

FINAL

STUDY PLAN for LONG TERM ADAPTIVE MANAGEMENT of the CARMEL RIVER STATE BEACH AND LAGOON

Stakeholders:

Big Sur Land Trust
California American Water
Calif. State University Monterey Bay
Carmel Area Wastewater District
Carmel River Lagoon Coalition
Carmel River Steelhead Association
Carmel River Watershed Conservancy
Monterey County Service Area 50

Technical Advisory Committee:

California Coastal Commission
California Department of Fish and Game
California State Parks
Monterey County Public Works Department
Monterey County Water Resources Agency
Monterey Peninsula Water Management District
NOAA Fisheries
U.S. Army Corps of Engineers
U.S. Fish and Wildlife Service



photo by Paul Miller, Carmel Pine Cone, August 25, 2004

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Executive Summary

The Carmel River State Beach, including its adjacent Lagoon area wetlands preserve, is one of the most scenic and ecologically important public resources on California's Central Coast. Because of its uniquely attractive and valuable location, agricultural uses began and houses were built on lands immediately adjacent to the Beach and Lagoon, many decades before the state acquired the property. Primarily because the Carmel River has served as the Monterey Peninsula's main water resource for over 100 years, the Lagoon level remains depressed through the summer after spring flows cease and into late fall when the lower river is dry; wind and waves build the Beach into a natural barrier to outflow and in the winter, the level rises as storms cause the river and the ocean to fill the Lagoon to a level that threatens adjoining homes. In most winters since the early 20th century, private property owners, the State itself and, for the last two decades, the County of Monterey have created an opening in the Beach prior to the river becoming powerful enough to break through to the ocean. This action is taken in order to protect adjacent homes and private lands from flooding. With Central Coast steelhead trout, California red-legged frogs and other threatened species having come under the protection of the Endangered Species Act over the past decade, federal and state environmental enforcement agencies have become increasingly concerned about the adverse impact of these emergency breaching actions to artificially lower the Lagoon water level. The result is a problematic convergence of competing interests: Homeowners expect protection from potential flood inundation caused by an expanding Lagoon; while federal and state agencies demand action to protect rare fish and amphibian species, which need adequate Lagoon water levels and water quality to survive.

This Study Plan represents the first, comprehensive effort by affected federal, state and local public agencies to analyze and devise the best Beach and Lagoon management scheme to effectively meet both of these competing interests. The catalyst for this coordinated planning effort was a winter 2004-2005 emergency action by the County of Monterey to protect homes from flooding. This action involved breaching the barrier Beach in a non-traditional direction at the urging of the National Marine Fisheries Service (NMFS), which was intended to maintain Lagoon water levels as high, and for as long, as possible. The unintended results were severe erosion of a portion of the Beach bluff that threatened the stability of the County-maintained frontage road (Scenic Road) and damage to the Carmel River State Beach parking facility, both of which alarmed adjacent homeowners. In June 2005, the Carmel River Watershed Conservancy (CRWC) and the NMFS organized a meeting of affected agencies and concerned residents to discuss the breaching effects issue. The outcome of the meeting was two-fold: first, the voluntary formation of a Technical Advisory Committee (TAC) comprised of State Parks and Recreation staff responsible for managing the Beach and Lagoon, plus water resource engineers, environmental scientists and other technical staff from those local, state and other federal agencies with functional responsibilities related to the Beach and Lagoon; and second, a Coalition of community and neighborhood groups was formed whose interests include flood protection, Beach sand management, and Lagoon habitat preservation.

In the course of developing this Study Plan, many potential actions to address the problems discussed in the June 2005 meeting were identified by the TAC, including some

which have been promoted by Coalition members. The TAC thoroughly reviewed and analyzed available facts and data on the Beach and Lagoon. The TAC concluded that an insufficient body of technical knowledge exists regarding the complex physical interaction of the Beach and Lagoon, and its effect both on Beach stability and the threatened fish and other species that use the Lagoon as habitat. In order to complete and implement a viable long-term management plan, as well as to secure required permits, the TAC concluded that adequate baseline data and information is required. Thus, through its creation of this Study Plan, the TAC has prepared a detailed scope of work that 1) sets out short- and long-term objectives for integrated management of the Beach and Lagoon, in order to effectively resolve the competing interests noted above; and 2) describes technical studies of sediment transport and other physical processes involving the Beach and Lagoon, plus preliminary engineering investigations of potential flood and habitat protection solution alternatives, which would guide long-term plan completion. The total estimated cost of these studies and investigations is approximately \$850,000. The TAC has set of goal of completing these studies within three years of receiving a funding commitment. The cost to complete and implement the long-term management plan cannot be estimated at present, but easily could be several multiples of that figure.

The TAC has researched, but been unable able to identify any known federal, state or local resources in existing agency budgets to fund this Study Plan. The TAC and Coalition share an interest in pursuing possible funding resources that could be applied for under current federal or state flood protection and/or ecosystem restoration grant programs. The Monterey County Water Resources Agency (Agency) and the Monterey Peninsula Water Management District (District), aided by Coalition members, will investigate possible funding through annual State budget line items or special appropriations that the Legislature will be making to implement Prop. 84 and 1E bond acts that California voters approved in November 2006, and other funding opportunities as they arise. The Agency and District, as well as members of the Coalition, have preliminarily researched existing federal and state programs, under which special status is granted to unique coastal wetlands resources that lack a permanent institutional structure to integrate management, operation, funding, preservation, and environmental education. A nearby example of such special status is the Elkhorn Slough National Estuarine Research Reserve, which is a partnership of federal and state resource agencies, educational institutions, and local non-profit organizations. While the Study Plan is being completed, the Agency, District and Coalition will continue to investigate and pursue, with the appropriate government decision-makers, the potential for Carmel River State Beach and Lagoon being granted a special reserve program status.

This document has been prepared by representatives of the federal, state and local agencies serving on the TAC. It does not necessarily represent the opinions, beliefs, or stated positions of any individual, group, private or public entity. This document is intended to be a plan to gather information for developing a comprehensive long term management program for the Carmel River Lagoon and surrounding areas. This document is not intended to be used in formulating policies, amending existing regulations or requirements, or for proposing any management actions other than planning.

Background

The Carmel River Lagoon is a high value environment, both in human and ecologic terms. The lagoon and adjacent Carmel River State Beach (see [Figure 1](#)) are popular recreation sites. Multi-million dollar homes with spectacular vistas dot the bluffs above the lagoon and beach to the north and south of the river mouth. An historic resort and several homes line the northern shore of the lagoon in a pastoral setting. Ecologically, the lagoon serves as keystone habitat for multiple threatened and protected species, including a distinct population segment of steelhead (*Oncorhynchus mykiss*) and the elusive California Red-legged frog (CRLF) (*Rana aurora draytonii*). The ecosystem is a dynamic interface between the marine and freshwater river system that incorporates freshwater wetlands and open water habitat. As such, this area provides an extremely rich and abundant environment for fish and wildlife.

The value of this environment to the people of California was recognized in the last century with the establishment of Carmel River State Beach in 1949. The one-mile long beach borders Carmel Bay (see [Figure 1](#)), which was designated as an Area of Special Biological Significance (ASBS) by the California Legislature in 1974. This ASBS includes 6.7 miles of coastline bordering the City of Carmel and the Pebble Beach Golf Course, lies entirely within the Monterey Bay National Marine Sanctuary (MBNMS), and contains the Carmel Bay State Marine Conservation Area. The Point Lobos Ecological Reserve ASBS is adjacent to and just south of the Carmel Bay ASBS. The beach lies at the head of the Carmel Submarine Canyon, which leads into one of North America's largest underwater canyons – the Monterey Canyon.

The Carmel River, a portion of which lies in the Ventana Wilderness, is the largest freshwater stream flowing into Carmel Bay. The lagoon and adjacent wetlands are formed at the interface between the marine and freshwater environments in a suburban setting. In 1974, State Parks purchased what is known as the “Odello West” land, a low-lying floodplain area adjacent to the lagoon and immediately west of Highway 1. The lagoon and surrounding area, which total about 300 acres, were designated the Carmel River Lagoon and Wetlands Natural Preserve in 1995.

With the establishment of the nearby Carmel Mission in 1770 by the Capuchins, the area around the lagoon was converted from riparian forests and wetlands to agricultural use. Beginning in the 1920's, the Odello Family grew artichokes on the property. In 1996, in cooperation with the California Department of Transportation (CALTRANS), State Parks began converting the agricultural lands back to wetlands and riparian forest. Habitat restoration efforts are ongoing. This area has also been the site of numerous natural history research and education efforts.

The natural function of the lagoon ecosystem has been compromised by development and resource use in the immediate vicinity and in the contributing watershed. There are several significant impacts to the lagoon ecosystem. First, the annual withdrawal of up to about 15,000 acre feet of water from the river system to supply the needs of the Monterey Peninsula causes the river to go dry during most summers, deprives the

lagoon of surface inflow, and significantly reduces groundwater inflow. Thus, there is little or no freshwater input during the dry season in most years. Second, low lying homes built before modern floodplain regulations were enacted flood if lagoon elevations fluctuate naturally. To prevent flooding in the neighborhood of the lagoon, the barrier beach is frequently manipulated.



Avian species at river/ocean interface

The Carmel River Lagoon is habitat for species protected by the Federal Endangered Species Act (ESA). Several agencies including the National Marine Fisheries Service (NMFS or NOAA Fisheries), the US Fish and Wildlife Service (USFWS) and the California Department of Fish and Game (CDFG) are concerned about artificial breaching of the barrier beach, which can result in dangerously low water levels in the lagoon.

Figure 1

Carmel River Lagoon Area



Image file = D:\larry\CRprojects\Lagoon\vicmap.tif

Third, the supply of sand to the beach has been sharply reduced by sand and gravel mining at the beach and along the river, construction of Carmel River main stem reservoirs that trap sand from the upper watershed, and floodplain development in the main portion of Carmel Valley that has also reduced the supply of sand to the beach.

Normally, the nexus for taking action to manage the beach during the winter is the threat of flooding in low-lying area around the lagoon. When the river begins flowing into the lagoon each fall or early winter, the lagoon rises and would, under natural conditions, keep rising until it overtops the barrier beach and creates an outlet channel through the beach. If this process were allowed to occur naturally, the low-lying residential neighborhood to the north of the lagoon would likely be flooded. Historically, the cut for the lagoon outlet has been located on the southern end of the barrier beach, near rocky outcrops. The resultant outflow from the lagoon often cuts a large, nearly straight channel in the barrier beach (a breach) that is low enough to cause the lagoon to drain to a level that significantly reduces or completely eliminates habitat for steelhead and other aquatic species.



In this c. 1900 photograph, a four-horse team is dragging a scoop, used to create a low spot, so the river mouth would open, decreasing the water level of the lagoon and surrounding farmland. As the land was subdivided and houses began to encroach on the wetlands, it was not unusual to see men take out their shovels and dig a ditch to start the river flowing out, preventing their homes from flooding. (Monterey Public Library Collection.) - Adapted from a new pictorial history book Images of America - Carmel by the Sea by Monica Hudson.

Evidence from historical photographs (see photo above) and local accounts suggests that the barrier beach has been routinely breached and the lagoon drained since at least the early 20th century. Photographs and oral stories (Hampson, personal

communication with John and Bruna Odello, 1991) relate that the Odello family managed the lagoon and lower part of the river for several decades between the 1920's and 1950's. It is unclear whether the lagoon was actively managed in the 1960's by private or public groups.

To prevent flooding, Monterey County Department of Public Works cuts a small channel through the barrier beach to allow the water to flow to the ocean before the lagoon rises to flood stage. Continued outflow widens the channel.



Cutting an outlet through the beach - December 2004

During the 1970's, State Parks contracted for the opening of the river mouth. By the late 1970's, this responsibility was taken over by Monterey County Public Works under the direction of the Monterey County Water Resources Agency (MCWRA) and the County Board of Supervisors. During the past several years, the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS or NOAA Fisheries) and the California Department of Fish and Game (CDFG) have given technical advice to Monterey County Public Works on how to minimize impacts to protected species. The resource agencies' basic goals are to minimize adverse impacts to fish and wildlife, minimize the need to mechanically breach the lagoon and to maintain adequate lagoon levels after a breach occurs.

In the winter of 2005, the river mouth was directed to the north end of the lagoon with the intent that an outlet channel would form across the barrier beach without completely evacuating the lagoon. NOAA Fisheries and CDFG considered the experiment a success in avoiding a breach and maintaining higher water levels in the lagoon. However, in the spring, large ocean swells and high tides lowered a portion of the beach. Above average river flows combined with large waves overtopping the beach removed much of the sand dune that was adjacent to the Scenic Road bluff. The lagoon outlet channel was pushed back to the base of the bluff, undermined the edge of the State Beach parking lot, and threatened the stability of Scenic Road. In March and again in May, Monterey County Public Works brought equipment onto the beach to divert the flow of the river farther to the south and to push sand against the bluff that supports the road.



In the past the river mouth has migrated to the north on several occasions. To protect Scenic Road (at the top of the sandy bluff in the center of the photo), the County has redirected the river away from the north end of the beach in five years of the 12-year period between 1993 and 2005 (see next photo).

Simultaneous closing of the north outlet and opening of an outlet to the south, March 1993.



Developing a Solution

On June 14, 2005, NOAA Fisheries and the Carmel River Watershed Conservancy (CRWC) organized a stakeholder meeting on the issue of management of the Carmel River Lagoon and barrier beach. At that meeting, all agencies and stakeholder groups present agreed to form a technical advisory committee (TAC) charged with examining the basic sciences of coastal, marine and river processes and the impacts on beach dynamics. The TAC was charged with determining the information needed to make informed decisions and plans to preserve and enhance the geophysical and ecological functions of the Carmel River Lagoon and barrier beach.

After public input and discussion of the issues, State Parks volunteered to host and facilitate a series of working meetings to develop recommendations to ensure stability of the bluff that supports Scenic Road and develop protocols for effectively managing the Carmel River Lagoon and barrier beach. Subsequently, the facilitation role has been taken up by the Monterey Peninsula Water Management District (MPWMD).

An additional outcome of the June 14, 2005 meeting was that several stakeholders formed the Carmel River Lagoon Coalition¹ to advocate for solutions to the issues identified during the meeting.

Affected Organizations

- California State Parks - Landowner
- U.S. Army Corps of Engineers – Clean Water Act, Section 404 Permit
- California Department of Fish and Game – Fish and Game Code Section 1601, Streambed Alteration Agreement
- California Coastal Commission – Coastal Development Permit
- Monterey County Planning Department – Emergency Clearance
- Monterey County Public Works Department – Equipment Operators
- Monterey County Water Resources Agency – Flood Control
- NOAA Fisheries – Endangered Species Act – Steelhead
- US Fish & Wildlife Service - Endangered Species Act – Red-legged frog
- Monterey Peninsula Water Management District – Water and Habitat Management & Mitigation
- Carmel River Watershed Conservancy—Conservation Organization
- Carmel River Steelhead Association – Fisheries Conservation & Habitat Restoration
- Carmel Point and Lagoon Preservation Association – Protection of Private Property/Lagoon Environment
- Homeowners for Effective Lagoon Management (HELM) – Protection of Private Property/Lagoon Environment

Technical Advisory Committee (TAC)

The TAC consists of scientists and management representatives of the regulatory agencies: California State Parks, NOAA Fisheries, California Department of Fish and Game, California Coastal Commission, US Army Corp of Engineers, US Fish & Wildlife Services, Monterey Peninsula Water Management District, Monterey County Public Works Department, and Monterey County Water Resources Agency.

¹ The Carmel River Lagoon Coalition is a volunteer group that includes representatives of the Carmel River Steelhead Association (CRSA), the Carmel River Watershed Conservancy (CRWC), Homeowner's for Effective Lagoon Management (HELM), the Big Sur Land Trust (BSLT), County Services Area 50 (CSA 50), Save Carmel River Beach (SCRB), and the Carmel Point and Lagoon Preservation Association (CPLPA).

Progress to Date

Since forming in 2005, the TAC has met on a monthly basis to monitor beach, lagoon, and river conditions and to develop interim and long term management strategies. The TAC established a liaison (a representative from the TAC facilitating agency) between the TAC and the Carmel River Lagoon Coalition to communicate results of meetings and solicit public input on management strategies.

During the winters of 2005-06 and 2006-07, the TAC provided a forum for communicating technical information and making recommendations for managing the barrier beach. This study plan, which includes a description of the information needed, identifies what scientific studies are critical to make informed decisions and develop a Long Term Plan. The Scope of Work included is considered critical to ensuring management decisions will be effective in addressing the issues. Estimated costs for the studies are included.

In early 2007, the TAC began discussions of formulating an interim strategy based on adaptive management principles. This interim strategy will serve as a short-term management plan until the long term management plan described in this document is complete.

Next Steps

The next steps will be to complete an interim adaptive management plan, secure the appropriate authorizations to carry out the interim plan and secure funding for the proposed Scope of Work and Studies to be completed for a long term plan.

Problem Definition

The Carmel River Lagoon and barrier beach is the transition area between the 255 square-mile Carmel River watershed and the Carmel Bay. It is a dynamic environment with many natural forces, including high Carmel River flows, powerful ocean swells, constant wind and wave action, and a highly mobile landscape predominated by sand. High energy and mobile materials converge around the Carmel River Lagoon to generate flooding, erosion and sedimentation processes. The outlet for this dynamic power is through the barrier beach, which is confined laterally by bedrock outcrops to the north and south of the mouth.

Two physical processes collide with social expectations at this high energy boundary setting. First, erosion of the sandy bluffs adjacent to the lagoon is influenced by ocean dynamics, river flow, and sand supply. Second, the elevation of most of the barrier beach usually exceeds the first floor elevation of many of the low-lying structures near the lagoon. If the low point or outlet through the beach is allowed to remain higher than these structures, they are exposed to flooding when the lagoon fills as a result of river inflow and/or overtopping of the barrier beach by large ocean waves. In order to reduce the potential for flooding, frequent manipulation of the outlet location and elevation is

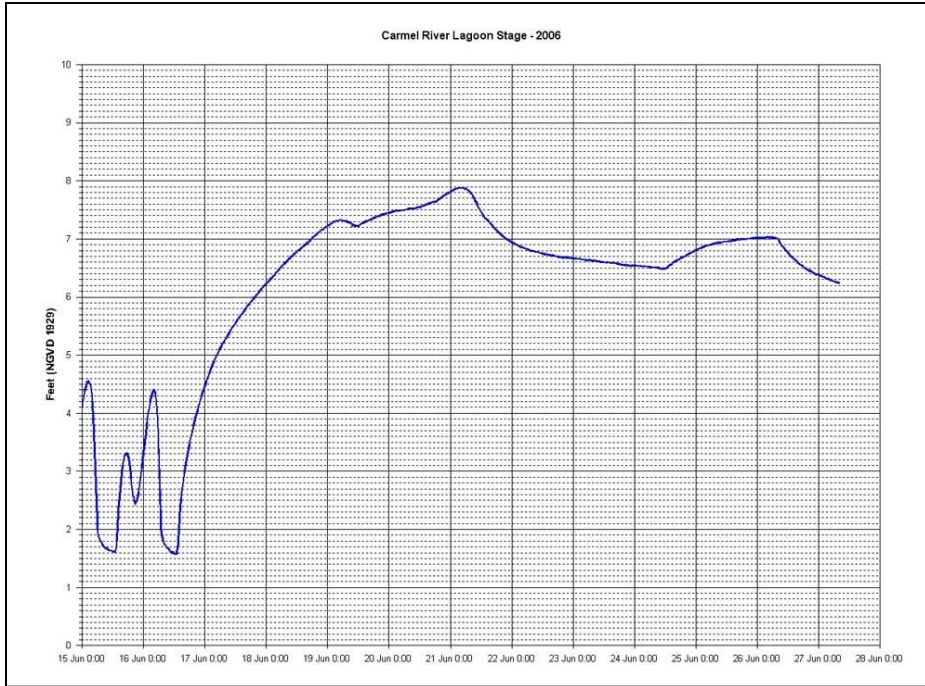
undertaken, which has resulted in many undesirable consequences to fish and wildlife. It should be noted that the configuration of the barrier beach is not a significant factor during floods resulting solely from high river flows – these are relatively infrequent events during which river flow is high enough to wash out most of the beach.

During the summer and fall, when Carmel River flows are not high enough to maintain an open channel through the beach to the ocean, the barrier beach is built up by wind and wave action. To reduce flood risk prior to the onset of increased river flows in late fall and early winter, Monterey County, which is the local agency responsible for responding to floods, manages the location of the lagoon outflow channel by lowering a section of the barrier beach from the lagoon to the ocean. Historically, this barrier beach management has resulted in artificial breaching of the barrier beach. In many years, this activity occurs just a few hours or within days before a natural outlet channel would form. However, during periods with sustained low flows (20 cubic feet per second or less), it is likely that artificial breaching occurs up to several weeks before a natural outlet channel would form. During periods in the winter and spring, when river flows drop and the lagoon mouth closes temporarily, mechanical breaching is often performed to prevent flooding of low-lying areas, even at relatively low river flows. The timing of these breaches is in contrast to a naturally functioning lagoon system that may have remained closed and full during low inflow periods.

In October 1996, Don Alley, a local aquatic biologist, conducted a population survey and estimated a total of approximately 5,640 juvenile steelhead. A somewhat similar survey conducted in December 2006 by the TAC and Carmel River Lagoon Coalition estimated a total of 3,730 juveniles (note that the surveys are not directly comparable). The winter run of adult steelhead counted at the San Clemente Dam (18.6 miles upstream of the lagoon) has ranged from about 300 to almost 900 since 1995. Estimates of the juvenile population in the Carmel River Basin range from about 90,000 up to about 175,000. Measurements of smolts and young-of-the-year in the main stem of the Carmel River during the spring migration in the early 1990's showed that up to 800 fish per day were moving downstream toward the lagoon during ideal conditions. The presence of CRLF has been documented in the vicinity of the Lagoon. But effects of artificial breaching on egg masses, tadpoles, and number of adults are unknown.

Habitat quantity is directly related to water elevation in the lagoon. At a water level of about two feet (NGVD 1929), the area of the lagoon is estimated to be about two acres. Whereas, at nine-foot level, the area of the lagoon is estimated to be about 80 acres, a forty-fold increase. It is known that artificial breaching can have significant effects on life cycle stages of at least two of the species of concern at the Lagoon – steelhead and CRLF. Breaching of the barrier beach for flood control purposes frequently results in low lagoon elevations, elimination of most of the aquatic habitat of the lagoon, and a short and steep outflow path to the ocean. In recent years, the County has attempted to manage the location of the lagoon outflow channel across the barrier beach by simulating a natural channel meander pattern to minimize environmental impacts. However, fixing the river mouth at a specific location on the beach is difficult due to the complex interaction of waves, tidal fluctuation, river flow, and sand transport. Because

more frequent and more expensive manipulations to maintain habitat have resulted, management of the barrier beach to minimize fish and wildlife impacts has been frustrating and failed to accomplish the desired results.



The graph at left shows lagoon water surface elevations between June 15 and June 28, 2006. Troughs in the line are associated with low tide and an outflow channel to the south, adjacent to bedrock outcrops. A steady rise beginning June 17 is due to a closure action conducted by State Parks to increase the elevation of the lagoon. Data from MPWMD gage station, South arm of Lagoon.

In addition to flood prevention, the County also manages the barrier beach to direct the lagoon outflow channel away from the eroding sandy bluff that underlies Scenic Road along the north half of the beach. Barrier beach management by Monterey County Public Works is carried out with heavy equipment when necessary and with hand labor when limited amounts of sand need to be moved. Another complicating factor is that private citizens digging at the beach with hand tools sometimes cause an illegal breach of the barrier beach.

Management Components

The challenge of managing the barrier beach and lagoon has several components including: Geologic, Ecologic; Regulatory; Financial; Social; and Institutional. These are discussed in more detail below.

Geologic

The lagoon outlet channel meanders across the beach and is constrained by rocky granodiorite outcrops underlying the north and south ends of the beach. These rocky outcrops are separated by approximately 600 feet of fine to coarse sands, with little gravel. The basic configuration of the rocky outcrops appear to be similar with wide, rounded slots cut by wave and water action that are filled in by beach sands. However, the effect of the outcrops as a control on the lagoon water surface elevation appears to

be somewhat different, which may be due to the orientation of the slots and the varying width of the beach from north to south. The beach width above sea level varies seasonally as sand moves on and offshore, but is generally larger at the north end (about 250 feet) near Stewart's Cove than at the south end (about 100 feet).

Three critical functions of the barrier beach have been identified:

- Protection of the shoreline bluffs.
- Prevention of combined storm and tidal surge from inundating low lying areas around the lagoon.
- Impoundment of water to form a fresh and seasonally brackish water lagoon above sea level.

Known interrelated factors affecting barrier beach dynamics include:

- Sediment supply/ watershed processes
- Littoral sediment transport along the beach
- Swell size, period, and direction in concert with tidal stage
- Migration of the river mouth

The lagoon outlet channel varies in width according to the volume of sand and water passing through it and can range from as little as 20 feet wide at low flows to more than 200 feet wide after a breach or during major river flow events. A critical feature of the outlet channel is the length over which the channel meanders through the beach. Breaching to the center of the barrier beach usually results in a short steep channel not controlled by bedrock shelves. This lowers the base elevation of the outflow channel to sea level, and thus drains most of the water in the lagoon.

A breach to the south or north adjacent to the bedrock outcrops can have similar results, if the channel cuts directly through the barrier beach. A meandering channel of up to 1,500 feet across the beach is associated with higher base water levels in the lagoon (i.e., above four feet). However, conditions for a meandering channel appear to include a combination of beach width sufficiently large to encourage meandering (i.e., greater than 150 feet), river flows that are not large enough to scour the lagoon outlet channel down to near sea level, and a swell height and direction along with tidal fluctuations that encourage beach building.

A northern outlet has been shown to risk erosion of the sandy bluff and dune adjacent to Stewart's Cove that supports Scenic Road. However, a northern outlet also results in a longer outlet channel and higher lagoon elevations more frequently than a southern outlet. The MPWMD Technical Memorandum 05-01 "Surface Water Dynamics at the Carmel River Lagoon, Water Years 1991 through 2005" showed that an elongated channel to the north formed in 1993, 1997, and 2005. In both 1993 and 2005, Monterey County Public Works took action to prevent loss of Scenic Road due to erosion of the sand dune adjacent to it. During powerful winter and early spring storms, there are

periods when ocean surge and river flows thwart or obstruct efforts to prevent beach sand erosion.

With the river flowing freely to the ocean, water levels in the lagoon frequently fluctuate diurnally, which suggests a strong tidal influence. Water level is directly related to habitat volume and quality in the lagoon. The lowest lagoon stage on record (since 1991), which was in June 2006 at 1.6 feet (NGVD 1929), was with an outlet configuration that was adjacent to the southern bedrock shelf. Since the early 1990's the County has often attempted to lower the barrier beach on the south or north end of the beach.

Breaching the barrier beach reduces the volume of water in the lagoon by as much as 300 to 700-acre feet and eliminates most of the open water habitats in the lagoon ecosystem. The north arm of the lagoon is completely dewatered along with much of the emergent shoreline vegetation around the whole lagoon, including the recently excavated south arm.

There is uncertainty regarding the long term trends related to the width and volume of sediment that make up the barrier beach. Based on data available and personal observations, some claim the barrier beach is as large and healthy as ever, while others point to the general trend of beach erosion along the Central Coast and to recent losses of sand at the Carmel River State Beach as proof of a long term trend. Factors influencing the supply of sand and the shape of the barrier beach complex may include:

- The sand supply has been reduced during the past century by upstream reservoirs and sand and gravel mining. Since the early 1900's, this reduction has totaled as much as five million cubic yards.
- Over the past two decades, bank stabilization projects along the lower 15 miles of the river have further reduced sand supply to the beach.
- The steepness of the beach and the configuration of the longshore bar may be affected by the size of sand being washed out of the watershed. Recent (MEI, 2002) sediment characterization studies at San Clemente Reservoir indicate that much of the material trapped in that reservoir is much finer (0.25-0.40 mm) than the material that is currently supplied to the beach from undammed tributaries and main stem bed and bank erosion (0.5-2 mm).
- Reduced sediment delivery, combined with sea level rise, may result in regression of the barrier beach and bluff erosion. It is not known if this process is already underway.
- Continued artificial breaching of the barrier beach may be contributing to beach sand losses by increasing the frequency of large magnitude outflows that can carry significant quantities of fine and medium grained sand offshore beyond the surf zone.
- Large magnitude, low frequency storm events may dramatically reshape the nearshore and offshore environment and create a sediment sink area that the reduced supply of sand cannot replenish.

The delivery of sediment by river flows to the beach is not well understood, nor are the hydraulic interactions between river flows, variable ocean waves, and tidal fluctuations impacting sediment transport to and from the barrier beach well understood. The historical size trends, migration of the barrier beach, and the stability of the sandy bluff are not well understood.

Ecologic

The artificial lowering of the outlet channel and the draining of freshwater from the lagoon has two direct and immediate impacts. First, it opens the barrier beach to ocean tides and waves, which allows seawater and organic material into the lagoon and can create poor (or lethal) water quality conditions in the remaining, limited open water habitats in the South Arm. Second, the greatly reduced open water area in the drained lagoon subjects fish to an increased risk of predation by birds. These effects are most severe during periods of low inflows.

Thus, a river channel that cuts deeply through the barrier beach through the winter and spring seasons (until flows have nearly ceased in late spring or early summer) keeps the lagoon water volume and elevation very low, which severely limits and compromises the quantity, quality and function of the freshwater lagoon ecosystem.



Temporary sandbags and tarps were used to raise the lagoon water level in Summer 2006

If the barrier beach forms during the spring/early summer period when there is sufficient river flow, the lagoon rises and converts to freshwater, which provides abundant and valuable breeding and rearing habitat during critical life history stages of fish and wildlife species. Alternatively, if the barrier beach forms late after river flows have nearly ceased, a significant volume of saltwater remains in the lagoon over the summer and the volume of aquatic habitat is reduced. The ecosystem remains compromised until winter rains return, bringing river, subsurface, and overland flows which flush out the salt water.

Under natural conditions, barrier beach freshwater lagoon ecosystems are seasonally formed by waves and ocean currents at river mouth beaches. These ecosystems provide abundant and valuable habitat during critical life history stages of many fish and wildlife species. However, it is a dynamic system subject to significant variation. Even under natural conditions, wide variations in habitat characteristics occur year to year.

Fish and wildlife have evolved life history strategies dependent upon these rich and abundant freshwater lagoon ecosystems for the survival of their populations. Compromising the quantity, quality, and function of these ecosystems is a factor in population declines of several fish and wildlife species.

Preliminary Ecologic and Geologic Conclusions

There is no comprehensive long-term, multi-agency plan linking management of the Carmel River and its watershed with management of the Carmel River Lagoon. Effective management of the Carmel River Lagoon will require an understanding of and the ability to effectively work with these complex geofluvial and coastal processes. Therefore, rigorous scientific investigations are necessary to better understand the ecosystem, develop alternative management strategies and assess effects of ongoing and proposed management actions. The understanding and information developed from these investigations are necessary to identify reasonable and prudent management solutions that protect and insure maximum multiple beneficial use of this undeniably beautiful, and potentially rich and abundant environment.



Tagging (shown below) and re-capture of steelhead in the lagoon indicate the numbers of fish that could be at risk.

Comprehensive studies addressing river and ocean sediment interactions as they influence the barrier beach as well as sandy beach bluff integrity are needed. These are the first among the several investigations that need to occur, and are of the highest immediate priority among the several components necessary for development of a comprehensive long term management plan.

Considering the values of the human environment and Public Trust resources at risk, and the potential legal liabilities involved, finding resources and funding for these rigorous scientific investigations should be a high priority.

Regulatory Issues

Since the late 1970's, the County has breached the lagoon as an emergency flood prevention action. In the early 1990's, the California Coastal Commission (CCC), U.S. Army Corps of Engineers (Corps), and California Dept of Fish and Game (CDFG) informed the County that its beach management actions were impacting natural resources and that these actions were not eligible for emergency permits due to the predictability of flooding (i.e., action is needed whenever the lagoon stage reaches an elevation of 10, which occurs regularly). The agencies requested that Monterey County apply for and obtain regular permits to authorize this ongoing activity. In response, Monterey County filed applications with the CCC, CDFG, and the Corps in October 1992 that included the "Monterey County Department of Public Works Interim Plan and Criteria for Emergency Breaching of the Carmel River Mouth, October 1, 1992." The County has followed up at various times in the past 10 years with additional applications and materials. However, the applications have been deemed incomplete due to lack of supporting data and analysis.

Private citizen actions to breach the lagoon outflow channel are without legal authorization. Public or private actions, whether otherwise legal, which result in harm to protected wildlife species, or modification of habitat that directly results in harm to individuals of the species, are illegal pursuant to the State and Federal laws protecting threatened and endangered wildlife. State and Federal wildlife agencies may issue permits for otherwise legal activities which may cause incidental harm, provided that they do not appreciably affect species population size, structure, or range.

Many wildlife species with declining populations, along with the ecosystems on which they depend, are protected pursuant to the statutes of the United States Endangered Species Act, United States Clean Water Act, the California Endangered Species Act, California Fish and Game Code, State Park regulations, and others.

The Carmel River Lagoon is known to support populations of multiple protected species including, Brown Pelicans, Snowy Plovers, South-Central California Coast Steelhead, California Red Legged Frogs, and Western Pond Turtles.

Management actions to preserve functions of the barrier beach and fresh water lagoon ecosystem, and management actions to protect public and private property are necessary. Cooperation of regulatory agencies and stakeholders is essential to the success of the development of an effective management plan intended to find a balance between protection of private property, public infrastructure and Public Trust resources.

Financial

Significant and sustained funding will be necessary to carry out the data collection, analysis and mitigation measures required to balance management of Public Trust resources with protection of public and private property. To date, sources for these funds have not been identified.

Table 1 – Estimate of Study Costs

Agency	Contact	Study	Estimated Cost (\$)	Time to complete study (months)
NMFS	B. Cluer	P 1	30,000	6
NMFS	B. Cluer	P 2	250,000	36
MPWMD	L. Hampson	P 3	60,000	12
MPWMD/ State Parks	K. Urquhart/ K. Gray	P4	125,000	36
MCWRA	B. Phillips	M 1	100,000	36
MCWRA	B. Phillips	M 2	25,000	6
MCWRA/ MCPW	B. Phillips/ V. Lewis	M 3	50,000	12
NMFS	B. Cluer	M 4	30,000	6
MPWMD	L. Hampson	BPS 1	8,000	3
MPWMD	L. Hampson	BPS 2	12,000	3
Estimated Cost (2005)			\$ 690,000	
Contingencies and inflation to 2010			x 1.24	
Total			\$ 855,600	
Study	Title			
P 1	Historical changes and trends of the Carmel River barrier beach and adjacent bluffs			
P 2	Sediment transport and hydrodynamics affecting the Carmel River barrier beach			
P 3	Monitoring beach and river mouth dynamics and correlating with physical processes			
P4	Biological and physical monitoring of Lagoon ecosystem habitat conditions			
M 1	Investigate funding resources to flood proof private residences and public assets within Carmel River lagoon			
M 2	Flood risk reduction for private residences and public assets within the Carmel River Lagoon			
M 3	Engineering analysis for stabilization of the sandy bluff underlying Scenic Road			
M 4	Engineering analysis for stabilization of the sandy bluff through beach replenishment.			
BPS 1	Topography, bathymetry, and historical changes in volume and area of the Carmel River lagoon			
BPS 2	Historical inflow and outflow to the Carmel River Lagoon			

Social

The lagoon and State Beach attract a large number of visitors annually. Historically, during periods of low flow in the winter and spring, waves can close off the lagoon outlet while the river continues to fill the lagoon. Visitors who see the lagoon at a level close to overtopping the barrier beach have sometimes attempted to breach the barrier beach to drain the lagoon. At high lagoon water elevations, this can be easily accomplished by excavating a short trench across the low point in the beach. State Parks has taken steps to discourage this activity, including posting signs prohibiting this activity and increasing ranger patrols at critical times. However, this activity is vandalism that continues to be a factor influencing the level of the lagoon and function of its habitat.

Institutional Issues

Development in low lying flood prone areas around the Lagoon predated modern floodplain regulations adopted in 1984 and modern legislation to protect the environment (e.g., CEQA in 1970, the ESA in 1973, and the California Coastal Act in 1976). More recently, with the listing of CRLF in 1996 and steelhead in 1997 as threatened species, there has been an increasing awareness at all agency levels of the immense value of the lagoon to these and other species of concern. However, responsibility for regulating and managing the resources around the lagoon is divided among no less than 10 local, State, and Federal agencies. None of these agencies have a mandate or the resources to integrate flood protection, recreation, beach restoration, habitat and species protection, infrastructure defense, and watershed management to benefit the lagoon.

Thus, agency actions to manage and regulate the lagoon, surrounding area, and the Carmel River watershed have generally been focused on satisfying individual agency responsibilities. This approach has resulted in uncoordinated management decisions, without an overall plan to balance the various competing interests, which is clearly not a model to continue into the future.

Formation of a TAC comprised of the regulatory and responsible agencies and the formation of the Carmel River Lagoon Coalition have been steps toward integrating resource management. However, there is a need to establish an organization with a mandate and resources to address the immediate problems and to manage the lagoon over the long term.

Overall Scope of Work

STUDY PLAN FOR LONG TERM ADAPTIVE MANAGEMENT OF THE CARMEL RIVER LAGOON AND BARRIER BEACH

1. Problem Definition Statement

- A.** Describe the problem at hand and need for Management Plan
- B.** Regulatory Setting – relevant regulatory agencies and requirements
- C.** Describe process and timeline for developing plan (and those involved in the process)
- D.** Objectives of plan
 - 1. Short-Term Objectives - can also be considered as interim approach to reaching long-term goals
 - (a)** Reduce risk of failure at Scenic Road slope
 - (b)** Reduce risk of erosion at toe of slope
 - (c)** Reduce risk of erosion of Scenic Road slope
 - (d)** Reduce risk of river mouth migration against Scenic Road
 - (e)** Investigate whether there are adverse impacts to sensitive species from flooding and minimize adverse impacts from short-term management actions as feasible
 - (f)** Monitor physical and biological parameters (monitoring plan being developed by MPWMD/State Parks; coordination with other sources of info)
 - 2. Long-term Objectives
 - (a)** Develop management solution that is consistent with all regulatory resource management requirements (e.g., Coastal Commission, NOAA, CDFG, USFWS, USACOE, et al.)
 - (b)** Conduct Alternatives Analysis and select preferred Alternative for managing lagoon and barrier beach
 - (c)** Reduce problems associated with flooding from Carmel River lagoon when river mouth is closed
 - (d)** Reduce adverse impacts to sensitive species from flooding and from breaching events
 - (e)** Restore and/or mitigate areas impacted by management activities (e.g., barrier beach, dune slope to Scenic Road, lagoon and freshwater habitats)
 - (f)** Monitor physical and biological parameters (monitoring plan being developed by MPWMD, and coordinate with other sources of information)

(g) Coordinate/integrate with other ongoing management plans for the Carmel River and watershed

(h) Develop process to allow for Adaptive Management

2. Geographic Extent of Management Plan –

- A.** Eastern boundary = Coastal Zone boundary (area that includes the lagoon) – note: consider expanding to eastern end of Big Sur Land Trust managed properties east of Highway 1.
- B.** North and south boundaries - inland of barrier beach berm crest. This area is approximately represented by the Federal Emergency Management Agency Flood Insurance Study 100-year flood zones (zones A7 and A8 inland of barrier beach berm crest). This area includes low-lying homes along the north side of the lagoon in the 100-year flood zone and areas of shallow flooding.
- C.** North and South boundaries - seaward of barrier beach berm crest. This area extends from the inland extent of Zone A seaward of barrier beach crest, as far north as Carmel River State Beach northern boundary near Carmel Point, and as far south as southern end of Carmel River State Beach (i.e., south unit of Carmel River State Beach), near Granite Point.
- D.** Western boundary. This coincides with the western boundary of the entire Carmel River State Beach (both northern and southern units)
- E.** The management area includes facilities and infrastructure, environmental resources, and public access and recreational amenities that are part of the Carmel River State Beach.
- F.** The management area is part of and affected by requirements of the Carmel Bay Area of Special Biological Significance and the Monterey Bay National Marine Sanctuary.
- G.** The management area is located in and affected by physical processes within the Carmel Bay Littoral Cell
- H.** The management area is part of and is affected by management decisions and actions taken in the Carmel River Watershed
- I.** The portion of Scenic Road along the boundary defined above is included as part of this management plan due to its proximity to the lagoon and potential impacts to the road from management actions.

3. Background Information

- A.** Historical and current physical setting of the management plan area
 - 1. Identify previous studies and work done and what information may be lacking
 - 2. Identify the historical and current conditions at onshore/beach/lagoon – wave climate / tides / flows/offshore bathymetry - can get information from existing documents, with references to these documents in bibliography

3. Historical conditions in the watershed – e.g., hydrology, land-use, water supply, streambank restoration efforts
 4. Identify what changes have occurred over time – prior to human intervention, and post human intervention
 - (a) Watershed overall
 - (b) Lagoon
 - (c) River mouth
- B. Describe History of Management of Carmel River Mouth – identify all the management approaches that have been used in the past to manage the river mouth**
1. Pre-county management history
 2. County involvement and management – including various protocols used in the past, and current protocols
 3. State Parks involvement and management – development of facilities, public access are recreational opportunities
- C. Describe History of Past Breaching Events**
1. Include a chronology of breaching events (natural and mechanical) - can use information from County records, previous documents (e.g., PWA Lagoon Enhancement Plan, etc.)
 2. Include a time-series analysis to show observed configuration/formation of river mouth over time, especially when the river was breached (get info from aerial photos, historical maps and charts)
- D. Describe Physical Processes Affecting Barrier Beach Dynamics and Lagoon Hydrology**
1. Beach morphology - extent and profile changes over time – topographic and geologic setting
 2. Tide, current and beach wave dynamics
 3. Watershed hydrology and climatologic conditions – note proposed FEMA/MCWRA restudy of Carmel River and revised Flood Insurance Rate Maps (confirm date of publication for new maps)
 4. Sediment transport regimes
 - (a) Carmel River watershed
 - (b) Carmel Bay Littoral cell
 5. Examine Effect Of Barrier Beach Management On Hydrology
 - (a) of the lagoon and surrounding aquifer
 - (b) implications for dry season water supply to the lagoon

- (c) potential seawater intrusion of the aquifer
6. Describe How Variability of Physical Dynamics and Management Approaches Can Affect Barrier Beach and Carmel River Mouth Morphology (can use example of what occurred from 2004/2005 and 2005/2006 breaching events—and how it can change the physical conditions at the Carmel River mouth, and lead to specific management actions/concerns)
 - (a) Changes to sand supply in watershed and littoral cell due to past and potential management actions in watershed and along coast
 - (b) Changes to barrier beach topography and beach volume due to past and potential changes in sand supply
 - (c) Changes to wave and tidal dynamics due to changes in sand supply, beach morphology and seasonal and cyclical variability of climatologic conditions
 - (d) Changes in Carmel River hydrology due to past and potential changes in water supply/demand
 - (e) Sediment transport and hydrodynamics (e.g., inputs from river, beach, bluffs, flux through littoral system, losses to submarine canyon due to proximity of Carmel Canyon head)
 - (f) Changes in management purpose/approach/protocols
 - (i) Take into account major changes that might happen in future, e.g.:
 - (1) San Clemente Dam
 - (2) Future water supply projects that might change (+/-) flow regime in river
 7. Potential impacts of flooding on land use and infrastructure - Identify what areas, structures and infrastructure, at what elevations, would be flooded if river mouth is not breached.
 8. Potential impacts to Scenic Road
 9. Potential impacts to State Parks facilities and infrastructure, environmental resources, and public access and recreational amenities
- E. Describe Biological factors and influences**
1. Describe biological setting and requirements
 - (a) aquatic habitats – fauna and flora
 - (b) terrestrial habitats – fauna and flora
 - (c) sensitive species status – known population characteristics and dynamics
 2. Describe factors influencing biological health
 - (a) water quality and salinity

- (i) increased salinity due to overtopping
- (ii) potential freshwater inputs

(b) storm water issues and relationship to Carmel Bay ASBS

F. Describe Cultural Resources and potential impacts

4. Describe and Analyze Alternatives – determine how best to resolve problems associated with river mouth breaching now and into the future. Describe the least environmentally damaging feasible alternative. Each alternative may have a short-term, mid-term and long-term aspect.
 - A. No action alternative – identify opportunities/constraints of unmanaged versus managed ecosystem (i.e., of managing the system, or letting natural processes occur)
 - B. Potential changes in short-term management approach to reduce risks and respond to current conditions.
 1. Establish protocol/barrier beach management practices for winter that reduce potential for a full breach to occur.
 2. Repair of Scenic Road slope - consider both temporary and long term project
 3. Stop or significantly curtail the practice of mechanically breaching lagoon and implement alternative flood control measures, such as construction of temporary flood barriers.
 4. Mechanically manage barrier beach berm crest height (through grading) to avoid accidental breaches in non-optimum locations
 5. Initiate and manage mechanical breach in preferred location to minimize potential erosion of Scenic Road slope
 6. Manage base elevation of outflow channel by maintaining a channel over a bedrock sill or install a temporary or permanent weir structure.
 - C. For short term - (some alternatives not used could be incorporated into long-term alternatives)
 1. Build up Scenic Road slope with compacted soil and/or sand
 2. Re-establish gentler gradient and revegetate slope / dune restoration component
 3. Protect Scenic Road slope from surface water runoff (e.g., improve curb and drainage, install drop inlets to storm-water system)
 4. If breaching is necessary, manage river mouth position away from base of Scenic Road
 5. Use breaching protocols to inform and perform breaching in an approved interim manner
 - D. For long term –

1. Restore beach topography/nearshore bathymetry as well as Scenic Road bluff/State Beach access - what sources are available (sediment sources may be from nearshore/offshore dredging, sediment bypassing of San Clemente Dam, importing of sediment) – factors include cost, transport requirements, other
 - (a) Replace sand lost in the past to raise beach elevation and widen beach
 - (b) Reestablish offshore bathymetry and widen beach to attenuate wave energy
2. Place revetment at toe and some portion of slope
3. Construct vertical retaining wall/seawall at base of bluff – use sand against wall to hide structural elements and revegetate
4. Reduce problems associated with flooding from Carmel River lagoon when river mouth is closed
 - (a) Look into potential to set up a zone of benefit to fund management plan implementation activities
 - (b) remove buildings that flood
 - (c) raise or otherwise flood-proof buildings that flood – look at potential flood-proofing approaches
 - (d) construct floodwall or levee (and possible pumping system) to prevent flooding of existing structures
 - (e) mechanical control of lagoon wse (using additional outlets, pumps, etc.- e.g., possible use of CAWD outfall or new pipe to control wse and improve water quality in lagoon)
 - (f) temporary and removable rubber bladder floodwall to protect north shore homes during high lagoon elevation events
 - (g) manage sandbar maximum elevation below flooding level by mechanically grading to lower berm crest in preferred locations
 - (h) allow breaching only if sensitive species and all coastal resources are protected from adverse impacts
 - (i) time breaching to occur when wave climate, tide conditions and inflow rates are optimum
 - (j) consider flood storage capabilities of adjacent lands in management plan area (e.g., additional storage ponds on Odello or State Parks properties?)
 - (k) consider adjacent land use activities as opportunities and/or constraints
5. describe alternative approaches to reduce adverse impacts to sensitive species from flooding and from sandbar management
 - (a) don't breach
 - (b) avoid breaching

- (c) control base elevation of breach channel to prevent complete lagoon evacuation.
 - (d) Additional freshwater input from wells located in the lower Carmel River Aquifer
 - (e) Additional freshwater input from CAWD treated water
 - (f) Additional (natural) freshwater input from a reduction in groundwater pumping in the Carmel River Aquifer
6. If continued breaching is necessary:
- (a) Reduce loss of sand from the system
 - (i) develop sand budget
 - (ii) initiate and manage breach channel location (if breaching still necessary) to keep sand in system
 - (iii) evaluate additional sand sources
 - (b) Build aesthetically pleasing sill to fix and maintain base elevation control
 - (c) Other measures to mitigate for unavoidable impacts
5. Identify additional info needed to understand impacts/risks/options/constraints
- A. Identify other interested agencies/stakeholders/other possible partners for data collection, management activities, funding coordination, and process for coordination and input
 - B. Obtain historical data from interested parties such as homeowner's associations
 - C. Need new and/or recent bathymetric survey of offshore and of lagoon area (MPWMD to complete lagoon survey and rating curve in 2007)
 - D. Need topographic survey of onshore beach/bluff change
 - E. Need to see if other sand supplies are possible
 - 1. from San Clemente Reservoir?
 - 2. from State Parks, other projects?
 - 3. from potential dredging in Carmel Bay, or other dredging projects in the region?
 - 4. from Beach to the South
 - F. Identify underlying topographic/geologic controls (e.g., bedrock sill) - determine exactly the elevation and extent of where the bedrock sill is under the barrier beach?
 - G. Identify habitat monitoring needs
 - 1. aquatic species – flora and fauna
 - 2. terrestrial species – flora and fauna
 - 3. sensitive species

- 4. water quality**
 - H.** Need elevations and relationship to tide and wave runup to see if sand replacement is really necessary
 - I.** Need to evaluate sand volume lost/needed
 - J.** Need to determine if that quantity is available
 - K.** Compile and complete baseline studies
- 6.** Identify capital and O&M funding sources, opportunities and constraints, potential for setting up zone of benefit and/or geohazard abatement district, potential funding from water users, etc
- 7.** Identify public outreach opportunities for community education, involvement and volunteer opportunities
- 8. Describe Proposed Management Strategy**
 - A.** Develop rating system or criteria for selecting the preferred alternative(s) in line with objectives established in Section 1 above.
 - B.** Describe preferred alternative (may be combination of actions), and any necessary mitigation measures necessary to avoid and/or reduce unavoidable project impacts
 - C.** Describe Implementation and Mitigation plan, including any standard protocols and BMPs that may be necessary
 - D.** Describe timing for implementation, including timelines for priority needs/actions and possibilities for implementing experimental or phased tasks that require and can give resulting information as feedback and input into next steps or phases of activities.
 - E.** Describe Permit Coordination needs
 - F.** Describe coordination with other management plans, ongoing activities
 - G.** Describe Monitoring and Reporting Plan
 - 1.** Physical conditions, including water quality
 - 2.** Biological conditions
 - H.** Describe Adaptive Management Process
 - I.** Describe Emergency Management protocols – identify possible emergency situations, evaluate existing emergency protocols and incorporate any new protocols needed, and how to coordinate with necessary permitting agencies

Baseline Studies to Develop a Long Term Management Plan ²

Investigation of Physical Processes

STUDY SCOPE: P 1 - Historical changes and trends of the Carmel River barrier beach and adjacent bluffs

Problem Statement:

The sand supply to the barrier beach complex has been reduced during the past century by upstream dams, and sand and gravel mining. In the past two decades, widespread bank stabilization has further reduced sand supply to the beach. Reduced sediment delivery and sea level rise may result in regression of the barrier beach, leading to accelerated bluff erosion. Although bluff instability presently exists, it is not known if beach regression is already underway. The historic size trends, seasonal migration of barrier beach sands on and off shore, and the effects on the stability of the sandy bluff are not well understood. Also, little is understood of the interactions between human activities and the natural physical processes in this complex environment.

The Carmel River barrier beach and surrounding sand bluffs have been developed with homes, roads, and recreational infrastructure over the past few decades. These valuable public and private assets are subject to the erosion and aggradation of the sandy deposits as ocean and river processes coalesce in the dynamic physical setting. Multiple changes in the watershed have modified the hydrology and sediment delivery to the barrier beach over the past century. Changes in ocean level and changes in nearby land use and vegetation patterns may also affect the dynamic setting where human constructs strain to coexist with natural processes.

Basic Approach:

Areal size, location, and sand volume of the barrier beach complex may be determined from a systematic analysis of historical photographs, maps and survey information. The areal extent of sandy beach has been examined in a couple previous efforts. These have used only partial data sets, not the entire catalogue of available information, and have not examined volume changes.

Products:

A chronology of sandy beach area and other geometric measures as monitored by the series of aerial photographs, maps, surveys, and bathymetry. The chronology should specify the long term trend in barrier beach size and location with respect to the sandy bluffs. Understanding the long term trend, valuable information needed to predict the future trajectory, is necessary to effectively manage the barrier beach complex.

² All cost estimates were made in February 2006 and should be considered preliminary.

Estimated Cost: NOAA has located and collected some of this historical information. A photogrammetric analysis of aerial photographs is required to determine past beach volumes---\$30k.

STUDY SCOPE: P 2 - Sediment transport and hydrodynamics affecting the Carmel River barrier beach

Problem Statement:

The Carmel River barrier beach is the focus of intense management activities to reduce flood elevations in the lagoon in order to protect low-lying homes and public and private infrastructure. The barrier beach is located where Carmel River delivers sediment via river flows from the dammed and depleted watershed, and where the river and dynamic Pacific Ocean meet. Breaching the barrier beach is also used to direct river flows away from the sandy bluff underlying Scenic Road. Continued mechanical breaching of the barrier beach may be contributing to beach sand losses in the already sediment-limited setting, potentially accelerating bluff erosion. The delivery of sediment to the beach and the hydraulic interactions between river flows, ocean waves, tidal cycles, and littoral currents, and the impacts on barrier beach dynamics are not understood in sufficient detail such that impacts of alternative, or current management schemes can be evaluated. In addition, managing the barrier beach outlet channel solely for human benefits by breaching interferes with the physical processes that sustain biologically productive lagoon elevations that are critical to sustaining populations of several Federal and/or State protected wildlife species.

Basic Approach:

Mapping of currents and sediment transport in the near shore and beach environment would demonstrate the processes of sediment transport within the barrier beach and littoral current setting. Sediment recycling and the fate of sand transported off the barrier beach by the Carmel River in various configurations and wave climates is necessary information to develop in order to manage the sediment resource for long term retention. Similarly, sand transport by wind from the barrier beach to the sandy bluffs is not quantified, but is likely an important process with management implications. These field research efforts should be conducted for multiple wave, tidal, and river flow conditions in order to develop understanding of the range of physical processes acting on beach dynamics.

Products:

Building on the historical trend analysis of beach changes, this scope will develop conceptual and numerical models that couple sediment transport processes in the complex hydrodynamic setting of river processes, near shore and barrier beach ocean processes. The model should reproduce the past history of beach changes as well as have predictive capabilities that can be used to assess different management scenarios and future watershed and ocean conditions.

Estimated Cost: The Coastal and Marine Geology Program of United States Geological Survey (USGS) has expressed interest and willingness to conduct these complex studies. Initial discussions indicate funding for a postdoctoral researcher would be required.----\$250k.

STUDY SCOPE: P 3 - Monitoring beach and river mouth dynamics and correlating with physical processes

Problem Statement

Continued artificial breaching of the barrier beach may be contributing to beach sand losses in the already sediment limited setting. The delivery of sediment via river flows to, and up and down the beach is not understood. Nor is the impact of hydraulic interactions between river flows, variable ocean waves, and tidal fluctuations on sediment transport to and from the barrier beach well understood. Starting in the early 1990's, the County has always attempted to lower the barrier beach on the south or north end of the beach in an effort to minimize impacts to the lagoon ecosystem and protected species. However, due to river mouth migration caused by little understood physical processes, and/or unauthorized breaches by private citizens, the lagoon has ended up being breached throughout critical breeding and rearing periods of threatened and endangered wildlife species, severely compromising the habitat value for populations of these protected wildlife species.

Basic Approach

It is known that the mouth of the Carmel River migrates either north or south along the barrier beach. The direction of migration is thought to depend on ocean swells, littoral current direction and perhaps tidal fluctuations. However, why it migrates one way or the other, and under what ocean conditions is not understood. Monitoring the river mouth and beach dynamics real time, and correlating with the recorded ocean physical processes of swell size and direction, tidal fluctuation, and correlated littoral current direction is necessary to develop the knowledge and understanding which will be necessary to ensure the effectiveness any plan for management of the Carmel River Lagoon. Real time monitoring would use one or two stationary video cameras to take time lapse photography of the river mouth and beach dynamics and could help discourage illegal breaching activity.

Products:

The time stamped video would be correlated with recorded ocean conditions of swell height and direction, tidal fluctuation and littoral current direction along with river flow levels. Analysis and correlation of these variables would determine which direction the river mouth might migrate under variable river and ocean conditions. This information would be invaluable in planning management actions to protect property and ecosystem values of the lagoon. The video would also be available on a website in near real time for viewer observation and analysis.

Estimated Cost:

Preliminary discussion with Dr. Ed Thornton of the Monterey Naval Post Graduate School indicate he would be interested and willing to fold this study scope into similar ongoing research he is conducting at other sites along the Central Coast with funding from NOAA. The costs of additional equipment and personnel for web posting and analysis of results.-----\$60k.

STUDY SCOPE: P4 - Biological and physical monitoring of Lagoon ecosystem habitat conditions

Problem Statement

The Carmel River Lagoon is known to support populations of multiple protected wildlife species including, Brown Pelicans, Snowy Plovers, South-Central California Steelhead, California Red Legged Frogs, and Western Pond Turtles. Continual breaching of the barrier beach through the winter and spring seasons (until flows have nearly ceased in late spring or early summer) severely limits and compromises the quantity, quality and function of the freshwater lagoon ecosystem. The ecosystem remains compromised until winter rains return, bringing river, subsurface, and overland flows, which flush out the salt water.

Basic Approach

A comprehensive monitoring of the physical habitat conditions and the seasonal responses of the biota of the lagoon is needed to ensure management planning takes into account the range of impacts management actions have on the primary and secondary productivity of the lagoon ecosystem. The recovery of threatened and endangered species will be much more likely if greater understanding of critical life history associations with the lagoon environment are incorporated into the long-term plan for management of the Carmel River Lagoon.

Products

Qualitative and quantitative description and modeling of lagoon wildlife species population responses to changing seasonal and physical habitat conditions, and projection of responses to management alternatives.

Estimated Cost:

Initial discussions between State Parks, the California Dept. of Fish and Game, US Fish and Wildlife Service, NOAA Fisheries, and the Monterey Peninsula Water Management District indicate a willingness to collaborate on these studies. Costs to State Parks and Fish and Game would be for seasonal aides, and analysis of data and report preparation. ---\$125k

Evaluation of Management Alternatives

STUDY SCOPE: M 1 – Investigate funding resources to flood proof private residences and public assets within Carmel River lagoon

Problem Statement:

Monterey County and other public and private agencies have infrastructure within the 100-year floodplain surrounding the Carmel River lagoon. Seasonal barrier beach elevations of Carmel State Beach cause flooding within the 100-year floodplain for flows in the Carmel River which have very short repeat frequencies (at least yearly or more frequently). To reduce flood risk, the County excavates an outflow channel across the barrier beach to lower lagoon water surface elevations. Additionally, private citizens take it upon themselves to continue to breach the river when they feel threatened, which is not legal and can have serious unintended consequences both to the physical setting and to legally protected wildlife species.

Flood reduction by artificially breaching the Carmel River barrier beach results in rapid evacuation of the highly productive lagoon ecosystem, an ecosystem crucial to the survival of declining populations of several State and Federally listed and protected species. Breaching is not authorized by any regulatory purview other than emergency measures. Repeated breachings yearly, and over several decades is not recognized as an emergency.

Basic Approach:

Federal and state programs have addressed repeat flood insurance problems through the development of flood protection programs. These programs include funds for relocating, elevating, purchasing, and other means of flood proofing homes and infrastructure in flood prone areas.

Products:

An exhaustive desktop investigation into funding resources from federal, state, local, and private sources. Alternatives analysis to determine which methods of flood proofing are feasible. Development of a public education program to foster support and buy-in for flood proofing. A management plan for implementing a funded flood proofing program.

Estimated Cost: \$100k

STUDY SCOPE: M 2 – Flood risk reduction for private residences and public assets within the Carmel River Lagoon

Problem Statement:

Monterey County has public infrastructure and permitted homes within the 100-year floodplain, and below Ordinary High Water elevations of the Carmel River Lagoon. To reduce flood risk, the County excavates an outflow channel across the barrier beach to lower lagoon water surface elevations. Additionally, private citizens take it upon themselves to continue to breach the river when they feel threatened, which is not legal and can have serious unintended consequences both to the physical setting and to legally protected sensitive wildlife species.

Flood reduction by artificially breaching the Carmel River barrier beach results in rapid evacuation of the highly productive lagoon ecosystem, an ecosystem crucial to the survival of declining populations several listed and protected species. Breaching is not authorized by any regulatory purview other than emergency measures. Repeated breachings yearly and over several decades is not recognized as an emergency by any regulatory agency and is thought to be taking a high toll on protected species. Alternative engineering innovations providing structural solutions to prevent flooding may be feasible methods to prevent the rise of floodwaters, which inundate homes and infrastructure surrounding the lagoon.

Basic Approach:

An exhaustive desktop evaluation of structural alternatives. Innovative structural alternatives to breaching the barrier beach may include surface and/or piped spillways, an inflatable buried dam or buried and anchored redwood logs, and perhaps other structures as well.

Products:

A comprehensive desktop evaluation of structural alternatives to determine which methods of flood reduction and control are technically feasible in this setting. Cost estimate for: raising, or purchasing (from willing sellers) and removing structures; constructing temporary or permanent flood control facilities; operation and maintenance costs for all alternatives or combination of alternatives.

Estimated Cost: \$25k

STUDY SCOPE: M 3 - Engineering analysis for stabilization of the sandy bluff underlying Scenic Road

Problem Statement:

The sandy bluff underlying Scenic Road is at risk for erosion from ocean waves, from sea level rise, from sediment depletion, from recreational uses, and from river flows. The bluff is a narrow and fragile defense between immensely powerful physical processes and the human environment of valuable public infrastructure and private homes. Solutions to bluff stabilization can be addressed independently of solutions to the lagoon flood management issues. A stabilized bluff can relieve the risk of river processes as well.

Basic Approach:

Gather and organize existing data on near shore bathymetry, barrier beach topography, ocean waves and currents, river scour potential, and engineering materials of the bluff. Standard engineering evaluation of forces applied to bluff and calculation of resistive strength required for stabilization.

Products:

An engineering evaluation of proven structural alternatives to stabilize the sandy bluff underlying Scenic Drive. Structure shall be capable of withstanding ocean processes including sea level rise and barrier beach diminishment, as well allowing for river flows to impinge along the toe of the slope. Preliminary engineering designs for feasible alternatives consistent with regulatory requirements, including cost estimation of constructing and maintaining the structures, and mitigation measures that may be necessary to avoid and/or reduce possible adverse impacts.

Estimated Cost:

\$50k

STUDY SCOPE: M 4 - Engineering analysis for stabilization of the sandy bluff through beach replenishment.

Problem Statement:

The sandy bluff underlying Scenic Road is at risk for erosion from ocean waves, from sea level rise, from sediment depletion, from recreational uses, and from river flows. The bluff is a narrow and fragile defense between immensely powerful physical processes and the human environment of valuable public infrastructure and private homes. Solutions to bluff stabilization can be addressed independently of solutions to the lagoon flood management issues. A stabilized bluff accomplished through beach replenishment, which extends the beach seaward and vertically, would also reduce the risk of river caused erosion as well.

Basic Approach:

Gather and organize existing data on near shore bathymetry, barrier beach topography, ocean waves and currents, river scour potential, and materials of the bluff. Standard engineering evaluation of forces applied to beach-bluff complex, and of the necessary sand volume and supply rate needed over time to prevent erosion of the beach-bluff complex. This evaluation would also incorporate the information developed from **STUDY SCOPE: P 2**, Sediment transport and hydrodynamics affecting the Carmel River barrier beach.

Products:

An engineering evaluation of the cost and feasibility to stabilize the beach and sandy bluff underlying Scenic Drive through beach replenishment. The evaluation would include evaluation and cost estimates for supply and transport of sand from potential sources such as the sediments stored behind San Clemente Dam, dredge materials from offshore in Carmel Bay or other dredging sites. Preliminary engineering evaluations would consider not only costs and feasibility, but also consider aesthetic and community concerns, and identify potential mitigations for impacts.

Estimated Cost: \$30k

Baseline Studies of Physical Setting

STUDY SCOPE: BPS 1 - Topography, bathymetry, and historical changes in volume and area of the Carmel River lagoon

Problem Statement:

Development of a reasonably accurate and predictive numerical model of the hydrodynamics in the Carmel River Lagoon and at the barrier beach depends on similarly qualified reconstructions of water volume in the lagoon over the historical period from 1991 through 2005. This period corresponds to the historical stage record for the lagoon, which can be correlated to estimates of volume during four periods: 1991-1994; 1995-1998; 1999-2003 and 2004-on.

Basic Approach:

Areal size, volume, and stage of the Carmel River Lagoon may be determined from a systematic analysis of historical photographs, maps, topographic survey information and updated with a new, topographic survey of the lagoon surface waters and surrounding wetlands. The volume of water has been determined in two previous efforts and this information as well as updated topographic surveys will be used to provide volume, depth and stage relationships during the four key periods. Once developed, these relationships can be used to reconstruct a historical time-series of volume and area for the period from 1991-2006 (current).

Products:

Relationships for volume, area and stage will be provided for key historical periods. A time-series of volume and area for the period from 1991 to 2006 (current) will be reconstructed using continuously recorded stage and runoff data and summarized in standard USGS formatted data report style. Understanding the long-term, seasonal and short-term changes in lagoon volume and area is valuable information needed to understand historical habitat values and predict the future changes in water quality and aquatic habitat values.

Estimated Cost: \$8K

Partially funded by MPWMD through Prop 50 Grant tasks (updated topography, but additional funds may be needed to conduct remainder of tasks.

STUDY SCOPE: BPS 2 – Historical inflow and outflow to the Carmel River Lagoon

Problem Statement:

The timing and volume rate of inflow and outflow to the Carmel River Lagoon are key components in developing understanding the complex nature and interaction of sediment movement and the hydraulic interactions of outflow with ocean waves, tidal cycles, and littoral currents. Yet, the existing information on inflow (streamflow at Highway One), lagoon stage and volumes has not been assembled into one coherent, reconstructed time series of inflow, stage, volume, and outflow. This information is needed in order to conduct the studies scoped in P1 and P2, following.

Basic Approach:

A standard model for reservoir operations will be applied to the lagoon using historical measurements of stream flow and lagoon stage and historical estimates of volume to solve for lagoon outflow.

Products:

A time-series of inflow, stage, volume and outflow will be provided for the period from 1991 to 2006 (current) and summarized in standard USGS formatted data report style. Understanding the long-term, seasonal and short-term changes in lagoon outflow is valuable information needed for developing an hydrodynamic model of flow and sediment and to understand historical habitat values and attraction events for adult steelhead and predict the future changes in water quality and aquatic habitat values.

Estimated Cost:

\$12K

As noted above, partially funded by MPWMD through Prop 50 Grant tasks but additional funds/staff time are needed to conduct remainder of tasks.

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