keeping a Los Padres Dam or some form of storage capability in the upper Carmel River watershed will be important, if nothing more than a safeguard against future water resource and water supply threats. Sole reliance on a single project in these times of growing uncertainty, both natural and regulatory, is very risky.

The next tier of questions following identification of MPWMD's objectives is to identify the sequence of steps or processes that would occur once a preference is noted. **Figure 11-4** differentiates between scenarios where Los Padres Dam is continually owned and operated by Cal-Am or by MPWMD. The "Leave as Is" option under MPWMD ownership identifies two possible outcomes for the dam; leaving it in place for inundation under the larger potential New Los Padres Dam alternative (see Subchapter 8.4 – New Los Padres Dam and Reservoir) or orphaning it. Under the Cal-Am ownership scenario which is the default condition, engagement with Cal-Am can provide opportunities for collaboration on either the Dam Removal or Reservoir Enhancement options. The third option under the Cal-Am ownership scenario is complete disengagement by MPWMD with Cal-Am on plans for the final disposition of the facility.

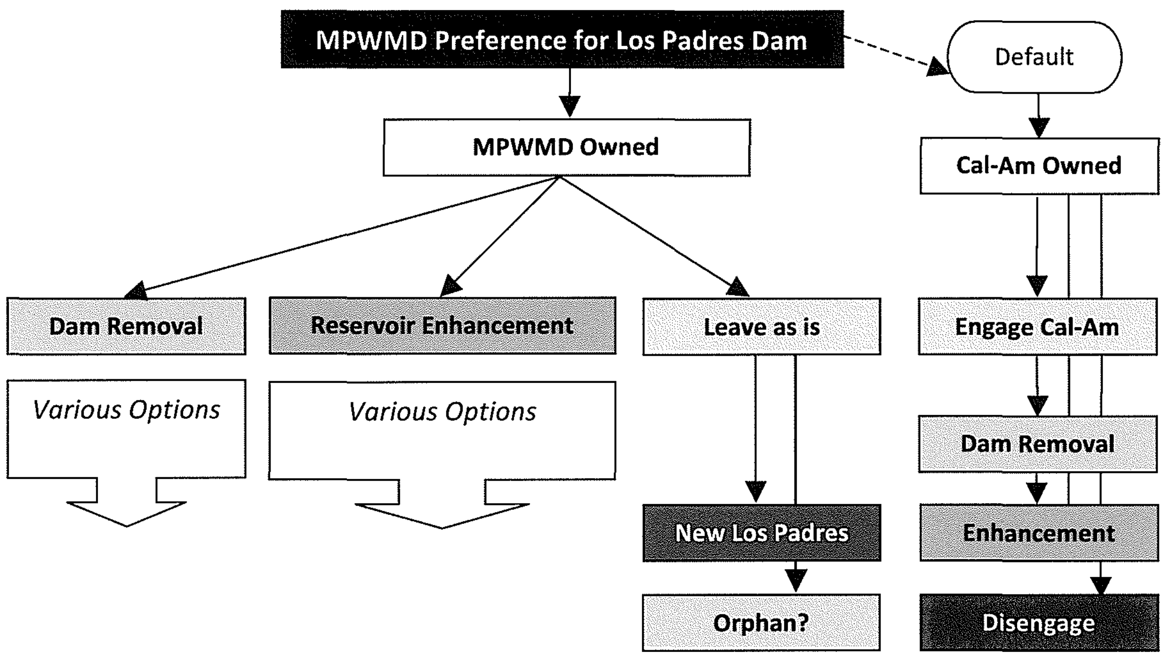


Figure 11-4.
Ownership Scenarios for Los Padres Dam

The notion of transferring all ownership of water resource facilities, be they for water supply or instream flows, over to public oversight and control is always a sensitive one. For Los Padres Dam, this could be a short-lived concern as one has to question whether ownership of an impending decommissioning is a judicious means of expending effort. **The larger issue, however, is who will have ultimate responsibility and management guidance over the storage and operational control of water storage within the Carmel River watershed**. Still, it is a real issue and one that certainly cannot be avoided in the upcoming CPUC hearings. There does not seem to be clear inclination from either NMFS or the

SWRCB as which scenario they would favor if given the choice. They may, and likely do, have their own preferences, but these have not been overtly stated in the public record. All else being equal, it is not stretching the truth to suggest that they would lean towards ownership by a notable *public* agency.

Accepting that MPWMD does not know the *true* intentions of Cal-Am regarding Los Padres Dam, continued engagement in light of the NMFS request for a plan of action regarding the facility and Cal-Am's initial response is highly desirable.

In Figure 11-4, the options for Los Padres Dam technically are shown as identical between the two ownership scenarios. While the oversight, administration, and certain implementation procedures would differ, the technical issues associated with any of the dam options would be consistent regardless of ownership.

The requirement for consultation and development of the technical issues shown in Figure 11-3, as depicted by the yellow circle would represent the key activities should New Storage actions be deemed the appropriate course to pursue. Much of these activities would fall under the New Storage action, but they are also applicable under the Sole Storage solution. The distinction, however, is that for the Sole Storage solution, many of the studies, options, and technical details associated with such activities as dredging, in-reservoir sediment management, downstream sedimentation, capacity increases, and related fish passage and instream habitat quality issues have been investigated at least to some level in the past. **What is less known are all the technical details associated with the development of <u>new</u> storage within the Carmel River watershed.**

Using the subjective dam removal issues from Figure 11-2, and taking minimum instream flows as an example, a conceptual schematic is provided that illustrates potential process steps that could be followed with NFMS and the SWRCB. The fundamental motivation behind any NMFS requirement for instream flows is related to fisheries life cycle needs in the various streams under their jurisdiction. For the SWRCB, however, the legislative mandates are broader and focus more on acceptable beneficial uses. For simplicity, **Figure 11-5** labels these two requirements differently, distinguishing between an *environmental* driver (e.g., NMFS) and a *regulatory* driver (e.g., SWRCB).

Within the Carmel River, NMFS clearly has identified instream flow needs that include a number of flow-related prescriptions tied to such things as timing (seasonal periods), flow rate, location, water year types, etc. To meet such important instream hydrologic needs, it is essential that an upstream "supply source" be available; one that has the ability to manage, schedule, and retain inter-annual runoff so that such requirements can be consistently met, to the best extent possible.

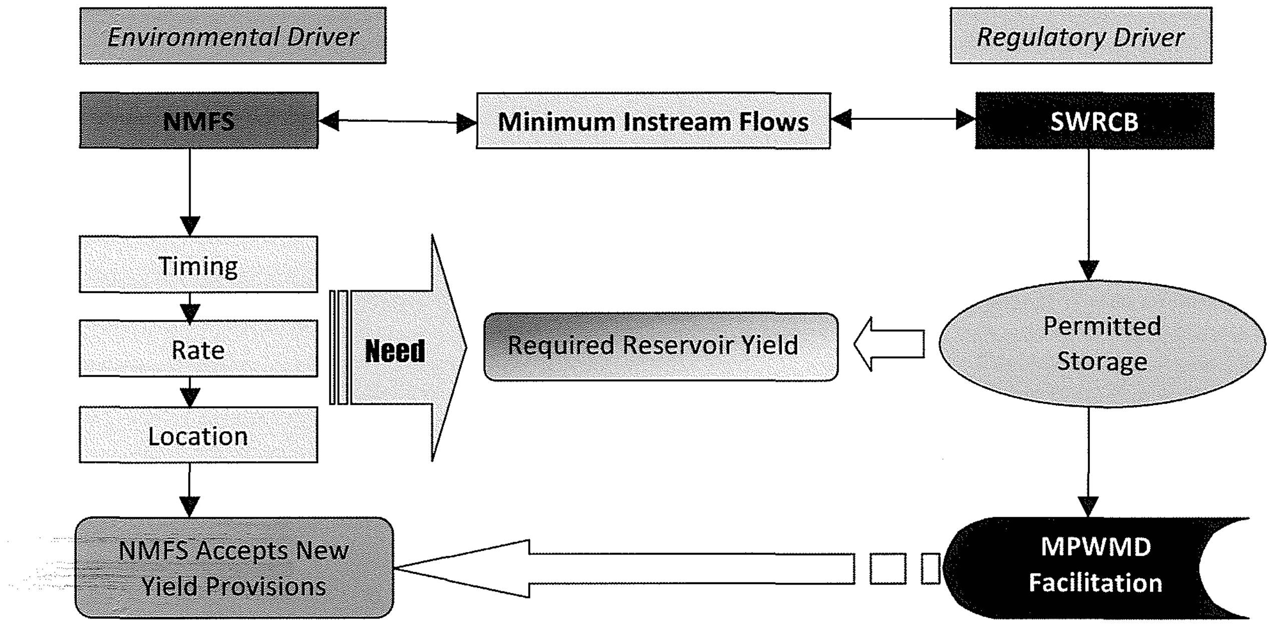


Figure 11-5.
Example Facilitation Process Between NMFS and SWRCB
Regarding Minimum Instream Flows

This requires a dedicated and firm yield source in order to meet dry season instream flow recommendations and winter season minimum flows for river diversions to the Seaside Basin; one that is more secure than relying on the natural unimpaired runoff of the watershed as already discussed in earlier sections. The SWRCB, through its permitting approvals has the authority to approve the right to storage of such yield (and has done so in the past with the New Los Padres Dam and Reservoir and permits for ASR). To continue to meet instream flow needs downstream, long established riparian water rights, diversions for regional groundwater recharge, and direct diversions to Cal-Am's WTPs, the SWRCB has the capability of facilitating the vital upstream storage necessary to meet these requirements. The SWRCB, through its broader regulatory interests, can potentially help provide MPWMD with the necessary leverage and faciliatory assistance to meet the more focal objectives of NMFS with regard to Los Padres Dam.

As noted at the outset of this Plan, the months ahead will be an active time for various institutional, regulatory, and legal proceedings regarding long-term water resources management on the Peninsula. While the focus will be on the MPWSP and its various elements; ASR, GWR, water purchase agreement, etc., the implications to the upper Carmel River watershed and, particularly, the fate of Los Padres Dam and Reservoir should not be overlooked.

As noted previously, MPWMD has embarked upon an aggressive schedule of new studies to help support its overall decision-making process regarding Los Padres Dam and Reservoir. There are several components studies to MPWMD's long-term strategy that should be carried out in order to evaluate the various options available for this facility. These include:

Unimpaired Flow Analysis – this analysis would be used as the "baseline" for comparing changes in flow with various alternatives. The most recent analysis of unimpaired flows was in 2002 using MPWMD's Carmel Valley Simulation Model (CVSIM). This model is no longer available and is proposed to be replaced with a linked, surface-groundwater model for the Carmel River Basin. Flow analyses are combined with aquatic habitat information to characterize the availability and quality of steelhead habitat under various flow conditions.

Flow Analyses associated with Alternatives – several flow analyses involving different levels of diversions would be required in order to evaluate alternatives including: existing conditions and Cal-Am operations; future Cal-Am operations as proposed in the MPWSP; and, the alternatives identified in this Plan. It is likely that a change petition to the SWRCB involving Permit 20808B would result in a new Permit that includes maintaining minimum instream flow requirements.

Updated Instream Flow Study – NMFS completed recommendations for maintaining instream flows in 2002. A modified version of those recommendations is currently being attached by the SWRCB to all new permits issued for the Carmel River. The 2002 NMFS study does not accurately reflect significant changes in river habitat conditions and Cal-Am operations over the past 25-years. MPWMD staff is currently working with a consultant to develop an updated instream flow analysis using the Instream Incremental Flow Method (IFIM). The study will likely take two years to complete.

Steelhead Habitat Evaluation of the Carmel River Watershed – MPWMD's 2004 evaluation of steelhead habitat in the watershed estimated that 50% of the spawning habitat in the watershed was upstream of Los Padres Dam. Similarly, MPWMD estimated that 42% of the suitable rearing areas in the watershed were above Los Padres Dam and that it was of exceptional quality due to its location within the Ventana Wilderness. The estimates for areas downstream of Los Padres Dam were based on habitat conditions between the 1980s and early 2000s and included the effects of unauthorized diversions.

The value of steelhead habitat both upstream and downstream of Los Padres Dam should be re-evaluated in the context of improvements to habitat in the mainstem due to removal of San Clemente Dam, stream restoration in the lower 15 miles of the river, proposed reductions in Cal-Am diversions, and any proposed gravel replenishment projects associated with sediment management at Los Padres Reservoir. A combination study using IFIM and habitat suitability index (HSI) assessments should be used to better understand the value of each reach of the river and each tributary and the potential for improvements downstream of Los Padres Dam.

Yield and Cost/Benefit Analysis – Each alternative identified in this Plan should be evaluated for costs and benefits to water supply.

Impacts Analysis – Each alternative would have varying environmental benefits and impacts that may make them infeasible to permit. An initial screening of alternatives (beyond that undertaken here in this Plan) should be carried out to rank alternatives and determine if there are genuine fatal flaws.

Sediment Management – Additional study on the various effects and options regarding both interim and long-term sediment management under each of the alternatives in this Plan should be performed.

11.5 Recommendations

It is **recommended that MPWMD hold a series of internal and open public meetings to engage the public, develop a strengthened administrative record, and work through each of the potential avenues of pursuit described herein and elsewhere.** Ideally, this would best occur in two phases. Initially, staff, management, and legal counsel should convene and confer over the implications and directions of these various elements. As part of that exercise, the internal "team" would work through an immediate near-term action plan; triaging immediate activities, relative to those on a longer timeframe. The pendency of the CDO December 31, 2016 deadline, however, presupposes any prolonged deferral.

Once management and staff have agreed on a definitive set of actions, Board workshops could be scheduled at key junctures. These would be determined by management and senior staff. All of these activities would occur under a dynamic and highly fluid process. Mapping out the key elements of this exercise early in 2014 and securing acceptance and commitment by the Board is deemed essential. There will likely be little time for hesitation and uncertainty as these 2014 dates rapidly emerge.

An important recommendation is for the District to undertake and complete the various studies described earlier in this section. The anticipated new information from these (and perhaps other necessary studies) will provide the Board with valuable details regarding the potential alternatives, affected environments, and integrative capacity with other initiatives ongoing within the Peninsula (e.g., MPWSP, ASR, GWR, etc.).

Elements of this Plan can help serve as guidance to assist MPWMD management, staff, and the Board in viewing the Los Padres Dam issue, **perhaps in a different light, but certainly with the benefit of having the latest alternatives and options scenarios before them. The manner with which the Los Padres Dam issue is ultimately integrated into the broader water supply security and resource protection objectives of the Peninsula at large will depend on how concisely the issues and alternatives have been set out and how assertively MPWMD chooses to act upon them.**

Appendix A

Pine Creek Dam and Reservoir (Alternative 1)

Estimated Diversion at <u>Carmel River Camp Diversion</u> into Pine Creek Tunnel, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	0	0	1,238	2,848	12,722	14,085	13,631	3,100	1,275	441	0	0	49,341
1959	0	3	45	2,548	6,638	1,638	677	381	0	0	0	132	12,062
1960	0	0	0	1,477	4,062	1,153	770	572	95	0	0	0	8,129
1961	0	62	828	378	743	878	333	67	0	0	0	0	3,290
1962	0	0	1,173	550	11,901	6,532	1,902	699	214	0	0	0	22,972
1963	1,103	94	616	4,822	11,247	4,447	10,220	4,060	1,461	411	219	0	38,698
1964	304	2,010	536	2,949	1,545	1,082	1,163	565	199	0	0	0	10,353
1965	0	867	3,473	7,643	1,512	1,266	4,298	1,638	506	203	0	0	21,407
1966	0	2,114	2,055	2,603	2,462	1,265	601	225	117	0	0	0	11,441
1967	0	339	7,631	7,283	4,864	10,499	13,631	5,341	1,451	602	0	0	51,640
1968	0	0	337	998	1,284	1,331	554	229	0	0	0	0	4,733
1969	0	0	728	14,085	12,722	14,085	6,114	2,088	1,224	432	0	0	51,479
1970	0	64	1,318	8,784	2,473	7,442	1,588	899	294	0	0	0	22,863
1971	0	1,992	4,546	2,715	954	1,243	1,019	490	145	0	0	0	13,102
1972	0	0	2,612	810	1,342	534	338	58	0	0	0	0	5,694
1973	0	2,494	843	8,192	12,722	13,616	4,231	1,702	805	0	0	0	44,606
1974	0	1,228	2,975	6,830	1,698	13,642	8,405	2,006	959	227	0	0	37,970
1975	0	123	1,278	590	11,961	14,085	5,152	2,093	900	290	12	0	36,484
1976	0	144	141	146	208	636	333	0	0	0	0	0	1,608
1977	0	0	0	279	0	113	0	0	0	0	0	0	392
1978	0	0	2,114	14,085	12,722	14,085	7,490	3,665	1,173	823	235	141	56,534
1979	58	399	360	2,019	5,049	5,358	4,145	1,523	896	255	0	0	20,062
1980	99	438	2,253	14,085	12,722	11,822	4,644	2,600	1,248	933	306	135	51,284
1981	0	116	431	4,413	2,059	5,894	2,537	1,070	375	0	0	0	16,895
1982	0	3,042	1,936	11,743	5,307	7,947	13,631	3,418	1,586	757	96	24	49,486
1983	256	2,275	11,400	14,085	12,722	14,085	13,631	11,648	3,374	1,505	838	381	86,200
1984	508	3,685	13,833	4,920	2,268	1,896	1,423	749	341	0	0	0	29,622
1985	46	1,368	1,425	737	1,514	2,687	1,522	608	84	0	0	0	9,992
1986	0	434	1,377	1,338	12,722	14,085	3,877	1,655	691	126	0	0	36,305
1987	0	0	107	292	2,081	1,803	624	95	0	0	0	0	5,002
1988	0	0	764	1,613	317	141	203	51	0	0	0	0	3,088
1989	0	0	300	560	409	1,318	476	28	0	0	0	0	3,092
1990	0	0	0	436	1,402	434	59	0	0	0	0	0	2,332
1991	0	0	0	0	0	8,658	1,794	423	0	0	0	0	10,876
1992	0	0	151	888	10,260	4,308	1,271	359	0	0	0	0	17,237
1993	0	0	1,174	14,085	12,722	7,511	2,802	1,195	730	111	0	0	40,330
1994	0	0	289	279	2,230	797	288	195	0	0	0	0	4,079
1995	0	0	149	14,085	3,790	14,085	4,237	3,344	1,841	826	95	8	42,459
1996	0	0	939	1,863	12,722	9,401	3,496	1,704	605	117	0	0	30,846
1997	0	644	6,601	14,085	6,646	2,245	1,072	424	172	32	0	0	31,921
1998	0	224	2,775	12,755	12,722	10,719	8,610	5,053	2,580	1,078	499	223	57,238
1999	273	762	1,318	2,030	5,270	3,729	5,169	1,401	463	10	0	0	20,425
2000	0	0	0	5,051	12,722	8,756	2,992	1,175	383	71	0	0	31,150
2001	127	156	55	2,406	4,340	8,801	1,844	1,118	371	0	0	0	19,218
2002	0	381	4,465	3,525	1,324	1,849	1,200	580	139	0	0	0	13,463
2007	8	31	381	252	1,204	978	247	38	0	0	0	0	3,138
2008	0	0	0	8,309	5,959	2,528	860	372	57	0	0	0	18,085
2009	0	21	289	306	6,206	9,555	1,612	894	459	114	0	0	19,455
2010	3,007	557	1,765	9,652	7,384	7,152	6,014	3,098	1,394	620	274	137	41,053
2011	93	293	3,521	5,103	6,286	14,085	5,697	2,175	2,086	697	298	114	40,447
2012	199	277	180	1,018	456	1,490	2,210	604	171	0	0	0	6,605
2013	0	49	6,229	2,639	894	603	348	99	0	0	0	0	10,860

Min =	0	0	0	0	0	113	0	0	0	0	0	0	392
Max =	3,007	3,685	13,833	14,085	12,722	14,085	13,631	11,648	3,374	1,505	838	381	86,200
Avg =	117	513	1,903	4,715	5,529	5,930	3,480	1,492	593	205	55	25	24,559

<u>Notes:</u>

5.0	Minimum bypass, cfs
275.0	Diversion capacity, cfs
0.85	diversion coefficient
44.8	Los Padres Reservoir drainage area, mi^2
32.9	Carmel River Camp Diversion drainage area, mi^2

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated Diversion at Danish Creek Diversion into Pine Creek Tunnel, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	4	25	327	714	1,145	1,267	1,227	774	335	136	14	0	5,968
1959	0	30	41	642	1,145	423	192	121	19	0	0	61	2,672
1960	5	9	11	384	1,002	307	214	167	52	0	0	0	2,151
1961	0	44	229	121	205	241	109	46	19	0	0	0	1,013
1962	0	1	312	162	1,145	1,267	486	198	80	4	0	0	3,654
1963	295	51	178	1,188	1,145	1,098	1,227	1,005	380	128	82	21	6,797
1964	103	512	159	738	398	290	308	165	77	21	0	0	2,769
1965	0	237	864	1,267	390	334	1,061	423	150	79	0	0	4,805
1966	0	536	523	655	618	334	173	84	57	0	0	0	2,980
1967	0	110	1,267	1,267	1,145	1,267	1,227	1,267	377	174	19	0	8,122
1968	13	25	111	270	335	349	162	85	0	0	0	0	1,349
1969	0	17	205	1,267	1,145	1,267	1,227	531	323	134	0	0	6,115
1970	13	44	346	1,267	621	1,267	410	246	99	0	0	0	4,315
1971	0	507	1,121	682	256	328	274	147	64	0	0	0	3,379
1972	0	3	657	224	349	158	110	44	0	0	0	0	1,546
1973	18	628	232	1,267	1,145	1,267	1,045	439	222	25	0	0	6,289
1974	19	324	744	1,267	435	1,267	1,227	512	259	84	0	0	6,138
1975	4	58	337	171	1,145	1,267	1,227	532	245	99	33	0	5,119
1976	30	63	64	65	77	183	109	22	0	0	0	0	612
1977	0	0	0	97	22	57	23	4	0	0	0	0	203
1978	0	0	537	1,267	1,145	1,267	1,227	910	311	227	86	63	7,040
1979	44	125	116	515	1,145	1,267	1,024	395	244	91	27	17	5,011
1980	54	134	571	1,267	1,145	1,267	1,144	654	329	254	103	61	6,983
1981	14	57	133	1,090	521	1,267	638	287	119	20	0	0	4,146
1982	14	759	495	1,267	1,145	1,267	1,227	851	410	212	53	35	7,733
1983	91	575	1,267	1,267	1,145	1,267	1,227	1,267	839	391	231	120	9,689
1984	152	914	1,267	1,211	572	485	370	210	111	3	0	0	5,294
1985	41	357	372	207	390	675	394	176	49	0	0	0	2,662
1986	0	133	360	351	1,145	1,267	960	427	195	60	0	0	4,899
1987	0	11	56	100	527	463	179	53	19	0	0	0	1,406
1988	0	0	213	417	103	64	78	42	0	0	0	0	917
1989	0	0	102	164	125	346	143	37	0	0	0	0	917
1990	0	0	0	135	364	134	43	0	0	0	0	0	675
1991	0	0	0	0	0	1,267	460	131	15	0	0	0	1,874
1992	0	1	66	243	1,145	1,064	334	116	24	0	0	0	2,994
1993	0	0	312	1,267	1,145	1,267	702	317	204	56	1	0	5,271
1994	0	18	99	97	562	221	98	77	5	0	0	0	1,178
1995	0	0	66	1,267	937	1,267	1,046	833	471	228	53	31	6,199
1996	10	14	255	477	1,145	1,267	868	439	174	58	6	0	4,714
1997	7	183	1,267	1,267	1,145	569	286	132	70	38	0	0	4,965
1998	0	83	696	1,267	1,145	1,267	1,227	1,243	648	289	150	82	8,097
1999	95	212	346	517	1,145	925	1,227	366	140	32	0	0	5,006
2000	0	25	28	1,243	1,145	1,267	747	312	121	47	0	0	4,935
2001	60	66	43	607	1,069	1,267	472	298	118	14	0	0	4,016
2002	0	120	1,102	876	345	474	317	169	62	0	0	0	3,466
2007	32	36	121	90	316	265	88	39	0	0	0	0	987
2008	0	0	20	1,267	1,145	637	235	119	43	3	0	0	3,469
2009	0	34	99	103	1,145	1,267	416	244	139	57	26	9	3,540
2010	752	163	454	1,267	1,145	1,267	1,227	774	363	179	96	62	7,747
2011	52	99	875	1,255	1,145	1,267	1,227	552	530	197	101	56	7,357
2012	78	95	73	274	136	388	560	175	70	22	0	0	1,870
2013	0	41	1,267	663	242	175	112	54	13	0	0	0	2,567

Min =	0	0	0	0	0	57	23	0	0	0	0	0	203
Max =	752	914	1,267	1,267	1,145	1,267	1,227	1,267	839	391	231	120	9,689
Avg =	38	144	392	712	760	821	622	356	165	65	21	12	4,108

Notes:

0.5	Minimum bypass, cfs
25.0	Diversion capacity, cfs
0.85	diversion coefficient
44.8	Los Padres Reservoir drainage area, mi^2
7.9	Danish Creek Diversion drainage area, mi^2

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Management District Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated Inflow to Pine Creek Reservoir from Pine Creek, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	1	23	347	761	1,347	1,491	1,443	826	355	142	11	0	6,746
1959	0	28	39	684	1,347	450	201	126	16	0	0	61	2,952
1960	1	6	8	408	1,071	325	225	175	51	0	0	0	2,271
1961	0	43	241	125	217	254	113	45	17	0	0	0	1,055
1962	0	0	330	169	1,347	1,491	517	208	82	0	0	0	4,144
1963	312	51	186	1,269	1,347	1,173	1,443	1,073	403	134	84	19	7,494
1964	106	545	166	787	423	306	327	173	78	18	0	0	2,929
1965	0	250	922	1,491	414	354	1,133	450	157	80	0	0	5,253
1966	0	571	557	698	659	354	182	86	57	0	0	0	3,163
1967	0	114	1,491	1,491	1,278	1,491	1,443	1,403	400	183	16	0	9,311
1968	9	22	115	285	356	371	170	87	0	0	0	0	1,414
1969	0	14	215	1,491	1,347	1,491	1,443	566	342	139	0	0	7,048
1970	10	43	367	1,491	662	1,491	436	259	103	0	0	0	4,863
1971	0	540	1,198	727	271	348	289	154	64	0	0	0	3,591
1972	0	0	700	236	371	165	114	43	0	0	0	0	1,630
1973	16	669	245	1,491	1,347	1,491	1,116	466	234	23	0	0	7,098
1974	17	343	794	1,491	462	1,491	1,443	544	274	86	0	0	6,946
1975	0	59	357	180	1,347	1,491	1,354	567	259	102	31	0	5,746
1976	28	64	64	65	79	192	113	20	0	0	0	0	624
1977	0	0	0	100	20	57	21	0	0	0	0	0	198
1978	0	0	572	1,491	1,347	1,491	1,443	971	329	240	88	63	8,036
1979	43	130	121	548	1,325	1,407	1,094	420	258	94	25	15	5,479
1980	53	140	608	1,491	1,347	1,491	1,223	697	348	268	107	62	7,835
1981	11	57	139	1,164	555	1,491	680	303	124	17	0	0	4,542
1982	11	810	526	1,491	1,347	1,491	1,443	908	435	223	53	33	8,771
1983	94	613	1,491	1,491	1,347	1,491	1,443	1,491	896	415	244	125	11,140
1984	159	976	1,491	1,295	609	516	393	221	115	0	0	0	5,774
1985	40	379	395	218	415	720	419	184	49	0	0	0	2,818
1986	0	139	382	372	1,347	1,491	1,025	454	205	60	0	0	5,476
1987	0	8	55	103	561	492	188	52	16	0	0	0	1,476
1988	0	0	225	443	107	64	79	41	0	0	0	0	959
1989	0	0	105	172	130	367	150	35	0	0	0	0	960
1990	0	0	0	140	386	140	42	0	0	0	0	0	708
1991	0	0	0	0	0	1,491	489	137	13	0	0	0	2,130
1992	0	0	67	256	1,347	1,137	354	120	22	0	0	0	3,304
1993	0	0	330	1,491	1,347	1,491	748	336	215	56	0	0	6,014
1994	0	15	102	100	599	233	101	78	1	0	0	0	1,231
1995	0	0	66	1,491	1,001	1,491	1,118	889	501	241	52	29	6,879
1996	7	11	270	507	1,347	1,491	927	467	183	58	3	0	5,270
1997	4	193	1,491	1,491	1,347	606	303	137	71	36	0	0	5,679
1998	0	85	742	1,491	1,347	1,491	1,443	1,329	691	306	156	84	9,165
1999	98	223	367	551	1,347	988	1,358	389	146	31	0	0	5,497
2000	0	23	26	1,328	1,347	1,491	797	331	125	46	0	0	5,514
2001	61	67	42	647	1,143	1,491	502	316	123	11	0	0	4,402
2002	0	125	1,177	935	366	504	336	177	63	0	0	0	3,684
2007	30	35	126	93	335	280	91	38	0	0	0	0	1,026
2008	0	0	17	1,491	1,347	679	248	124	42	0	0	0	3,947
2009	0	32	102	107	1,347	1,491	442	258	145	57	24	5	4,011
2010	802	170	482	1,491	1,347	1,491	1,443	826	386	187	98	62	8,786
2011	52	102	934	1,342	1,347	1,491	1,443	588	564	207	105	56	8,231
2012	79	98	74	290	143	412	596	183	71	19	0	0	1,965
2013	0	40	1,491	707	255	183	117	53	10	0	0	0	2,857

Min =	0	0	0	0	0	57	21	0	0	0	0	0	198
Max =	802	976	1,491	1,491	1,347	1,491	1,443	1,491	896	415	244	125	11,140
Avg =	39	151	430	801	869	940	692	381	174	67	21	12	4,578

Notes:

44.8 Los Padres Reservoir drainage area, mi^2

7.2 Pine Creek drainage area, mi^2

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Management District Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated Total Inflow to Pine Creek Reservoir, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	5	48	1,912	4,322	15,214	16,844	16,300	4,700	1,966	719	24	0	62,054
1959	0	60	125	3,874	9,130	2,511	1,070	628	35	0	0	253	17,686
1960	6	15	19	2,269	6,135	1,785	1,210	914	198	0	0	0	12,551
1961	0	149	1,298	623	1,165	1,373	555	158	36	0	0	0	5,358
1962	0	1	1,815	881	14,393	9,291	2,904	1,105	376	4	0	0	30,769
1963	1,709	196	980	7,279	13,739	6,717	12,889	6,137	2,245	673	385	40	52,989
1964	512	3,067	861	4,474	2,365	1,677	1,798	904	353	39	0	0	16,051
1965	0	1,355	5,259	10,402	2,316	1,954	6,492	2,511	814	362	0	0	31,465
1966	0	3,222	3,135	3,956	3,740	1,952	955	394	231	0	0	0	17,585
1967	0	563	10,390	10,041	7,287	13,258	16,300	8,011	2,228	959	35	0	69,073
1968	22	47	563	1,553	1,974	2,051	885	400	0	0	0	0	7,496
1969	0	31	1,148	16,844	15,214	16,844	8,784	3,185	1,889	705	0	0	64,642
1970	23	151	2,032	11,542	3,755	10,200	2,435	1,404	496	0	0	0	32,040
1971	0	3,039	6,865	4,123	1,480	1,919	1,582	791	272	0	0	0	20,072
1972	0	3	3,969	1,270	2,062	858	563	144	0	0	0	0	8,870
1973	34	3,791	1,320	10,951	15,214	16,375	6,391	2,607	1,262	48	0	0	57,993
1974	36	1,895	4,513	9,589	2,595	16,401	11,074	3,063	1,492	397	0	0	51,054
1975	4	240	1,972	941	14,452	16,844	7,732	3,192	1,404	492	76	0	47,349
1976	57	271	269	276	364	1,010	555	42	0	0	0	0	2,844
1977	0	0	0	476	42	227	44	4	0	0	0	0	793
1978	0	0	3,223	16,844	15,214	16,844	10,160	5,546	1,813	1,290	410	268	71,610
1979	144	654	597	3,082	7,519	8,033	6,264	2,338	1,397	439	53	32	30,552
1980	206	711	3,431	16,844	15,214	14,581	7,010	3,952	1,925	1,454	516	258	66,102
1981	25	230	704	6,667	3,136	8,652	3,855	1,660	617	37	0	0	25,583
1982	25	4,612	2,957	14,502	7,798	10,706	16,300	5,176	2,431	1,191	202	91	65,990
1983	441	3,462	14,158	16,844	15,214	16,844	16,300	14,406	5,108	2,312	1,312	627	107,029
1984	818	5,574	16,592	7,426	3,449	2,897	2,186	1,180	566	3	0	0	40,690
1985	127	2,105	2,192	1,161	2,319	4,082	2,336	968	182	0	0	0	15,473
1986	0	706	2,119	2,062	15,214	16,844	5,861	2,536	1,090	247	0	0	46,680
1987	0	19	218	496	3,168	2,758	990	199	35	0	0	0	7,884
1988	0	0	1,201	2,473	526	269	360	134	0	0	0	0	4,964
1989	0	0	508	897	664	2,032	769	100	0	0	0	0	4,969
1990	0	0	0	711	2,152	707	145	0	0	0	0	0	3,715
1991	0	0	0	0	0	11,417	2,743	692	28	0	0	0	14,880
1992	0	1	285	1,387	12,751	6,510	1,959	596	46	0	0	0	23,535
1993	0	0	1,815	16,844	15,214	10,270	4,252	1,848	1,149	224	1	0	51,616
1994	0	33	491	476	3,391	1,251	488	350	6	0	0	0	6,487
1995	0	0	281	16,844	5,727	16,844	6,401	5,066	2,812	1,294	201	67	55,537
1996	17	26	1,464	2,847	15,214	12,159	5,291	2,610	962	233	9	0	40,831
1997	11	1,020	9,359	16,844	9,137	3,419	1,661	693	314	106	0	0	42,565
1998	0	391	4,214	15,514	15,214	13,477	11,279	7,625	3,920	1,673	805	390	74,501
1999	466	1,197	2,032	3,098	7,762	5,643	7,753	2,156	749	73	0	0	30,928
2000	0	48	54	7,622	15,214	11,514	4,537	1,818	629	164	0	0	41,599
2001	249	289	139	3,660	6,552	11,559	2,818	1,733	612	26	0	0	27,637
2002	0	627	6,744	5,337	2,035	2,827	1,853	927	264	0	0	0	20,613
2007	69	102	629	435	1,855	1,523	425	114	0	0	0	0	5,151
2008	0	0	36	11,068	8,450	3,844	1,343	614	142	3	0	0	25,500
2009	0	87	491	516	8,697	12,313	2,469	1,396	743	229	49	14	27,005
2010	4,561	890	2,701	12,411	9,876	9,910	8,683	4,698	2,143	986	468	261	57,586
2011	197	495	5,330	7,700	8,778	16,844	8,366	3,316	3,179	1,101	504	226	56,036
2012	356	471	327	1,582	735	2,290	3,366	962	312	41	0	0	10,440
2013	0	130	8,987	4,009	1,391	960	577	206	23	0	0	0	16,283

Min =	0	0	0	0	0	227	44	0	0	0	0	0	793
Max =	4,561	5,574	16,592	16,844	15,214	16,844	16,300	14,406	5,108	2,312	1,312	627	107,029
Avg =	195	808	2,725	6,229	7,158	7,691	4,795	2,229	933	337	97	49	33,244

Notes:

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Management District Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated Flow from Pine Creek Reservor to Meet 5 CFS Requirment at Sleepy Hollow, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	359	317	12	0	0	0	0	0	0	148	328	333	1,496
1959	319	241	275	0	0	0	4	276	364	401	400	380	2,659
1960	375	348	355	160	0	0	0	96	373	403	400	385	2,896
1961	379	348	156	202	146	334	296	394	392	410	400	385	3,842
1962	379	348	354	343	0	0	0	0	292	396	401	385	2,898
1963	257	256	120	0	0	0	0	0	0	166	373	319	1,491
1964	292	0	0	0	0	0	0	59	312	401	401	385	1,850
1965	379	348	0	0	0	0	0	0	70	373	396	380	1,946
1966	379	59	0	0	0	0	169	380	390	409	400	385	2,572
1967	379	348	0	0	0	0	0	0	0	350	372	378	1,827
1968	375	348	322	225	0	0	9	375	394	400	400	385	3,234
1969	379	348	354	0	0	0	0	0	0	85	372	384	1,923
1970	373	316	0	0	0	0	0	0	225	389	399	385	2,086
1971	379	142	0	0	0	0	0	0	194	383	400	385	1,882
1972	379	348	0	0	0	244	167	413	391	400	400	385	3,126
1973	375	0	0	0	0	0	0	0	154	339	389	386	1,643
1974	340	0	0	0	0	0	0	0	41	276	369	366	1,392
1975	346	288	0	0	0	0	0	0	0	226	361	355	1,577
1976	339	290	291	300	279	270	336	405	394	402	400	385	4,092
1977	373	350	354	347	334	378	385	419	393	400	400	385	4,519
1978	379	350	0	0	0	0	0	0	0	123	253	298	1,404
1979	247	63	0	0	0	0	0	0	105	234	338	363	1,349
1980	339	51	0	0	0	0	0	0	0	32	276	254	952
1981	229	281	0	0	0	0	0	0	245	340	359	349	1,804
1982	249	0	0	0	0	0	0	0	0	87	320	301	957
1983	293	0	0	0	0	0	0	0	0	0	45	96	434
1984	0	0	0	0	0	0	0	0	127	238	277	323	966
1985	283	0	0	0	0	0	0	21	205	259	348	305	1,421
1986	332	262	0	0	0	0	0	0	61	183	203	177	1,219
1987	189	155	127	112	0	0	0	290	272	344	357	338	2,184
1988	320	266	215	0	0	166	294	306	299	330	330	326	2,853
1989	304	261	174	170	53	0	75	185	352	370	362	331	2,636
1990	292	252	267	199	0	0	258	316	322	349	336	315	2,907
1991	290	296	347	344	312	0	0	0	155	293	305	287	2,629
1992	358	342	211	0	0	0	0	0	254	382	389	383	2,319
1993	377	345	0	0	0	0	0	0	0	209	331	358	1,620
1994	354	281	150	133	0	0	0	30	295	395	399	383	2,420
1995	365	331	262	0	0	0	0	0	0	0	191	287	1,436
1996	298	256	0	0	0	0	0	0	0	214	360	373	1,501
1997	356	0	0	0	0	0	0	28	257	361	388	376	1,767
1998	361	12	0	0	0	0	0	0	0	0	0	183	555
1999	82	0	0	0	0	0	0	0	0	227	319	352	980
2000	359	264	261	0	0	0	0	0	22	271	371	368	1,917
2001	280	159	204	0	0	0	0	0	224	367	394	381	2,009
2002	375	217	0	0	0	0	0	0	227	377	399	384	1,980
2007	315	166	0	0	0	0	0	112	220	301	268	264	1,645
2008	250	241	187	0	0	0	0	0	109	284	305	310	1,685
2009	290	249	144	28	0	0	0	0	8	183	305	296	1,502
2010	0	217	0	0	0	0	0	0	0	0	255	375	847
2011	314	171	0	0	0	0	0	0	0	0	162	323	969
2012	227	27	65	0	0	0	0	0	191	383	404	355	1,652
2013	345	215	0	0	0	0	0	237	335	410	422	397	2,362

Min =	0	0	0	0	0	0	0	0	0	0	0	96	434
Max =	379	350	355	347	334	378	385	419	394	410	422	397	4,519
Avg =	312	207	100	49	22	27	38	84	167	275	337	341	1,958

Notes:

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Management District Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated Consumptive Water Demands Met From Pine Creek Reservoir, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1959	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1960	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1961	0	0	0	0	0	0	500	500	700	1,000	1,000	500	4,200
1962	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1963	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1964	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1965	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1966	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1967	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1968	0	0	0	0	0	0	500	500	700	1,000	1,000	500	4,200
1969	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1970	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1971	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1972	0	0	0	0	0	0	500	500	700	1,000	1,000	500	4,200
1973	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1974	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1975	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1976	0	0	0	0	0	0	500	500	700	1,000	1,000	500	4,200
1977	0	0	0	0	0	0	500	500	700	1,000	1,000	500	4,200
1978	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1979	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1980	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1981	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1982	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1983	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1984	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1985	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1986	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1987	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1988	0	0	0	0	0	0	500	500	700	1,000	1,000	500	4,200
1989	0	0	0	0	0	0	500	500	700	1,000	1,000	500	4,200
1990	0	0	0	0	0	0	500	500	700	1,000	1,000	500	4,200
1991	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1992	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1993	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1994	0	0	0	0	0	0	500	500	700	1,000	1,000	500	4,200
1995	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1996	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1997	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1998	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
1999	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
2000	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
2001	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
2002	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
2007	0	0	0	0	0	0	500	500	700	1,000	1,000	500	4,200
2008	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
2009	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
2010	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
2011	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
2012	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
2013	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600

Min =	0	0	0	0	0	0	500	500	700	1,000	1,000	500	4,200
Max =	0	0	0	0	500	1,000	1,200	1,200	1,200	1,000	1,000	500	7,600
Avg =	0	0	0	0	404	808	1,065	1,065	1,104	1,000	1,000	500	6,946

Notes:

0.5 Minimum bypass, cfs

5.0 Sleepy Hollow Wier Minimum Flow, cfs

- Water Demand Monthly Distribution Assumed
- Shading denotes Critically Dry Year

Estimated End of Month Storage of Pine Creek Reservoir, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1958	16,000	15,719	17,581	20,000	20,000	20,000	20,000	20,000	20,000	19,457	18,064	17,165
1959	16,816	16,623	16,467	20,000	20,000	20,000	19,818	18,892	17,285	15,771	14,281	13,588
1960	13,189	12,844	12,501	14,605	20,000	20,000	19,962	19,501	18,048	16,531	15,041	14,090
1961	13,682	13,470	14,606	15,021	16,016	17,008	16,719	15,905	14,771	13,247	11,757	10,806
1962	10,397	10,038	11,493	12,025	20,000	20,000	20,000	19,827	18,633	17,126	15,636	14,685
1963	16,107	16,036	16,889	20,000	20,000	20,000	20,000	20,000	20,000	19,393	18,315	17,470
1964	17,661	20,000	20,000	20,000	20,000	20,000	20,000	19,567	18,330	16,854	15,363	14,411
1965	14,003	14,997	20,000	20,000	20,000	20,000	20,000	20,000	19,466	18,342	16,856	15,910
1966	15,501	18,651	20,000	20,000	20,000	20,000	19,539	18,275	16,837	15,314	13,824	12,873
1967	12,464	12,667	20,000	20,000	20,000	20,000	20,000	20,000	20,000	19,495	18,069	17,124
1968	16,741	16,428	16,663	17,984	19,890	20,000	20,000	19,447	18,276	16,762	15,272	14,321
1969	13,912	13,583	14,370	20,000	20,000	20,000	20,000	20,000	20,000	19,505	18,043	17,093
1970	16,713	16,537	18,519	20,000	20,000	20,000	20,000	20,000	18,993	17,491	16,002	15,051
1971	14,642	17,527	20,000	20,000	20,000	20,000	20,000	19,513	18,313	16,817	15,327	14,376
1972	13,967	13,610	17,528	18,748	20,000	20,000	19,848	19,002	17,832	16,318	14,829	13,877
1973	13,507	17,242	18,511	20,000	20,000	20,000	20,000	20,000	19,830	18,425	16,946	15,994
1974	15,659	17,498	20,000	20,000	20,000	20,000	20,000	20,000	20,000	19,008	17,549	16,617
1975	16,245	16,184	18,105	18,996	20,000	20,000	20,000	20,000	20,000	19,151	17,776	16,855
1976	16,543	16,513	16,484	16,454	16,514	17,207	16,878	15,937	14,765	13,248	11,759	10,808
1977	10,404	10,042	9,682	9,804	9,488	9,289	8,400	7,406	6,236	4,722	3,233	2,282
1978	1,873	1,510	4,683	20,000	20,000	20,000	20,000	20,000	20,000	20,000	19,067	18,470
1979	18,337	18,916	19,462	20,000	20,000	20,000	20,000	20,000	20,000	19,091	17,717	16,820
1980	16,657	17,305	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	19,149	18,587
1981	18,352	18,289	18,943	20,000	20,000	20,000	20,000	20,000	19,094	17,677	16,228	15,313
1982	15,059	19,614	20,000	20,000	20,000	20,000	20,000	20,000	20,000	19,990	18,782	18,006
1983	18,123	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	19,965
1984	20,000	20,000	20,000	20,000	20,000	20,000	20,000	19,902	19,063	17,713	16,346	15,457
1985	15,272	17,320	19,462	20,000	20,000	20,000	20,000	19,669	18,367	16,994	15,556	14,685
1986	14,323	14,755	16,824	18,835	20,000	20,000	20,000	20,000	19,751	18,701	17,408	16,665
1987	16,445	16,298	16,383	16,761	19,405	20,000	19,742	18,374	16,859	15,400	13,953	13,050
1988	12,699	12,421	13,402	15,824	16,282	16,336	15,854	15,104	14,027	12,583	11,163	10,271
1989	9,937	9,665	9,993	10,713	11,301	13,240	13,386	12,722	11,593	10,108	8,657	7,760
1990	7,438	7,174	6,901	7,407	9,490	10,105	9,443	8,550	7,449	5,986	4,560	3,679
1991	3,359	3,051	2,698	2,348	1,512	11,881	13,376	12,789	11,385	9,978	8,582	7,729
1992	7,341	6,989	7,056	8,393	20,000	20,000	20,000	19,318	17,832	16,336	14,857	13,908
1993	13,501	13,144	14,908	20,000	20,000	20,000	20,000	20,000	19,871	18,772	17,352	16,428
1994	16,044	15,784	16,120	16,457	19,780	20,000	19,940	19,682	18,615	17,105	15,616	14,667
1995	14,272	13,929	13,942	20,000	20,000	20,000	20,000	20,000	20,000	20,000	18,920	18,135
1996	17,823	17,581	18,994	20,000	20,000	20,000	20,000	20,000	19,684	18,589	17,148	16,208
1997	15,833	16,797	20,000	20,000	20,000	20,000	20,000	19,387	18,166	16,796	15,319	14,376
1998	13,985	14,320	18,483	20,000	20,000	20,000	20,000	20,000	20,000	20,000	19,715	19,357
1999	19,711	20,000	20,000	20,000	20,000	20,000	20,000	20,000	19,471	18,202	16,793	15,875
2000	15,486	15,258	15,045	20,000	20,000	20,000	20,000	20,000	19,329	18,108	16,646	15,712
2001	15,651	15,769	15,698	19,308	20,000	20,000	20,000	20,000	19,110	17,655	16,171	15,224
2002	14,819	15,216	20,000	20,000	20,000	20,000	20,000	19,649	18,407	16,917	15,428	14,478
2007	13,000	12,924	13,502	13,886	15,672	17,102	16,979	16,403	15,406	13,991	12,633	11,803
2008	11,524	11,270	11,114	20,000	20,000	20,000	20,000	19,336	18,091	16,696	15,301	14,426
2009	14,106	13,933	14,273	14,739	20,000	20,000	20,000	20,000	19,457	18,389	17,044	16,196
2010	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	19,872	18,994	18,314
2011	18,167	18,479	20,000	20,000	20,000	20,000	20,000	20,000	20,000	19,987	19,239	18,576
2012	18,675	19,089	19,345	20,000	20,000	20,000	20,000	19,684	18,527	17,070	15,576	14,655
2013	14,280	14,182	20,000	20,000	20,000	19,912	19,241	17,932	16,342	14,818	13,306	12,343

Min =	1,873	1,510	2,698	2,348	1,512	9,289	8,400	7,406	6,236	4,722	3,233	2,282
Max =	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	19,965
Avg =	14,543	14,946	16,281	17,852	18,757	19,078	19,022	18,688	17,952	16,856	15,522	14,664

Notes:

0.5	Minimum bypass, cfs
5.0	Sleepy Hollow Wier Minimum Flow, cfs
600	Annual Evaporation, AF
20,000	Storage, AF

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Management District Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated Pine Creek Reservoir Outflow (Release and Spill), AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	500	317	45	1,897	15,190	16,796	16,252	4,622	1,888	1,148	1,328	833	60,815
1959	319	241	275	335	9,106	2,463	1,204	1,476	1,564	1,401	1,400	880	20,663
1960	375	348	355	160	716	1,737	1,200	1,296	1,573	1,403	1,400	885	11,449
1961	379	348	156	202	146	334	796	894	1,092	1,410	1,400	885	8,042
1962	379	348	354	343	6,393	9,243	2,856	1,200	1,492	1,396	1,401	885	26,291
1963	257	256	120	4,162	13,715	6,669	12,841	6,059	2,167	1,166	1,373	819	49,604
1964	292	715	855	4,468	2,341	1,629	1,750	1,259	1,512	1,401	1,401	885	18,510
1965	379	348	251	10,396	2,292	1,906	6,444	2,433	1,270	1,373	1,396	880	29,367
1966	379	59	1,780	3,950	3,716	1,904	1,369	1,580	1,590	1,409	1,400	885	20,021
1967	379	348	3,051	10,035	7,263	13,210	16,252	7,933	2,150	1,350	1,372	878	64,221
1968	375	348	322	225	45	1,893	837	875	1,094	1,400	1,400	885	9,699
1969	379	348	354	11,208	15,190	16,796	8,736	3,107	1,811	1,085	1,372	884	61,270
1970	373	316	45	10,055	3,731	10,152	2,387	1,326	1,425	1,389	1,399	885	33,482
1971	379	142	4,386	4,117	1,456	1,871	1,534	1,200	1,394	1,383	1,400	885	20,147
1972	379	348	45	45	786	810	667	913	1,091	1,400	1,400	885	8,768
1973	375	45	45	9,456	15,190	16,327	6,343	2,529	1,354	1,339	1,389	886	55,277
1974	340	45	2,004	9,583	2,571	16,353	11,026	2,985	1,414	1,276	1,369	866	49,831
1975	346	288	45	45	13,424	16,796	7,684	3,114	1,326	1,226	1,361	855	46,511
1976	339	290	291	300	279	270	836	905	1,094	1,402	1,400	885	8,292
1977	373	350	354	347	334	378	885	919	1,093	1,400	1,400	885	8,719
1978	379	350	45	1,521	15,190	16,796	10,112	5,468	1,735	1,176	1,253	798	54,822
1979	247	63	45	2,538	7,495	7,985	6,216	2,260	1,319	1,234	1,338	863	31,602
1980	339	51	730	16,838	15,190	14,533	6,962	3,874	1,847	1,340	1,276	754	63,735
1981	229	281	45	5,604	3,112	8,604	3,807	1,582	1,445	1,340	1,359	849	28,257
1982	249	45	2,565	14,496	7,774	10,658	16,252	5,098	2,353	1,087	1,320	801	62,698
1983	293	1,574	14,152	16,838	15,190	16,796	16,252	14,328	5,030	2,198	1,222	596	104,470
1984	753	5,562	16,586	7,420	3,425	2,849	2,138	1,200	1,327	1,238	1,277	823	44,597
1985	283	45	45	617	2,295	4,034	2,288	1,221	1,405	1,259	1,348	805	15,644
1986	332	262	45	45	14,025	16,796	5,813	2,458	1,261	1,183	1,203	677	44,101
1987	189	155	127	112	500	2,115	1,200	1,490	1,472	1,344	1,357	838	10,899
1988	320	266	215	45	45	166	794	806	999	1,330	1,330	826	7,142
1989	304	261	174	170	53	45	575	685	1,052	1,370	1,362	831	6,880
1990	292	252	267	199	45	45	758	816	1,022	1,349	1,336	815	7,196
1991	290	296	347	344	812	1,000	1,200	1,200	1,355	1,293	1,305	787	10,229
1992	358	342	211	45	1,120	6,462	1,911	1,200	1,454	1,382	1,389	883	16,756
1993	377	345	45	11,746	15,190	10,222	4,204	1,770	1,200	1,209	1,331	858	48,496
1994	354	281	150	133	45	983	500	530	995	1,395	1,399	883	7,648
1995	365	331	262	10,779	5,703	16,796	6,353	4,988	2,734	1,180	1,191	787	51,469
1996	298	256	45	1,835	15,190	12,111	5,243	2,532	1,200	1,214	1,360	873	42,157
1997	356	45	6,150	16,838	9,113	3,371	1,613	1,228	1,457	1,361	1,388	876	43,797
1998	361	45	45	13,991	15,190	13,429	11,231	7,547	3,842	1,559	1,000	683	68,921
1999	82	896	2,026	3,092	7,738	5,595	7,705	2,078	1,200	1,227	1,319	852	33,809
2000	359	264	261	2,661	15,190	11,466	4,489	1,740	1,222	1,271	1,371	868	41,162
2001	280	159	204	45	5,836	11,511	2,770	1,655	1,424	1,367	1,394	881	27,525
2002	375	217	1,954	5,331	2,011	2,779	1,805	1,200	1,427	1,377	1,399	884	20,759
2007	500	166	45	45	45	45	500	612	920	1,301	1,268	764	6,209
2008	250	241	187	2,175	8,426	3,796	1,295	1,200	1,309	1,284	1,305	810	22,278
2009	290	249	144	45	3,412	12,265	2,421	1,318	1,208	1,183	1,305	796	24,635
2010	727	878	2,695	12,405	9,852	9,862	8,635	4,620	2,065	1,000	1,255	875	54,869
2011	314	171	3,804	7,694	8,754	16,796	8,318	3,238	3,101	1,000	1,162	823	55,173
2012	227	45	65	921	711	2,242	3,318	1,200	1,391	1,383	1,404	855	13,761
2013	345	215	3,164	4,003	1,367	1,000	1,200	1,437	1,535	1,410	1,422	897	17,996

Min =	82	45	45	45	45	45	500	530	920	1,000	1,000	596	6,209
Max =	753	5,562	16,586	16,838	15,190	16,796	16,252	14,328	5,030	2,198	1,422	897	104,470
Avg =	346	393	1,384	4,652	6,229	7,321	4,803	2,485	1,590	1,319	1,341	841	32,705

Notes:

0.5 Minimum bypass, cfs

5.0 Sleepy Hollow Wier Minimum Flow, cfs

Boronda Creek Dam and Reservoir (Alternative 2)

Estimated Diversion at <u>Carmel River Camp Diversion</u> into Boronda Creek Tunnel, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	0	0	1,238	2,326	2,101	2,326	2,251	2,326	1,275	441	0	0	14,283
1959	0	3	45	2,326	2,101	1,638	677	381	0	0	0	132	7,302
1960	0	0	0	1,477	2,101	1,153	770	572	95	0	0	0	6,168
1961	0	62	828	378	743	878	333	67	0	0	0	0	3,290
1962	0	0	1,173	550	2,101	2,326	1,902	699	214	0	0	0	8,965
1963	1,103	94	616	2,326	2,101	2,326	2,251	2,326	1,461	411	219	0	15,232
1964	304	2,010	536	2,326	1,545	1,082	1,163	565	199	0	0	0	9,729
1965	0	867	2,326	2,326	1,512	1,266	2,251	1,638	506	203	0	0	12,895
1966	0	2,114	2,055	2,326	2,101	1,265	601	225	117	0	0	0	10,802
1967	0	339	2,326	2,326	2,101	2,326	2,251	2,326	1,451	602	0	0	16,045
1968	0	0	337	998	1,284	1,331	554	229	0	0	0	0	4,733
1969	0	0	728	2,326	2,101	2,326	2,251	2,088	1,224	432	0	0	13,475
1970	0	64	1,318	2,326	2,101	2,326	1,588	899	294	0	0	0	10,916
1971	0	1,992	2,326	2,326	954	1,243	1,019	490	145	0	0	0	10,494
1972	0	0	2,326	810	1,342	534	338	58	0	0	0	0	5,408
1973	0	2,251	843	2,326	2,101	2,326	2,251	1,702	805	0	0	0	14,604
1974	0	1,228	2,326	2,326	1,698	2,326	2,251	2,006	959	227	0	0	15,346
1975	0	123	1,278	590	2,101	2,326	2,251	2,093	900	290	12	0	11,963
1976	0	144	141	146	208	636	333	0	0	0	0	0	1,608
1977	0	0	0	279	0	113	0	0	0	0	0	0	392
1978	0	0	2,114	2,326	2,101	2,326	2,251	2,326	1,173	823	235	141	15,815
1979	58	399	360	2,019	2,101	2,326	2,251	1,523	896	255	0	0	12,186
1980	99	438	2,253	2,326	2,101	2,326	2,251	2,326	1,248	933	306	135	16,740
1981	0	116	431	2,326	2,059	2,326	2,251	1,070	375	0	0	0	10,954
1982	0	2,251	1,936	2,326	2,101	2,326	2,251	2,326	1,586	757	96	24	17,978
1983	256	2,251	2,326	2,326	2,101	2,326	2,251	2,326	2,251	1,505	838	381	21,136
1984	508	2,251	2,326	2,326	2,101	1,896	1,423	749	341	0	0	0	13,919
1985	46	1,368	1,425	737	1,514	2,326	1,522	608	84	0	0	0	9,631
1986	0	434	1,377	1,338	2,101	2,326	2,251	1,655	691	126	0	0	12,298
1987	0	0	107	292	2,081	1,803	624	95	0	0	0	0	5,002
1988	0	0	764	1,613	317	141	203	51	0	0	0	0	3,088
1989	0	0	300	560	409	1,318	476	28	0	0	0	0	3,092
1990	0	0	0	436	1,402	434	59	0	0	0	0	0	2,332
1991	0	0	0	0	0	2,326	1,794	423	0	0	0	0	4,544
1992	0	0	151	888	2,101	2,326	1,271	359	0	0	0	0	7,095
1993	0	0	1,174	2,326	2,101	2,326	2,251	1,195	730	111	0	0	12,213
1994	0	0	289	279	2,101	797	288	195	0	0	0	0	3,950
1995	0	0	149	2,326	2,101	2,326	2,251	2,326	1,841	826	95	8	14,247
1996	0	0	939	1,863	2,101	2,326	2,251	1,704	605	117	0	0	11,905
1997	0	644	2,326	2,326	2,101	2,245	1,072	424	172	32	0	0	11,341
1998	0	224	2,326	2,326	2,101	2,326	2,251	2,326	2,251	1,078	499	223	17,930
1999	273	762	1,318	2,030	2,101	2,326	2,251	1,401	463	10	0	0	12,934
2000	0	0	0	2,326	2,101	2,326	2,251	1,175	383	71	0	0	10,632
2001	127	156	55	2,326	2,101	2,326	1,844	1,118	371	0	0	0	10,424
2002	0	381	2,326	2,326	1,324	1,849	1,200	580	139	0	0	0	10,125
2007	8	31	381	252	1,204	978	247	38	0	0	0	0	3,138
2008	0	0	0	2,326	2,101	2,326	860	372	57	0	0	0	8,041
2009	0	21	289	306	2,101	2,326	1,612	894	459	114	0	0	8,121
2010	2,326	557	1,765	2,326	2,101	2,326	2,251	2,326	1,394	620	274	137	18,400
2011	93	293	2,326	2,326	2,101	2,326	2,251	2,175	2,086	697	298	114	17,084
2012	199	277	180	1,018	456	1,490	2,210	604	171	0	0	0	6,605
2013	0	49	2,326	2,326	894	603	348	99	0	0	0	0	6,644

Min =	0	0	0	0	0	113	0	0	0	0	0	0	392
Max =	2,326	2,251	2,326	2,326	2,101	2,326	2,251	2,326	2,251	1,505	838	381	21,136
Avg =	104	465	1,092	1,660	1,695	1,817	1,502	1,067	566	205	55	25	10,254

<u>**Notes:**</u>

5.0	Minimum bypass, cfs
50.0	Diversion capacity, cfs
0.85	diversion coefficient
44.8	Los Padres Reservoir drainage area, mi^2
32.9	Carmel River Camp Diversion drainage area, mi^2

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated Inflow to Boronda Creek Reservoir from Boronda Creek, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	0	0	145	346	1,347	1,491	1,443	378	150	45	0	0	5,345
1959	0	0	0	309	822	195	75	38	0	0	0	7	1,445
1960	0	0	0	175	499	134	87	61	2	0	0	0	958
1961	0	0	94	37	84	100	32	0	0	0	0	0	346
1962	0	0	137	59	1,347	807	228	77	17	0	0	0	2,672
1963	128	2	67	593	1,347	546	1,269	498	173	41	17	0	4,682
1964	28	242	57	359	184	125	136	61	15	0	0	0	1,206
1965	0	99	425	946	180	148	528	195	54	15	0	0	2,590
1966	0	255	247	316	299	148	65	18	5	0	0	0	1,353
1967	0	33	945	901	600	1,304	1,443	658	172	65	0	0	6,121
1968	0	0	32	115	151	156	59	19	0	0	0	0	533
1969	0	0	81	1,491	1,347	1,491	755	251	143	44	0	0	5,604
1970	0	0	155	1,089	300	921	189	102	27	0	0	0	2,784
1971	0	239	559	330	110	145	118	51	8	0	0	0	1,561
1972	0	0	317	91	159	57	33	0	0	0	0	0	656
1973	0	302	95	1,015	1,347	1,491	520	203	91	0	0	0	5,064
1974	0	144	362	845	203	1,491	1,042	241	110	18	0	0	4,457
1975	0	6	150	64	1,347	1,491	635	252	103	26	0	0	4,073
1976	0	8	8	8	17	69	32	0	0	0	0	0	142
1977	0	0	0	25	0	4	0	0	0	0	0	0	29
1978	0	0	254	1,491	1,347	1,491	928	449	137	93	19	8	6,217
1979	0	40	35	243	623	660	509	180	102	22	0	0	2,414
1980	2	45	272	1,491	1,347	1,469	571	315	146	107	28	7	5,801
1981	0	5	44	542	249	727	308	124	37	0	0	0	2,035
1982	0	371	232	1,460	655	984	1,443	418	189	85	2	0	5,838
1983	22	275	1,417	1,491	1,347	1,491	1,443	1,448	412	178	95	38	9,656
1984	53	451	1,491	606	275	227	168	84	33	0	0	0	3,388
1985	0	161	168	82	180	326	181	66	1	0	0	0	1,166
1986	0	45	162	157	1,347	1,491	475	197	77	6	0	0	3,957
1987	0	0	3	26	251	216	68	2	0	0	0	0	566
1988	0	0	85	192	30	7	16	0	0	0	0	0	331
1989	0	0	27	60	42	155	50	0	0	0	0	0	334
1990	0	0	0	44	166	44	0	0	0	0	0	0	255
1991	0	0	0	0	0	1,073	215	43	0	0	0	0	1,331
1992	0	0	9	101	1,275	529	149	35	0	0	0	0	2,098
1993	0	0	137	1,491	1,347	930	341	139	82	4	0	0	4,470
1994	0	0	26	25	270	90	26	14	0	0	0	0	451
1995	0	0	9	1,491	465	1,491	520	408	221	93	2	0	4,700
1996	0	0	107	223	1,347	1,166	428	203	66	4	0	0	3,545
1997	0	71	816	1,491	823	271	124	43	12	0	0	0	3,650
1998	0	18	337	1,491	1,347	1,331	1,068	622	313	125	52	18	6,723
1999	24	86	155	244	650	457	637	165	48	0	0	0	2,466
2000	0	0	0	622	1,347	1,086	365	137	38	0	0	0	3,594
2001	6	10	0	291	534	1,091	221	130	37	0	0	0	2,319
2002	0	38	549	431	157	221	140	63	8	0	0	0	1,606
2007	0	0	38	21	141	112	21	0	0	0	0	0	334
2008	0	0	0	1,030	737	306	98	36	0	0	0	0	2,207
2009	0	0	26	28	768	1,186	192	102	48	4	0	0	2,353
2010	366	60	211	1,198	915	885	743	378	165	67	24	7	5,019
2011	2	27	431	629	778	1,491	703	262	251	77	27	4	4,681
2012	15	25	12	117	48	176	267	65	12	0	0	0	737
2013	0	0	769	320	103	65	34	2	0	0	0	0	1,294

Min =	0	0	0	0	0	4	0	0	0	0	0	0	29
Max =	366	451	1,491	1,491	1,347	1,491	1,443	1,448	412	178	95	38	9,656
Avg =	12	59	225	543	627	684	407	178	67	22	5	2	2,830

Notes:

0.5 Minimum bypass, cfs

44.8 Los Padres Reservoir drainage area, mi^2

3.5 Boronda Creek drainage area, mi^2

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Management District Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated Total Inflow to Boronda Creek Reservoir, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	0	0	1,383	2,672	3,447	3,817	3,694	2,704	1,425	486	0	0	19,628
1959	0	3	45	2,635	2,922	1,833	752	418	0	0	0	139	8,746
1960	0	0	0	1,652	2,600	1,287	857	633	97	0	0	0	7,126
1961	0	62	922	415	827	978	365	67	0	0	0	0	3,636
1962	0	0	1,310	608	3,447	3,133	2,130	777	231	0	0	0	11,637
1963	1,230	96	683	2,919	3,447	2,872	3,520	2,824	1,635	452	236	0	19,914
1964	331	2,252	593	2,685	1,729	1,207	1,299	626	214	0	0	0	10,936
1965	0	966	2,750	3,272	1,692	1,415	2,779	1,833	560	219	0	0	15,485
1966	0	2,369	2,302	2,641	2,400	1,413	666	243	121	0	0	0	12,155
1967	0	371	3,271	3,227	2,700	3,630	3,694	2,984	1,622	667	0	0	22,166
1968	0	0	369	1,113	1,435	1,487	613	247	0	0	0	0	5,265
1969	0	0	809	3,817	3,447	3,817	3,006	2,340	1,367	476	0	0	19,079
1970	0	64	1,473	3,415	2,401	3,247	1,777	1,002	321	0	0	0	13,700
1971	0	2,231	2,885	2,655	1,064	1,389	1,137	541	153	0	0	0	12,054
1972	0	0	2,642	901	1,501	591	371	58	0	0	0	0	6,064
1973	0	2,553	939	3,341	3,447	3,817	2,770	1,905	896	0	0	0	19,669
1974	0	1,372	2,688	3,170	1,901	3,817	3,293	2,247	1,069	245	0	0	19,803
1975	0	128	1,428	654	3,447	3,817	2,886	2,345	1,003	316	12	0	16,036
1976	0	152	149	154	225	706	365	0	0	0	0	0	1,750
1977	0	0	0	304	0	117	0	0	0	0	0	0	421
1978	0	0	2,368	3,817	3,447	3,817	3,178	2,774	1,310	916	255	149	22,032
1979	58	439	395	2,262	2,724	2,986	2,760	1,703	998	277	0	0	14,601
1980	101	483	2,524	3,817	3,447	3,795	2,822	2,641	1,395	1,039	334	142	22,541
1981	0	121	475	2,868	2,307	3,053	2,558	1,194	412	0	0	0	12,989
1982	0	2,622	2,168	3,785	2,756	3,310	3,694	2,743	1,775	841	98	24	23,816
1983	278	2,526	3,742	3,817	3,447	3,817	3,694	3,773	2,663	1,683	933	419	30,793
1984	561	2,702	3,817	2,931	2,375	2,123	1,591	833	374	0	0	0	17,307
1985	46	1,530	1,594	819	1,694	2,652	1,703	674	85	0	0	0	10,796
1986	0	479	1,539	1,496	3,447	3,817	2,726	1,852	767	132	0	0	16,255
1987	0	0	110	319	2,332	2,019	692	96	0	0	0	0	5,568
1988	0	0	849	1,805	347	148	219	51	0	0	0	0	3,419
1989	0	0	328	620	451	1,473	526	28	0	0	0	0	3,426
1990	0	0	0	481	1,568	478	59	0	0	0	0	0	2,587
1991	0	0	0	0	0	3,399	2,009	466	0	0	0	0	5,875
1992	0	0	160	988	3,376	2,855	1,420	394	0	0	0	0	9,193
1993	0	0	1,310	3,817	3,447	3,256	2,592	1,335	812	115	0	0	16,683
1994	0	0	315	304	2,371	887	315	209	0	0	0	0	4,401
1995	0	0	157	3,817	2,566	3,817	2,771	2,734	2,061	919	97	8	18,947
1996	0	0	1,046	2,086	3,447	3,492	2,678	1,907	671	121	0	0	15,450
1997	0	714	3,142	3,817	2,923	2,515	1,196	467	184	32	0	0	14,992
1998	0	242	2,663	3,817	3,447	3,657	3,318	2,948	2,564	1,203	551	241	24,653
1999	297	847	1,473	2,274	2,751	2,782	2,888	1,566	511	10	0	0	15,400
2000	0	0	0	2,948	3,447	3,411	2,615	1,312	421	71	0	0	14,226
2001	133	165	55	2,617	2,635	3,417	2,065	1,248	408	0	0	0	12,743
2002	0	419	2,874	2,757	1,481	2,070	1,340	643	146	0	0	0	11,731
2007	8	31	419	273	1,345	1,091	268	38	0	0	0	0	3,471
2008	0	0	0	3,356	2,837	2,632	957	408	57	0	0	0	10,248
2009	0	21	315	334	2,868	3,511	1,803	995	506	119	0	0	10,474
2010	2,692	617	1,976	3,524	3,016	3,211	2,994	2,703	1,558	687	298	144	23,419
2011	95	320	2,756	2,954	2,878	3,817	2,954	2,438	2,337	774	325	118	21,765
2012	214	302	192	1,135	504	1,667	2,477	669	183	0	0	0	7,342
2013	0	49	3,095	2,646	997	668	382	101	0	0	0	0	7,938

Min =	0	0	0	0	0	117	0	0	0	0	0	0	421
Max =	2,692	2,702	3,817	3,817	3,447	3,817	3,694	3,773	2,663	1,683	933	419	30,793
Avg =	116	524	1,317	2,203	2,322	2,501	1,908	1,245	633	227	60	27	13,084

Notes:

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Management District Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated Flow from Boronda Creek Reservor to <u>Meet 5 CFS Requirment at Sleepy Hollow</u>, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	359	317	12	0	0	0	0	0	0	148	328	333	1,496
1959	319	241	275	0	0	0	4	276	364	401	400	380	2,659
1960	375	348	355	160	0	0	0	96	373	403	400	385	2,896
1961	379	348	156	202	146	334	296	394	392	410	400	385	3,842
1962	379	348	354	343	0	0	0	0	292	396	401	385	2,898
1963	257	256	120	0	0	0	0	0	0	166	373	319	1,491
1964	292	0	0	0	0	0	0	59	312	401	401	385	1,850
1965	379	348	0	0	0	0	0	0	70	373	396	380	1,946
1966	379	59	0	0	0	0	169	380	390	409	400	385	2,572
1967	379	348	0	0	0	0	0	0	0	350	372	378	1,827
1968	375	348	322	225	0	0	9	375	394	400	400	385	3,234
1969	379	348	354	0	0	0	0	0	0	85	372	384	1,923
1970	373	316	0	0	0	0	0	0	225	389	399	385	2,086
1971	379	142	0	0	0	0	0	0	194	383	400	385	1,882
1972	379	348	0	0	0	244	167	413	391	400	400	385	3,126
1973	375	0	0	0	0	0	0	0	154	339	389	386	1,643
1974	340	0	0	0	0	0	0	0	41	276	369	366	1,392
1975	346	288	0	0	0	0	0	0	0	226	361	355	1,577
1976	339	290	291	300	279	270	336	405	394	402	400	385	4,092
1977	373	350	354	347	334	378	385	419	393	400	400	385	4,519
1978	379	350	0	0	0	0	0	0	0	123	253	298	1,404
1979	247	63	0	0	0	0	0	0	105	234	338	363	1,349
1980	339	51	0	0	0	0	0	0	0	32	276	254	952
1981	229	281	0	0	0	0	0	0	245	340	359	349	1,804
1982	249	0	0	0	0	0	0	0	0	87	320	301	957
1983	293	0	0	0	0	0	0	0	0	0	45	96	434
1984	0	0	0	0	0	0	0	0	127	238	277	323	966
1985	283	0	0	0	0	0	0	21	205	259	348	305	1,421
1986	332	262	0	0	0	0	0	0	61	183	203	177	1,219
1987	189	155	127	112	0	0	0	290	272	344	357	338	2,184
1988	320	266	215	0	0	166	294	306	299	330	330	326	2,853
1989	304	261	174	170	53	0	75	185	352	370	362	331	2,636
1990	292	252	267	199	0	0	258	316	322	349	336	315	2,907
1991	290	296	347	344	312	0	0	0	155	293	305	287	2,629
1992	358	342	211	0	0	0	0	0	254	382	389	383	2,319
1993	377	345	0	0	0	0	0	0	0	209	331	358	1,620
1994	354	281	150	133	0	0	0	30	295	395	399	383	2,420
1995	365	331	262	0	0	0	0	0	0	0	191	287	1,436
1996	298	256	0	0	0	0	0	0	0	214	360	373	1,501
1997	356	0	0	0	0	0	0	28	257	361	388	376	1,767
1998	361	12	0	0	0	0	0	0	0	0	0	183	555
1999	82	0	0	0	0	0	0	0	0	227	319	352	980
2000	359	264	261	0	0	0	0	0	22	271	371	368	1,917
2001	280	159	204	0	0	0	0	0	224	367	394	381	2,009
2002	375	217	0	0	0	0	0	0	227	377	399	384	1,980
2007	315	166	0	0	0	0	0	112	220	301	268	264	1,645
2008	250	241	187	0	0	0	0	0	109	284	305	310	1,685
2009	290	249	144	28	0	0	0	0	8	183	305	296	1,502
2010	0	217	0	0	0	0	0	0	0	0	255	375	847
2011	314	171	0	0	0	0	0	0	0	0	162	323	969
2012	227	27	65	0	0	0	0	0	191	383	404	355	1,652
2013	345	215	0	0	0	0	0	237	335	410	422	397	2,362

Min =	0	0	0	0	0	0	0	0	0	0	0	96	434
Max =	379	350	355	347	334	378	385	419	394	410	422	397	4,519
Avg =	312	207	100	49	22	27	38	84	167	275	337	341	1,958

<u>**Notes:**</u>

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Management District Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated Consumptive Water Demands Met From Boronda Creek Reservoir, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0

Min =	0	0	0	0	0	0	0	0	0	0	0	0	0
Max =	0	0	0	0	0	0	0	0	0	0	0	0	0
Avg =	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes:

0.5 Minimum bypass, cfs

5.0 Sleepy Hollow Wier Minimum Flow, cfs

- Water Demand Monthly Distribution Assumed

- Shading denotes Critically Dry Year

Estimated End of Month Storage of Boronda Creek Reservoir, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1958	4,000	3,678	5,014	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,635	5,274
1959	4,943	4,700	4,468	6,000	6,000	6,000	6,000	6,000	5,603	5,155	4,717	4,449
1960	4,061	3,708	3,350	4,839	6,000	6,000	6,000	6,000	5,692	5,241	4,804	4,391
1961	4,000	3,709	4,472	4,682	5,353	5,978	6,000	5,641	5,216	4,759	4,321	3,909
1962	3,517	3,164	4,117	4,380	6,000	6,000	6,000	6,000	5,906	5,463	5,025	4,612
1963	5,573	5,408	5,968	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,826	5,479
1964	5,506	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,869	5,420	4,982	4,569
1965	4,178	4,791	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,799	5,365	4,958
1966	4,567	6,000	6,000	6,000	6,000	6,000	6,000	5,830	5,528	5,072	4,635	4,222
1967	3,831	3,849	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,591	5,185
1968	4,797	4,444	4,489	5,374	6,000	6,000	6,000	5,840	5,413	4,966	4,528	4,116
1969	3,725	3,371	3,823	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,590	5,178
1970	4,793	4,536	5,963	6,000	6,000	6,000	6,000	6,000	6,000	5,564	5,128	4,715
1971	4,324	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,927	5,496	5,059	4,646
1972	4,255	3,902	6,000	6,000	6,000	6,000	6,000	5,613	5,189	4,741	4,304	3,892
1973	3,504	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,614	5,187	4,773
1974	4,420	5,743	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,922	5,516	5,122
1975	4,763	4,598	5,979	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,614	5,231
1976	4,879	4,737	4,591	4,443	4,378	4,794	4,803	4,365	3,939	3,489	3,052	2,639
1977	2,253	1,898	1,541	1,495	1,151	870	465	13	0	0	0	0
1978	0	0	2,321	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,964	5,787
1979	5,585	5,957	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,995	5,620	5,230
1980	4,979	5,406	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,860
1981	5,618	5,453	5,882	6,000	6,000	6,000	6,000	6,000	6,000	5,612	5,215	4,839
1982	4,577	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,740	5,435
1983	5,407	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
1984	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,714	5,400	5,049
1985	4,800	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,847	5,540	5,155	4,822
1986	4,478	4,689	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,901	5,661	5,456
1987	5,254	5,094	5,075	5,280	6,000	6,000	6,000	5,774	5,469	5,077	4,683	4,318
1988	3,985	3,713	4,345	6,000	6,000	5,962	5,867	5,579	5,248	4,870	4,502	4,149
1989	3,833	3,567	3,719	4,166	4,554	5,963	6,000	5,810	5,426	5,008	4,609	4,251
1990	3,946	3,689	3,420	3,699	5,213	5,626	5,407	5,059	4,704	4,307	3,934	3,591
1991	3,289	2,988	2,638	2,291	1,970	5,304	6,000	6,000	5,813	5,472	5,129	4,815
1992	4,444	4,097	4,044	4,986	6,000	6,000	6,000	6,000	5,714	5,284	4,858	4,447
1993	4,057	3,707	4,970	6,000	6,000	6,000	6,000	6,000	6,000	5,858	5,490	5,104
1994	4,738	4,451	4,615	4,784	6,000	6,000	6,000	6,000	5,672	5,229	4,793	4,382
1995	4,004	3,668	3,561	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,869	5,562
1996	5,252	4,991	5,990	6,000	6,000	6,000	6,000	6,000	6,000	5,860	5,463	5,062
1997	4,693	5,358	6,000	6,000	6,000	6,000	6,000	6,000	5,895	5,518	5,093	4,689
1998	4,315	4,508	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
1999	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,736	5,379	5,000
2000	4,628	4,359	4,095	6,000	6,000	6,000	6,000	6,000	6,000	5,752	5,343	4,948
2001	4,789	4,790	4,638	6,000	6,000	6,000	6,000	6,000	6,000	5,585	5,154	4,745
2002	4,357	4,554	6,000	6,000	6,000	6,000	6,000	6,000	5,887	5,462	5,026	4,614
2007	1,152	1,012	1,384	1,609	2,900	3,926	4,129	4,022	3,770	3,422	3,117	2,825
2008	2,563	2,317	2,127	5,436	6,000	6,000	6,000	6,000	5,916	5,584	5,242	4,905
2009	4,603	4,370	4,539	4,826	6,000	6,000	6,000	6,000	6,000	5,888	5,546	5,223
2010	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,742
2011	5,510	5,654	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	5,768
2012	5,742	5,994	6,000	6,000	6,000	6,000	6,000	6,000	5,959	5,528	5,087	4,704
2013	4,346	4,175	6,000	6,000	6,000	6,000	6,000	5,832	5,464	5,006	4,546	4,122

Min =	0	0	1,384	1,495	1,151	870	465	13	0	0	0	0
Max =	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Avg =	4,401	4,515	4,983	5,467	5,683	5,816	5,821	5,757	5,636	5,383	5,048	4,708

Notes:

0.5	Minimum bypass, cfs
5.0	Sleepy Hollow Wier Minimum Flow, cfs
250	Annual Evaporation, AF
6,000	Storage, AF

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Management District Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated Boronda Creek Reservoir Outflow (Release and Spill), AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	300	317	45	1,683	3,437	3,797	3,674	2,671	1,393	439	328	333	18,416
1959	319	241	275	1,100	2,912	1,813	732	386	364	401	400	380	9,322
1960	375	348	355	160	1,429	1,267	837	601	373	403	400	385	6,933
1961	379	348	156	202	146	334	323	394	392	410	400	385	3,869
1962	379	348	354	343	1,818	3,113	2,110	744	292	396	401	385	10,683
1963	257	256	120	2,884	3,437	2,852	3,500	2,791	1,602	404	373	319	18,797
1964	292	1,753	591	2,682	1,719	1,187	1,279	593	312	401	401	385	11,595
1965	379	348	1,539	3,270	1,682	1,395	2,759	1,800	527	373	396	380	14,847
1966	379	930	2,299	2,639	2,390	1,393	646	380	390	409	400	385	12,641
1967	379	348	1,117	3,225	2,690	3,610	3,674	2,952	1,590	619	372	378	20,953
1968	375	348	322	225	800	1,467	593	375	394	400	400	385	6,084
1969	379	348	354	1,638	3,437	3,797	2,986	2,307	1,335	428	372	384	17,766
1970	373	316	45	3,375	2,391	3,227	1,757	969	289	389	399	385	13,914
1971	379	550	2,882	2,653	1,054	1,369	1,117	508	194	383	400	385	11,873
1972	379	348	542	899	1,491	571	351	413	391	400	400	385	6,569
1973	375	52	936	3,338	3,437	3,797	2,750	1,872	864	339	389	386	18,537
1974	340	45	2,428	3,168	1,891	3,797	3,273	2,215	1,036	276	369	366	19,204
1975	346	288	45	630	3,437	3,797	2,866	2,312	970	268	361	355	15,677
1976	339	290	291	300	279	270	336	405	394	402	400	385	4,092
1977	373	350	354	347	334	378	385	419	-19	-48	-38	-28	2,810
1978	-13	-5	45	135	3,437	3,797	3,158	2,742	1,278	868	253	298	15,995
1979	247	63	349	2,259	2,714	2,966	2,740	1,671	965	234	338	363	14,908
1980	339	51	1,928	3,814	3,437	3,775	2,802	2,609	1,362	992	296	254	21,660
1981	229	281	45	2,747	2,297	3,033	2,538	1,162	379	340	359	349	13,761
1982	249	1,194	2,166	3,783	2,746	3,290	3,674	2,711	1,742	794	320	301	22,969
1983	293	1,928	3,740	3,814	3,437	3,797	3,674	3,741	2,631	1,636	895	392	29,978
1984	548	2,697	3,814	2,929	2,365	2,103	1,571	800	341	238	277	323	18,008
1985	283	325	1,591	816	1,684	2,632	1,683	642	205	259	348	305	10,773
1986	332	262	225	1,493	3,437	3,797	2,706	1,820	735	183	203	177	15,372
1987	189	155	127	112	1,602	1,999	672	290	272	344	357	338	6,457
1988	320	266	215	147	337	166	294	306	299	330	330	326	3,337
1989	304	261	174	170	53	45	468	185	352	370	362	331	3,074
1990	292	252	267	199	45	45	258	316	322	349	336	315	2,996
1991	290	296	347	344	312	45	1,294	434	155	293	305	287	4,401
1992	358	342	211	45	2,351	2,835	1,400	362	254	382	389	383	9,311
1993	377	345	45	2,785	3,437	3,236	2,572	1,302	779	209	331	358	15,775
1994	354	281	150	133	1,144	867	295	177	295	395	399	383	4,873
1995	365	331	262	1,375	2,556	3,797	2,751	2,702	2,029	871	191	287	17,517
1996	298	256	45	2,073	3,437	3,472	2,658	1,875	638	214	360	373	15,700
1997	356	45	2,497	3,814	2,913	2,495	1,176	435	257	361	388	376	15,115
1998	361	45	1,168	3,814	3,437	3,637	3,298	2,916	2,531	1,156	514	214	23,092
1999	284	842	1,471	2,272	2,741	2,762	2,868	1,534	478	227	319	352	16,150
2000	359	264	261	1,040	3,437	3,391	2,595	1,280	388	271	371	368	14,028
2001	280	159	204	1,252	2,625	3,397	2,045	1,216	375	367	394	381	12,695
2002	375	217	1,426	2,754	1,471	2,050	1,320	610	227	377	399	384	11,612
2007	500	166	45	45	45	45	45	112	220	301	268	264	2,053
2008	250	241	187	45	2,263	2,612	937	376	109	284	305	310	7,918
2009	290	249	144	45	1,684	3,491	1,783	963	474	183	305	296	9,906
2010	1,902	612	1,973	3,521	3,006	3,191	2,974	2,671	1,526	639	260	375	22,650
2011	314	171	2,408	2,952	2,868	3,797	2,934	2,405	2,304	726	287	323	21,489
2012	227	45	184	1,133	494	1,647	2,457	637	191	383	404	355	8,156
2013	345	215	1,268	2,643	987	648	362	237	335	410	422	397	8,270

Min =	-13	-5	45	45	45	45	45	112	-19	-48	-38	-28	2,053
Max =	1,902	2,697	3,814	3,814	3,437	3,797	3,674	3,741	2,631	1,636	895	397	29,978
Avg =	358	404	847	1,717	2,096	2,348	1,884	1,276	722	432	358	339	12,780

Notes:

0.5 Minimum bypass, cfs

5.0 Sleepy Hollow Wier Minimum Flow, cfs

San Clemente Creek Dam and Reservoir (Alternative 3)

Estimated Diversion at Los Padres Reservoir Diversion into San Clemente Creek Tunnel, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	0	0	1,317	3,010	12,722	14,085	13,631	3,275	1,356	479	0	0	49,874
1959	0	17	62	2,695	6,995	1,737	727	415	0	0	0	153	12,801
1960	0	0	0	1,568	4,285	1,228	825	616	114	0	0	0	8,636
1961	0	80	886	412	795	938	365	85	0	0	0	0	3,561
1962	0	0	1,249	593	12,530	6,885	2,015	750	239	0	0	0	24,260
1963	1,174	113	662	5,086	11,842	4,691	10,762	4,284	1,551	447	245	0	40,858
1964	334	2,129	579	3,116	1,638	1,152	1,238	609	223	0	0	0	11,019
1965	0	927	3,668	8,053	1,603	1,347	4,534	1,737	547	229	0	0	22,644
1966	0	2,238	2,176	2,752	2,603	1,345	646	251	137	0	0	0	12,148
1967	0	371	8,040	7,674	5,129	11,056	13,631	5,632	1,540	648	0	0	53,721
1968	0	0	370	1,065	1,363	1,415	597	256	0	0	0	0	5,064
1969	0	0	780	14,085	12,722	14,085	6,445	2,211	1,301	469	0	0	52,099
1970	0	81	1,401	9,253	2,614	7,841	1,685	961	324	0	0	0	24,160
1971	0	2,109	4,795	2,870	1,016	1,322	1,086	530	166	0	0	0	13,895
1972	0	0	2,761	866	1,425	577	370	76	0	0	0	0	6,076
1973	0	2,638	902	8,630	12,722	14,085	4,464	1,805	861	0	0	0	46,107
1974	0	1,306	3,143	7,198	1,799	14,085	8,853	2,125	1,023	253	0	0	39,786
1975	0	143	1,359	635	12,592	14,085	5,433	2,216	961	320	28	0	37,773
1976	13	166	163	168	232	684	365	0	0	0	0	0	1,791
1977	0	0	0	309	0	134	0	0	0	0	0	0	442
1978	0	0	2,238	14,085	12,722	14,085	7,891	3,869	1,248	880	262	163	57,445
1979	75	434	393	2,138	5,324	5,650	4,374	1,616	956	283	5	0	21,249
1980	119	475	2,384	14,085	12,722	12,448	4,898	2,749	1,327	996	336	156	52,696
1981	0	137	468	4,656	2,179	6,213	2,682	1,140	409	0	0	0	17,884
1982	0	3,214	2,051	12,365	5,594	8,373	13,631	3,609	1,682	811	116	39	51,485
1983	284	2,407	12,004	14,085	12,722	14,085	13,631	12,265	3,563	1,598	896	416	87,954
1984	549	3,889	14,085	5,189	2,399	2,009	1,510	803	373	0	0	0	30,806
1985	64	1,453	1,514	790	1,605	2,841	1,615	654	103	0	0	0	10,639
1986	0	471	1,463	1,422	12,722	14,085	4,091	1,756	741	148	0	0	36,899
1987	0	0	128	322	2,202	1,911	670	114	0	0	0	0	5,347
1988	0	0	818	1,711	346	163	228	68	0	0	0	0	3,335
1989	0	0	331	604	443	1,401	515	44	0	0	0	0	3,339
1990	0	0	0	474	1,488	471	77	0	0	0	0	0	2,510
1991	0	0	0	0	0	9,120	1,902	460	0	0	0	0	11,482
1992	0	0	174	948	10,803	4,546	1,351	393	0	0	0	0	18,215
1993	0	0	1,249	14,085	12,722	7,914	2,961	1,272	782	131	0	0	41,117
1994	0	0	319	309	2,358	853	318	220	0	0	0	0	4,377
1995	0	0	171	14,085	3,999	14,085	4,470	3,532	1,950	883	115	22	43,313
1996	0	0	1,002	1,974	12,722	9,901	3,691	1,807	650	138	0	0	31,886
1997	0	691	6,957	14,085	7,002	2,375	1,142	461	196	49	0	0	32,958
1998	0	250	2,933	13,429	12,722	11,287	9,069	5,329	2,728	1,149	540	249	59,685
1999	302	815	1,401	2,150	5,556	3,937	5,450	1,488	501	26	0	0	21,626
2000	0	0	7	5,327	12,722	9,223	3,161	1,251	417	89	0	0	32,197
2001	149	178	72	2,545	4,578	9,271	1,954	1,191	405	0	0	0	20,342
2002	0	415	4,710	3,722	1,406	1,959	1,276	625	160	0	0	0	14,275
2007	23	47	416	280	1,279	1,044	274	54	0	0	0	0	3,416
2008	0	0	0	8,753	6,280	2,674	918	406	75	0	0	0	19,106
2009	0	37	319	337	6,540	10,063	1,709	955	497	135	0	0	20,591
2010	3,177	600	1,871	10,166	7,779	7,536	6,339	3,273	1,480	666	303	158	43,349
2011	113	323	3,718	5,381	6,625	14,085	6,005	2,303	2,208	747	328	134	41,970
2012	224	306	204	1,085	493	1,582	2,339	650	194	0	0	0	7,077
2013	0	66	6,565	2,790	954	649	380	119	0	0	0	0	11,523

Min =	0	0	0	0	0	134	0	0	0	0	0	0	442
Max =	3,177	3,889	14,085	14,085	12,722	14,085	13,631	12,265	3,563	1,598	896	416	87,954
Avg =	127	549	2,005	4,873	5,685	6,127	3,619	1,583	634	223	61	29	25,516

Notes:

5.0	Minimum bypass, cfs
275.0	Diversion capacity, cfs
0.85	diversion coefficient
44.8	Los Padres Reservoir drainage area, mi^2
34.6	Los Padres Reservoir Diversion drainage area, mi

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated Inflow to San Clemente Creek Reservoir from San Clemente Creek, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	51	96	772	1,491	1,347	1,491	1,443	1,491	789	345	72	41	9,429
1959	27	106	132	1,475	1,347	987	468	312	82	0	0	175	5,111
1960	53	60	66	900	1,347	727	518	415	156	0	0	0	4,241
1961	0	138	552	311	496	579	283	144	83	0	0	0	2,587
1962	0	43	737	403	1,347	1,491	1,125	483	219	49	0	0	5,898
1963	699	155	438	1,491	1,347	1,491	1,443	1,491	888	328	225	88	10,085
1964	271	1,183	396	1,491	926	688	729	411	211	87	0	0	6,393
1965	1	570	1,491	1,491	908	787	1,443	987	376	217	5	20	8,298
1966	2	1,238	1,210	1,491	1,347	786	427	229	167	0	0	0	6,898
1967	1	286	1,491	1,491	1,347	1,491	1,443	1,491	883	431	84	31	10,470
1968	69	95	289	644	786	822	402	231	41	0	0	0	3,378
1969	1	78	498	1,491	1,347	1,491	1,443	1,228	761	340	20	3	8,702
1970	71	139	815	1,491	1,347	1,491	957	590	262	28	0	0	7,192
1971	0	1,173	1,491	1,491	609	775	651	371	182	22	0	0	6,766
1972	0	47	1,491	542	817	395	286	139	0	0	0	0	3,718
1973	83	1,443	560	1,491	1,347	1,491	1,443	1,021	537	97	0	0	9,512
1974	85	763	1,491	1,491	1,008	1,491	1,443	1,184	619	230	36	3	9,844
1975	50	170	794	424	1,347	1,491	1,443	1,231	587	263	115	0	7,916
1976	107	182	184	186	209	449	283	91	0	0	0	0	1,692
1977	0	0	35	258	87	169	92	50	0	0	0	0	690
1978	0	0	1,242	1,491	1,347	1,491	1,443	1,491	734	549	234	180	10,203
1979	139	319	301	1,191	1,347	1,491	1,443	925	585	245	103	79	8,167
1980	161	339	1,316	1,491	1,347	1,491	1,443	1,491	774	608	272	177	10,911
1981	73	167	339	1,491	1,202	1,491	1,443	682	306	86	0	0	7,280
1982	72	1,443	1,146	1,491	1,347	1,491	1,443	1,491	955	514	160	117	11,671
1983	245	1,325	1,491	1,491	1,347	1,491	1,443	1,491	1,443	915	557	309	13,549
1984	380	1,443	1,491	1,491	1,314	1,125	868	510	287	47	0	26	8,982
1985	133	838	873	503	910	1,491	921	434	150	0	0	0	6,253
1986	0	338	846	826	1,347	1,491	1,443	996	475	176	30	14	7,981
1987	33	65	166	265	1,214	1,075	439	159	82	0	0	0	3,499
1988	0	19	518	973	267	184	214	135	15	0	0	0	2,325
1989	0	3	269	409	317	815	360	123	9	0	0	0	2,306
1990	10	30	32	342	850	341	136	27	0	0	0	0	1,769
1991	0	0	0	0	3	1,491	1,067	335	75	0	0	0	2,971
1992	0	43	189	584	1,347	1,491	786	301	94	0	0	0	4,836
1993	0	0	738	1,491	1,347	1,491	1,443	749	496	168	43	5	7,971
1994	13	80	263	258	1,294	536	259	213	51	0	0	0	2,966
1995	0	33	188	1,491	1,347	1,491	1,443	1,491	1,092	551	159	109	9,395
1996	64	72	612	1,107	1,347	1,491	1,443	1,022	429	171	55	17	7,830
1997	58	450	1,491	1,491	1,347	1,312	679	336	197	125	38	0	7,525
1998	11	225	1,491	1,491	1,347	1,491	1,443	1,491	1,443	686	376	224	11,719
1999	254	513	815	1,197	1,347	1,491	1,443	860	353	114	13	0	8,400
2000	0	96	104	1,491	1,347	1,491	1,443	739	310	146	37	30	7,234
2001	176	188	137	1,398	1,347	1,491	1,094	708	304	74	0	0	6,917
2002	2	309	1,491	1,491	808	1,100	748	419	179	15	0	0	6,562
2007	112	121	313	243	743	633	237	128	40	0	0	0	2,570
2008	6	18	85	1,491	1,347	1,464	566	307	135	48	35	21	5,523
2009	28	116	263	272	1,347	1,491	969	587	351	169	99	59	5,752
2010	1,491	403	1,055	1,491	1,347	1,491	1,443	1,491	852	440	255	178	11,937
2011	158	262	1,491	1,491	1,347	1,491	1,443	1,275	1,223	482	268	166	11,096
2012	215	253	205	654	342	907	1,290	432	196	90	17	0	4,602
2013	15	131	1,491	1,491	577	431	291	161	70	2	0	0	4,661

Min =	0	0	0	0	3	169	92	27	0	0	0	0	690
Max =	1,491	1,443	1,491	1,491	1,347	1,491	1,443	1,491	1,443	915	557	309	13,549
Avg =	104	339	719	1,070	1,079	1,160	968	704	395	170	64	40	6,811

Notes:

0.5 Minimum bypass, cfs

44.8 Los Padres Reservoir drainage area, mi^2

15.0 San Clemente Creek drainage area, mi^2

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Management District Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated Total Inflow to San Clemente Creek Reservoir, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	51	96	2,089	4,501	14,069	15,576	15,074	4,766	2,144	824	72	41	59,303
1959	27	123	194	4,170	8,341	2,724	1,195	728	82	0	0	328	17,913
1960	53	60	66	2,468	5,632	1,954	1,342	1,031	270	0	0	0	12,877
1961	0	217	1,438	723	1,291	1,517	648	229	83	0	0	0	6,148
1962	0	43	1,986	996	13,876	8,376	3,140	1,233	459	49	0	0	30,158
1963	1,874	268	1,101	6,577	13,189	6,182	12,205	5,775	2,440	775	470	88	50,944
1964	605	3,312	975	4,608	2,564	1,840	1,966	1,020	435	87	0	0	17,412
1965	1	1,496	5,159	9,544	2,512	2,134	5,977	2,724	923	446	5	20	30,942
1966	2	3,476	3,386	4,243	3,950	2,131	1,073	480	304	0	0	0	19,046
1967	1	657	9,532	9,165	6,476	12,547	15,074	7,123	2,422	1,079	84	31	64,191
1968	69	95	659	1,708	2,149	2,237	998	486	41	0	0	0	8,443
1969	1	78	1,279	15,576	14,069	15,576	7,888	3,439	2,062	809	20	3	60,801
1970	71	220	2,217	10,744	3,961	9,332	2,641	1,551	586	28	0	0	31,352
1971	0	3,282	6,286	4,361	1,625	2,097	1,738	900	348	22	0	0	20,661
1972	0	47	4,253	1,409	2,242	972	656	215	0	0	0	0	9,794
1973	83	4,080	1,462	10,121	14,069	15,576	5,906	2,826	1,398	97	0	0	55,619
1974	85	2,069	4,634	8,689	2,808	15,576	10,296	3,309	1,641	483	36	3	49,630
1975	50	314	2,153	1,060	13,939	15,576	6,876	3,447	1,548	583	143	0	45,689
1976	121	347	347	354	441	1,133	649	91	0	0	0	0	3,484
1977	0	0	35	567	87	302	92	50	0	0	0	0	1,132
1978	0	0	3,479	15,576	14,069	15,576	9,334	5,360	1,982	1,430	497	344	67,647
1979	214	753	695	3,329	6,671	7,141	5,817	2,541	1,541	528	107	79	29,416
1980	280	814	3,700	15,576	14,069	13,939	6,341	4,240	2,102	1,604	609	333	63,607
1981	73	303	808	6,147	3,381	7,704	4,125	1,822	714	86	0	0	25,164
1982	72	4,657	3,197	13,856	6,941	9,864	15,074	5,100	2,638	1,325	276	156	63,156
1983	529	3,731	13,495	15,576	14,069	15,576	15,074	13,756	5,005	2,513	1,453	725	101,503
1984	929	5,332	15,576	6,680	3,713	3,133	2,378	1,313	660	47	0	26	39,788
1985	197	2,292	2,387	1,293	2,515	4,332	2,537	1,089	252	0	0	0	16,892
1986	0	809	2,309	2,248	14,069	15,576	5,534	2,751	1,216	323	30	14	44,880
1987	33	65	293	587	3,415	2,986	1,110	273	82	0	0	0	8,846
1988	0	19	1,336	2,685	614	346	442	204	15	0	0	0	5,660
1989	0	3	600	1,013	760	2,216	875	167	9	0	0	0	5,644
1990	10	30	32	816	2,338	812	213	27	0	0	0	0	4,278
1991	0	0	0	0	3	10,611	2,969	795	75	0	0	0	14,453
1992	0	43	363	1,532	12,150	6,037	2,137	693	94	0	0	0	23,051
1993	0	0	1,987	15,576	14,069	9,405	4,404	2,021	1,278	299	43	5	49,088
1994	13	80	582	567	3,652	1,389	577	433	51	0	0	0	7,343
1995	0	33	359	15,576	5,346	15,576	5,913	5,023	3,042	1,434	274	131	52,709
1996	64	72	1,614	3,081	14,069	11,392	5,134	2,829	1,079	308	55	17	39,716
1997	58	1,141	8,448	15,576	8,349	3,687	1,821	797	393	174	38	0	40,483
1998	11	475	4,424	14,920	14,069	12,778	10,512	6,820	4,171	1,835	916	474	71,405
1999	556	1,329	2,216	3,347	6,903	5,428	6,893	2,348	853	139	13	0	30,026
2000	0	96	111	6,818	14,069	10,714	4,604	1,989	726	235	37	30	39,431
2001	325	366	210	3,943	5,925	10,762	3,048	1,899	708	74	0	0	27,260
2002	2	724	6,201	5,213	2,214	3,059	2,025	1,045	339	15	0	0	20,837
2007	135	168	728	523	2,022	1,677	511	183	40	0	0	0	5,986
2008	6	18	85	10,244	7,627	4,138	1,484	713	210	48	35	21	24,629
2009	28	152	582	609	7,886	11,554	2,678	1,542	848	305	99	59	26,343
2010	4,668	1,004	2,926	11,657	9,126	9,027	7,782	4,764	2,332	1,107	558	336	55,287
2011	271	585	5,209	6,872	7,972	15,576	7,448	3,578	3,431	1,229	596	300	53,066
2012	439	559	409	1,739	835	2,490	3,629	1,082	391	90	17	0	11,679
2013	15	197	8,056	4,281	1,531	1,080	671	280	70	2	0	0	16,184

Min =	0	0	0	0	3	302	92	27	0	0	0	0	1,132
Max =	4,668	5,332	15,576	15,576	14,069	15,576	15,074	13,756	5,005	2,513	1,453	725	101,503
Avg =	231	887	2,724	5,943	6,764	7,287	4,587	2,287	1,030	393	125	69	32,327

Notes:

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Management District Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated Flow from San Clemente Creek Reservor to Meet 5 CFS Requirment at Sleepy Hollow, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	359	317	12	0	0	0	0	0	0	148	328	333	1,496
1959	319	241	275	0	0	0	4	276	364	401	400	380	2,659
1960	375	348	355	160	0	0	0	96	373	403	400	385	2,896
1961	379	348	156	202	146	334	296	394	392	410	400	385	3,842
1962	379	348	354	343	0	0	0	0	292	396	401	385	2,898
1963	257	256	120	0	0	0	0	0	0	166	373	319	1,491
1964	292	0	0	0	0	0	0	59	312	401	401	385	1,850
1965	379	348	0	0	0	0	0	0	70	373	396	380	1,946
1966	379	59	0	0	0	0	169	380	390	409	400	385	2,572
1967	379	348	0	0	0	0	0	0	0	350	372	378	1,827
1968	375	348	322	225	0	0	9	375	394	400	400	385	3,234
1969	379	348	354	0	0	0	0	0	0	85	372	384	1,923
1970	373	316	0	0	0	0	0	0	225	389	399	385	2,086
1971	379	142	0	0	0	0	0	0	194	383	400	385	1,882
1972	379	348	0	0	0	244	167	413	391	400	400	385	3,126
1973	375	0	0	0	0	0	0	0	154	339	389	386	1,643
1974	340	0	0	0	0	0	0	0	41	276	369	366	1,392
1975	346	288	0	0	0	0	0	0	0	226	361	355	1,577
1976	339	290	291	300	279	270	336	405	394	402	400	385	4,092
1977	373	350	354	347	334	378	385	419	393	400	400	385	4,519
1978	379	350	0	0	0	0	0	0	0	123	253	298	1,404
1979	247	63	0	0	0	0	0	0	105	234	338	363	1,349
1980	339	51	0	0	0	0	0	0	0	32	276	254	952
1981	229	281	0	0	0	0	0	0	245	340	359	349	1,804
1982	249	0	0	0	0	0	0	0	0	87	320	301	957
1983	293	0	0	0	0	0	0	0	0	0	45	96	434
1984	0	0	0	0	0	0	0	0	127	238	277	323	966
1985	283	0	0	0	0	0	0	21	205	259	348	305	1,421
1986	332	262	0	0	0	0	0	0	61	183	203	177	1,219
1987	189	155	127	112	0	0	0	290	272	344	357	338	2,184
1988	320	266	215	0	0	166	294	306	299	330	330	326	2,853
1989	304	261	174	170	53	0	75	185	352	370	362	331	2,636
1990	292	252	267	199	0	0	258	316	322	349	336	315	2,907
1991	290	296	347	344	312	0	0	0	155	293	305	287	2,629
1992	358	342	211	0	0	0	0	0	254	382	389	383	2,319
1993	377	345	0	0	0	0	0	0	0	209	331	358	1,620
1994	354	281	150	133	0	0	0	30	295	395	399	383	2,420
1995	365	331	262	0	0	0	0	0	0	0	191	287	1,436
1996	298	256	0	0	0	0	0	0	0	214	360	373	1,501
1997	356	0	0	0	0	0	0	28	257	361	388	376	1,767
1998	361	12	0	0	0	0	0	0	0	0	0	183	555
1999	82	0	0	0	0	0	0	0	0	227	319	352	980
2000	359	264	261	0	0	0	0	0	22	271	371	368	1,917
2001	280	159	204	0	0	0	0	0	224	367	394	381	2,009
2002	375	217	0	0	0	0	0	0	227	377	399	384	1,980
2007	315	166	0	0	0	0	0	112	220	301	268	264	1,645
2008	250	241	187	0	0	0	0	0	109	284	305	310	1,685
2009	290	249	144	28	0	0	0	0	8	183	305	296	1,502
2010	0	217	0	0	0	0	0	0	0	0	255	375	847
2011	314	171	0	0	0	0	0	0	0	0	162	323	969
2012	227	27	65	0	0	0	0	0	191	383	404	355	1,652
2013	345	215	0	0	0	0	0	237	335	410	422	397	2,362

Min =	0	0	0	0	0	0	0	0	0	0	0	96	434
Max =	379	350	355	347	334	378	385	419	394	410	422	397	4,519
Avg =	312	207	100	49	22	27	38	84	167	275	337	341	1,958

Notes:

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Management District Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

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- Flow for 2003 - 2006, unavailable.

Estimated Consumptive Water Demands Met From San Clemente Creek Reservoir, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1959	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1960	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1961	0	0	0	0	0	0	0	0	500	500	500	500	2,000
1962	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1963	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1964	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1965	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1966	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1967	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1968	0	0	0	0	0	0	0	0	500	500	500	500	2,000
1969	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1970	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1971	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1972	0	0	0	0	0	0	0	0	500	500	500	500	2,000
1973	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1974	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1975	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1976	0	0	0	0	0	0	0	0	500	500	500	500	2,000
1977	0	0	0	0	0	0	0	0	500	500	500	500	2,000
1978	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1979	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1980	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1981	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1982	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1983	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1984	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1985	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1986	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1987	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1988	0	0	0	0	0	0	0	0	500	500	500	500	2,000
1989	0	0	0	0	0	0	0	0	500	500	500	500	2,000
1990	0	0	0	0	0	0	0	0	500	500	500	500	2,000
1991	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1992	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1993	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1994	0	0	0	0	0	0	0	0	500	500	500	500	2,000
1995	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1996	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1997	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1998	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
1999	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
2000	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
2001	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
2002	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
2007	0	0	0	0	0	0	0	0	500	500	500	500	2,000
2008	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
2009	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
2010	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
2011	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
2012	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
2013	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500

Min =	0	0	0	0	0	0	0	0	500	500	500	500	2,000
Max =	0	0	0	0	500	500	1,000	1,000	1,000	500	500	500	5,500
Avg =	0	0	0	0	404	404	808	808	904	500	500	500	4,827

Notes:

0.5 Minimum bypass, cfs

5.0 Sleepy Hollow Wier Minimum Flow, cfs

- Water Demand Monthly Distribution Assumed

- Shading denotes Critically Dry Year

Estimated End of Month Storage of San Clemente Creek Reservoir, AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1958	11,000	10,769	12,807	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,162	11,309
1959	10,990	10,861	10,775	13,000	13,000	13,000	13,000	12,381	11,027	10,022	9,039	8,428
1960	8,078	7,779	7,484	9,787	13,000	13,000	13,000	12,863	11,688	10,681	9,699	8,753
1961	8,347	8,205	9,482	9,997	11,120	12,260	12,568	12,332	11,452	10,437	9,455	8,509
1962	8,103	7,786	9,413	10,060	13,000	13,000	13,000	13,000	12,095	11,144	10,161	9,215
1963	10,805	10,806	11,781	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,515	11,723
1964	12,008	13,000	13,000	13,000	13,000	13,000	13,000	12,890	11,941	11,022	10,039	9,093
1965	8,688	9,825	13,000	13,000	13,000	13,000	13,000	13,000	12,781	12,250	11,277	10,357
1966	9,953	13,000	13,000	13,000	13,000	13,000	12,860	11,888	10,731	9,717	8,735	7,789
1967	7,384	7,681	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,130	11,222
1968	10,889	10,625	10,956	12,434	13,000	13,000	13,000	13,000	12,075	11,071	10,089	9,143
1969	8,738	8,457	9,376	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,065	11,124
1970	10,795	10,688	12,855	13,000	13,000	13,000	13,000	13,000	12,290	11,325	10,344	9,398
1971	8,992	12,121	13,000	13,000	13,000	13,000	13,000	12,829	11,912	10,947	9,965	9,019
1972	8,613	8,301	12,503	13,000	13,000	13,000	13,000	12,731	11,768	10,763	9,781	8,835
1973	8,516	12,540	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,154	11,182	10,235
1974	9,952	11,966	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,603	11,688	10,764
1975	10,440	10,455	12,558	13,000	13,000	13,000	13,000	13,000	13,000	12,752	11,951	11,036
1976	10,790	10,836	10,886	10,935	11,075	11,895	12,163	11,777	10,812	9,805	8,823	7,877
1977	7,476	7,115	6,790	7,003	6,734	6,614	6,277	5,836	4,872	3,868	2,886	1,940
1978	1,534	1,172	4,602	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,661	12,145
1979	12,085	12,765	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,689	11,877	11,032
1980	10,945	11,698	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,750	12,268
1981	12,084	12,096	12,853	13,000	13,000	13,000	13,000	13,000	12,398	11,539	10,597	9,688
1982	9,484	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,373	11,668
1983	11,876	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
1984	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,462	11,666	10,806	9,948
1985	9,835	12,071	13,000	13,000	13,000	13,000	13,000	12,996	11,971	11,108	10,177	9,312
1986	8,952	9,487	11,746	13,000	13,000	13,000	13,000	13,000	13,000	12,536	11,780	11,056
1987	10,873	10,773	10,933	11,403	13,000	13,000	13,000	11,912	10,650	9,701	8,762	7,864
1988	7,516	7,258	8,373	11,007	11,554	11,691	11,794	11,620	10,765	9,830	8,918	8,031
1989	7,700	7,432	7,853	8,690	9,375	11,502	12,259	12,169	11,255	10,281	9,337	8,445
1990	8,136	7,904	7,663	8,275	10,546	11,269	11,179	10,819	9,925	8,971	8,053	7,177
1991	6,860	6,553	6,200	5,851	5,020	13,000	13,000	12,724	11,572	10,674	9,786	8,939
1992	8,553	8,244	8,391	9,873	13,000	13,000	13,000	12,622	11,391	10,405	9,433	8,489
1993	8,084	7,728	9,665	13,000	13,000	13,000	13,000	13,000	13,000	12,485	11,615	10,702
1994	10,333	10,122	10,549	10,977	13,000	13,000	13,000	13,000	12,184	11,184	10,203	9,259
1995	8,866	8,558	8,650	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,501	11,785
1996	11,524	11,328	12,892	13,000	13,000	13,000	13,000	13,000	13,000	12,490	11,603	10,687
1997	10,361	11,447	13,000	13,000	13,000	13,000	13,000	12,697	11,761	10,969	10,037	9,100
1998	8,723	9,142	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,730
1999	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,782	12,090	11,201	10,289
2000	9,902	9,723	9,568	13,000	13,000	13,000	13,000	13,000	12,633	11,993	11,076	10,178
2001	10,196	10,392	10,392	13,000	13,000	13,000	13,000	13,000	12,413	11,515	10,539	9,598
2002	9,196	9,692	13,000	13,000	13,000	13,000	13,000	12,973	12,014	11,048	10,066	9,121
2007	11,000	10,991	11,669	12,141	13,000	13,000	13,000	12,999	12,248	11,342	10,492	9,668
2008	9,397	9,162	9,055	13,000	13,000	13,000	13,000	12,642	11,671	10,831	9,979	9,129
2009	8,840	8,733	9,165	9,724	13,000	13,000	13,000	13,000	12,768	12,285	11,497	10,700
2010	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,720	12,121
2011	12,050	12,453	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	12,852	12,268
2012	12,452	12,956	13,000	13,000	13,000	13,000	13,000	13,000	12,128	11,230	10,261	9,345
2013	8,988	8,959	13,000	13,000	13,000	13,000	12,627	11,599	10,261	9,249	8,244	7,287

Min =	1,534	1,172	4,602	5,851	5,020	6,614	6,277	5,836	4,872	3,868	2,886	1,940
Max =	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Avg =	9,729	10,128	11,171	12,099	12,508	12,754	12,764	12,621	12,071	11,436	10,619	9,785

Notes:

0.5	Minimum bypass, cfs
5.0	Sleepy Hollow Wier Minimum Flow, cfs
550	Annual Evaporation, AF
13,000	Storage, AF

- Los Padres unimpaired flow information for 1958 - 2002 from "Water Availability Analysis For Petition Requesting Changes to Water Rights Permits 7130B and 20808 of the Monterey Peninsula Water Management District Carmel River and Carmel River Subterranean Stream, Darby W. Fuerst, November 17, 2003

- Los Padres unimpaired flow information from 2007 - 2013 taken from Excel Spreadsheet provided by MPWMD "Copy of est_dailyq_wy07.xls", 2013

- Flow for 2003 - 2006, unavailable.

Estimated San Clemente Creek Reservoir Outflow (Release and Spill), AF

WY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1958	300	317	45	4,303	14,047	15,532	15,030	4,695	2,073	719	828	833	58,720
1959	319	241	275	1,939	8,319	2,680	1,151	1,276	1,364	901	900	880	20,244
1960	375	348	355	160	2,397	1,910	1,298	1,096	1,373	903	900	885	12,001
1961	379	348	156	202	146	334	296	394	892	910	900	885	5,842
1962	379	348	354	343	10,915	8,332	3,096	1,162	1,292	896	901	885	28,902
1963	257	256	120	5,352	13,167	6,138	12,161	5,704	2,368	671	873	819	47,886
1964	292	2,309	969	4,602	2,542	1,796	1,922	1,059	1,312	901	901	885	19,492
1965	379	348	1,979	9,538	2,490	2,090	5,933	2,652	1,070	873	896	880	29,128
1966	379	418	3,381	4,238	3,928	2,087	1,169	1,380	1,390	909	900	885	21,064
1967	379	348	4,207	9,159	6,454	12,503	15,030	7,051	2,351	974	872	878	60,207
1968	375	348	322	225	1,561	2,193	954	415	894	900	900	885	9,972
1969	379	348	354	11,947	14,047	15,532	7,844	3,368	1,991	704	872	884	58,271
1970	373	316	45	10,593	3,939	9,288	2,597	1,479	1,225	889	899	885	32,527
1971	379	142	5,401	4,355	1,603	2,053	1,694	1,000	1,194	883	900	885	20,489
1972	379	348	45	907	2,220	928	612	413	891	900	900	885	9,428
1973	375	45	997	10,116	14,047	15,532	5,862	2,754	1,327	839	889	886	53,669
1974	340	45	3,595	8,684	2,786	15,532	10,252	3,238	1,570	776	869	866	48,552
1975	346	288	45	612	13,917	15,532	6,832	3,375	1,477	726	861	855	44,867
1976	339	290	291	300	279	270	336	405	894	902	900	885	6,092
1977	373	350	354	347	334	378	385	419	893	900	900	885	6,519
1978	379	350	45	7,173	14,047	15,532	9,290	5,288	1,911	1,325	753	798	56,892
1979	247	63	454	3,324	6,649	7,097	5,773	2,469	1,470	734	838	863	29,979
1980	339	51	2,392	15,571	14,047	13,895	6,297	4,169	2,030	1,499	776	754	61,821
1981	229	281	45	5,995	3,359	7,660	4,081	1,751	1,245	840	859	849	27,194
1982	249	1,130	3,192	13,850	6,919	9,820	15,030	5,029	2,566	1,220	820	801	60,626
1983	293	2,597	13,489	15,571	14,047	15,532	15,030	13,684	4,934	2,409	1,371	664	99,621
1984	901	5,321	15,571	6,675	3,691	3,089	2,334	1,241	1,127	738	777	823	42,290
1985	283	45	1,452	1,288	2,493	4,288	2,493	1,021	1,205	759	848	805	16,979
1986	332	262	45	989	14,047	15,532	5,490	2,680	1,144	683	703	677	42,586
1987	189	155	127	112	1,796	2,942	1,066	1,290	1,272	844	857	838	11,489
1988	320	266	215	45	45	166	294	306	799	830	830	826	4,942
1989	304	261	174	170	53	45	75	185	852	870	862	831	4,680
1990	292	252	267	199	45	45	258	316	822	849	836	815	4,996
1991	290	296	347	344	812	2,587	2,925	1,000	1,155	793	805	787	12,141
1992	358	342	211	45	9,001	5,993	2,093	1,000	1,254	882	889	883	22,950
1993	377	345	45	12,236	14,047	9,361	4,360	1,949	1,207	709	831	858	46,325
1994	354	281	150	133	1,607	1,345	533	361	795	895	899	883	8,236
1995	365	331	262	11,220	5,324	15,532	5,869	4,951	2,970	1,330	691	787	49,633
1996	298	256	45	2,968	14,047	11,348	5,090	2,758	1,008	714	860	873	40,264
1997	356	45	6,889	15,571	8,327	3,643	1,777	1,028	1,257	861	888	876	41,519
1998	361	45	561	14,915	14,047	12,734	10,468	6,748	4,099	1,731	833	683	67,224
1999	259	1,318	2,211	3,342	6,881	5,384	6,849	2,276	1,000	727	819	852	31,918
2000	359	264	261	3,380	14,047	10,670	4,560	1,918	1,022	771	871	868	38,992
2001	280	159	204	1,330	5,903	10,718	3,004	1,828	1,224	867	894	881	27,290
2002	375	217	2,888	5,208	2,192	3,015	1,981	1,000	1,227	877	899	884	20,763
2007	500	166	45	45	1,142	1,633	467	112	720	801	768	764	7,160
2008	250	241	187	6,294	7,605	4,094	1,440	1,000	1,109	784	805	810	24,618
2009	290	249	144	45	4,589	11,510	2,634	1,471	1,008	683	805	796	24,222
2010	2,341	993	2,920	11,652	9,104	8,983	7,738	4,693	2,261	1,002	755	875	53,316
2011	314	171	4,656	6,867	7,950	15,532	7,404	3,506	3,360	1,125	662	823	52,369
2012	227	45	359	1,734	813	2,446	3,585	1,010	1,191	883	904	855	14,051
2013	345	215	4,010	4,275	1,509	1,036	1,000	1,237	1,335	910	922	897	17,692

Min =	189	45	45	45	45	45	75	112	720	671	662	664	4,680
Max =	2,341	5,321	15,571	15,571	14,047	15,532	15,030	13,684	4,934	2,409	1,371	897	99,621
Avg =	380	477	1,676	5,009	6,333	6,997	4,533	2,358	1,508	924	859	842	31,897

Notes:

0.5 Minimum bypass, cfs

5.0 Sleepy Hollow Wier Minimum Flow, cfs