North Coast Highway 101 Streetscape Project
Leucadia Flood Abatement Design

Marine Biology Technical Report

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Technical Memorandum

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SUMMARY

The North Coast Highway 101 Streetscape Storm Drain Improvement Project will result in a smaller amount of stormwater runoff to the West Basin of Batiquitos Lagoon during 2-year storm events than presently occurs, but a larger discharge of stormwater runoff during 5-, 10-, 50, and 100-year storm events (MBI 2020). The West Basin supports sensitive vegetation habitats (e.g., pickleweed/cordgrass marsh and eelgrass beds), diverse fish, benthic invertebrate, and avian communities, including threatened and endangered bird species (Belding's savannah sparrow, California least tern, light-footed clapper rail, Western snowy plover). Water quality potentially could be degraded, and biological resources potentially could be adversely impacted by these increased stormwater discharges into the basin.

The analysis focused on the four primary effects of the increased runoff that would be expected to contribute to potential biological impacts within this unique setting: erosion from high velocity discharges; dilution and salinity depression; sedimentation in the West Basin; and increased pollutant load transported by runoff as a result of the project.

No adverse impacts to water quality or biological resources would be expected to occur due to the discharge of stormwater runoff into the West Basin of Batiquitos Lagoon under any of the scenarios evaluated (2-, 5-, 10-, 50-, and 100-year storm events). The dissipator structure associated with the storm drain outlet would reduce the velocity of the stormwater discharge for all storm event scenarios below the level at which scour of existing vegetation would occur, so no adverse impact would be expected. Minimal depression of salinity associated with stormwater runoff would not be expected to impact eelgrass or other wetland vegetation, fish and benthic invertebrate communities, or avian communities, including special status species. Very little deposition of sediment would occur within the West Basin due to the stormwater discharge, and "first flush" runoff from the project (that which contains the highest pollutant loads), would not be discharged into the lagoon, so no adverse impacts would be expected to eelgrass or other wetland vegetation, fish and benthic invertebrate communities, or avian communities, including special species status.

PROJECT DESCRIPTION

The North Coast Highway 101 Streetscape Storm Drain Improvement Project includes the installation of storm drains and conduits along Highway 101 in Northwest Encinitas / Leucadia to reduce the potential for flooding in the area. The Project will install pretreatment basins for water quality treatment of stormwater before the water enters the conduit, which will flow to the Ponto Beach basin on the west side of Highway 101 and eventually out to the Pacific Ocean. During many rainfall events, the Ponto storm drain system will not be able to handle all of the runoff water, and in that event pretreated stormwater will be diverted into the West Basin of Batiquitos Lagoon (Figure 1).

This technical memorandum provides a review of existing information pertaining to marine biological and marine water resources of Batiquitos Lagoon, particularly within and adjacent to the West Basin. The technical memorandum also includes an evaluation of the potential for adverse impacts related to the project.

Figure 1. Existing Batiquitos Lagoon stormwater outfalls and proposed junction box.

DESCRIPTION OF BATIQUITOS LAGOON

Batiquitos Lagoon is an approximately 600-acre coastal lagoon located in the City of Carlsbad in San Diego County, California. It is bounded by Pacific Coast Highway/Carlsbad Boulevard on the west, La Costa Avenue on the south, El Camino Real on the east, and Batiquitos Drive and the Aviara Community to the north.

El Camino Real and commercial and residential lands are present to the east of the lagoon. A golf course, agricultural lands, and additional residential development are present to the north. La Costa Avenue lies along the southern edge of the lagoon and separates the lagoon from steep bluffs. The area south of La Costa Avenue includes open land and residential development. Interstate 5 (I-5), Carlsbad Boulevard, and South Carlsbad State Beach are present to the west.

The Batiquitos Lagoon watershed is approximately 52 square miles and is drained by three stream systems that empty into the eastern end of the lagoon. San Marcos Creek is a major tributary and is dammed at Lake San Marcos within 5 miles of the lagoon. An unnamed tributary joins San Marcos Creek less than 1 mile upstream of the lagoon, and this small tributary drains a small area to the northeast. Additionally, water levels in the lagoon are controlled by tidal waters entering and exiting through the lagoon's outlet.

The lagoon is divided by several transportation corridors into Eastern, Central and Western Basins (Figure 2). In the larger Eastern Basin, post-restoration (1996 as-built) depths extended to -8 feet Mean Lower Low Water (MLLW) along a channel extending from the San Marcos Creek outlet to the I-5 underpass.

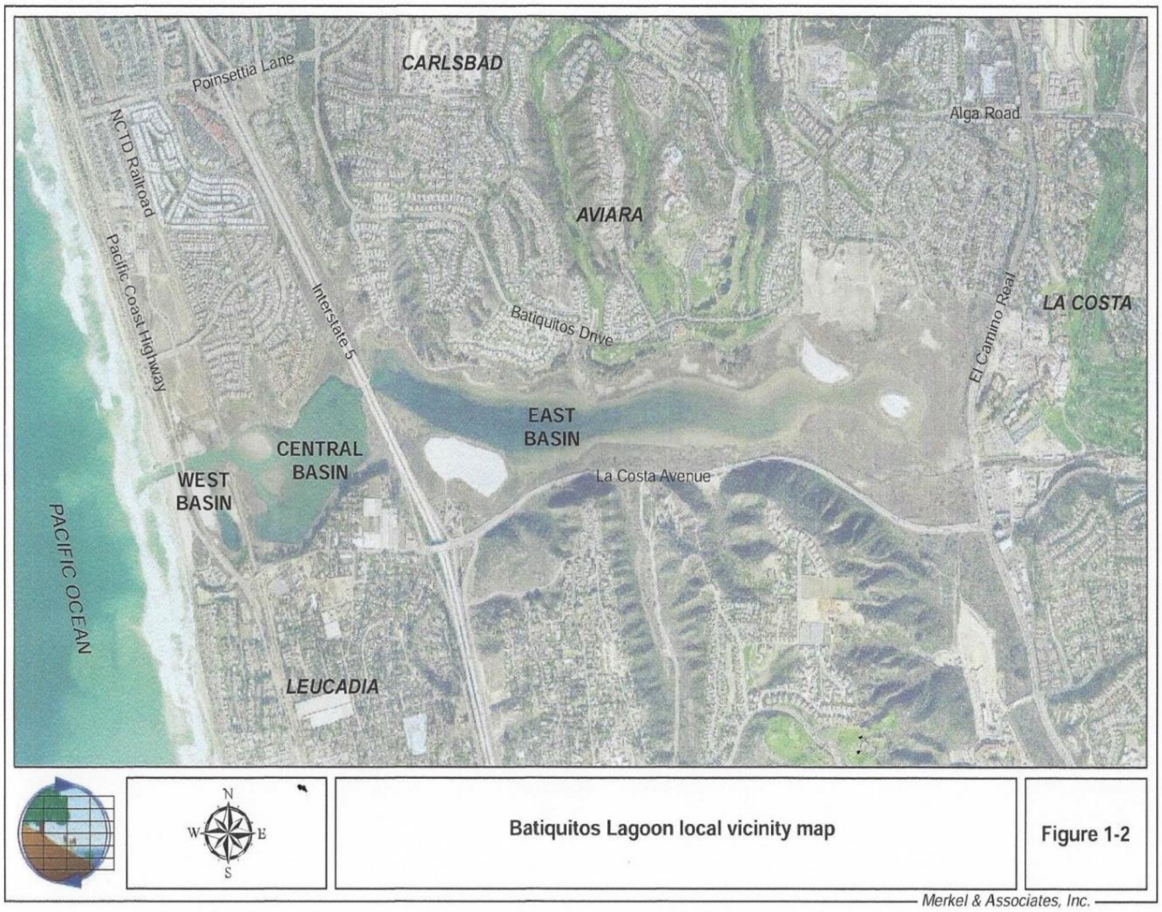


Figure 2. Batiquitos Lagoon local vicinity map (from Merkel and Associates 2009).

Stormwater discharges flow into various locations within Batiquitos Lagoon. Local surface drains discharge to the lagoon from I-5, La Costa Boulevard, El Camino Real, and residential streets adjacent to the lagoon. Caltrans has constructed a stormwater basin adjacent to the La Costa exit ramp off I-5. This stormwater basin has been designed to treat stormwater from I-5 prior to discharge to the Central and East Basins of the lagoon. Another significant stormwater outfall is located on the northern portion of the eastern basin that discharges stormwater from the Aviara community and golf course detention basin. Stormwater discharges also occur in the northeastern corner of the eastern basin from the developments bordering Alga Boulevard (WRA and AECOM 2009).

DEGRADATION AND ENHANCEMENT OF BATIQUITOS LAGOON

Historically, Batiquitos Lagoon was a tidal system. However, the lagoon was largely non-tidal for much of the 20th century, experiencing infrequent tidal circulation. Natural changes within the lagoon environments were accelerated and altered by human intervention in the form of poor watershed management and local modifications to the lagoon, including the construction of a number of partial fill and bridge crossings (Southern Railroad, Pacific Coast Highway, Santa Fe Railroad, and Interstate 5). Other factors causing degradation of the lagoon included the construction of the San Marcos Dam upstream of the lagoon in 1952, episodic flood events, the discharge of treated wastewater into the lagoon between 1967 and 1974, and a failed effort near the turn of the century to dike portions of the lagoon to establish salt harvesting ponds (California Coastal Conservancy 1989). The additional freshwater input from wastewater discharges altered salinity gradients within the lagoons, contributing to an expansion of freshwater/brackish vegetation in areas historically dominated by more salt-tolerant plants (Beller et al, 2014). The wastewater also contributed to elevated nutrient concentrations in the lagoons, leading to eutrophication and water quality problems. The bridge restrictions to flow within the lagoon and heavy development of the lagoon watershed resulted in a significant influx of sediment into the lagoon. Additionally, heavy agricultural and residential land-use resulted in nutrient loading from fertilizers and increased run-off (CH2M Hill 1989).

By the early 1970s, the lagoon ecosystem had notably deteriorated and by the early 1980s had achieved an advanced state of sediment infilling and eutrophication. The wetland habitat within the eastern lagoon was progressively being converted to uplands due to increased sedimentation. During spring months, algal blooms substantially covered the lagoon as evidenced by the large mats of green macroalgae and the green-colored phytoplankton blooms commonly present. During the summer months, an odor of decaying algae extended for up to two or more miles around the lagoon. Associated with the nutrient rich, shallow, closed conditions in the lagoon, dissolved oxygen, salinity, water temperature, pH, and other water quality parameters were highly variable on a diurnal and seasonal basis (CH2M Hill 1989; City of Carlsbad and U.S. Army Corps of Engineers 1990).

Local recognition of a need to intervene in the accelerating decline of Batiquitos Lagoon led to the establishment of an “enhancement group” to develop goals and objectives for restoration of the lagoon. This resulted in the development of an enhancement plan by the California Coastal Conservancy in 1987. Enhancement plan goals included restoration of tidal flushing, while maintaining existing habitat values (Merkel and Associates 2009).

In 1987, the Port of Los Angeles (Port), City of Carlsbad (City), U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), California Department of Fish and Game (CDFG), and State Lands Commission (SLC) signed an interagency agreement pertaining to the restoration of Batiquitos Lagoon. The restoration would serve as mitigation for loss of marine resources in Outer Los Angeles Harbor due to Port construction activities. The lagoon was to be maintained by CDFG using a maintenance fund account provided by the Port (Merkel and Associates 2009).

After a lengthy period of environmental documentation, design, and permitting, lagoon restoration began in March of 1994. Work entailed a sequential process of dredging and infrastructure improvements. The major construction elements included: 1) dredging sand from the central basin, located between the North County Transit District railroad trestle and Interstate 5 (I-5), for use in beach replenishment and creation of tern colonies in 1994-1995 and to create a borrow pit in the central basin; 2) placement of fine materials dredged from the east basin, located east of I-5, into the central basin borrow pit and construction of the lagoon mouth jetties in 1995-1996; and 3) capping the central basin borrow pit that had been filled with fine sediments with sand dredged from the west basin, between Pacific Coast Highway (Carlsbad Boulevard) and the railroad. On December 6, 1996, the restoration was completed with the opening of the lagoon mouth to reestablish continuous tidal flushing. Subsequent to the mouth opening, minor additional work was completed during the first quarter of 1997 to remove and re-contour launch facilities that were used for lagoon construction access in the east basin, remove a high sill within the entrance channel of the lagoon, enhance the revetment along the railroad bridge abutments, weed and repair erosion damage at nesting sites ahead of the 1997 nesting season, and plant pickleweed (*Sarcocornia pacifica*) along portions of the northern shore of the east basin (Merkel and Associates 2009). Total costs for the Batiquitos Lagoon Restoration Project were estimated at $55 million.

HYDROLOGY

Tidal Conditions

Comparison of historical tidal data for Batiquitos Lagoon revealed that the overall pattern of the tidal patterns was the same immediately after the restoration in 1997 as it was ten years later in 2008 (Merkel and Associates 2009). The lagoon high tides generally equaled or were close to the level of the ocean high tides, but the lagoon low tides did not fall to as low a level as the ocean low tides. The principal determinants of the tidal conditions in the lagoon were the ability of water to fill the lagoon as the ocean tide rose and then its ability to drain as the ocean tide fell within the time period of an ocean tide cycle.

The effects of constrictions on tidal exchange were most significant under low tidal amplitudes and ebbing (falling) tides (Merkel and Associates 2009). As the ocean tide dropped, creating a gradient between the ocean and lagoon, the surface water initially was able to exit the lagoon relatively unrestricted. However, as the lagoon became shallower, the water experienced a reduction in the differential head between the lagoon and the ocean, diminishing the cross-sectional area through constricted channels and increasing the effect of bed friction within the channels. Forcing the ebbing water through a smaller area impeded its flow to such a degree that the lagoon could not fully drain out before the ocean tide had already reached its low and begun to rise again. Tidal impairments of this sort were greatest during periods of high rates of water exchange during spring tide periods, when the lowest and highest tides occurred.

On the incoming tide, physical constraints on tidal exchange had less of an impact (Merkel and Associates 2009). As the tide rose, the widening of the effective flow areas and the increasing water depth both rapidly increased the cross-sectional flow area and reduced the importance of bed friction. Further, tidal flow was enhanced by wave propagation into the inlet from ocean swells.

From July 2 to October 6, 2008, the maximum tidal range in the Pacific Ocean at La Jolla was higher (8.9 feet), compared to 7.5, 7.2, and 6.7 feet in the West Basin, Central Basin, and East Basin of Batiquitos Lagoon (Merkel and Associates 2009). Although mean higher high water was similar in the ocean (5.7 feet) and the West, Central, and East Basins (6.0, 6.0, and 5.9 feet, respectively), mean lower low water was higher in the three basins (1.1, 1.2, and 1.4 feet in the West, Central and East Basins, respectively) than in the ocean (0.4 feet). Similarly, the highest water level in the ocean (7.4 feet) was similar to that in the three basins (7.5, 7.4, and 7.4 feet), but the lowest water level in the ocean (-1.5 feet) was lower than in the three basins (0.0, +0.3, and +0.7 feet). In addition, there was a significant lag of the low tide in Batiquitos Lagoon due in part to the “pinch points” at transportation corridor crossings and increased sediment accumulating in the lagoon’s basins. During the lowest spring tides (around the full and new moon periods), the maximum lag in the West, Central, and East Basins was 96, 120, and 186 minutes, respectively. Although there also was a time lag in the three basins during high tides, it was much less pronounced than during low tides. Maximum tidal velocity at the lagoon inlet during flood tide conditions during dry weather has been estimated at approximately 3.2 feet per second (Jenkins and Wasyl 2010) and 3.8 to 4.4 feet per second, compared to approximately 5.5 feet per second during ebb tide (Moffatt and Nichol 2012). Residence time for water in the West Basin was estimated at approximately 0.6 days (Moffatt and Nichol 2012).

Flood tide currents entering Batiquitos Lagoon form a well-defined jet through the West Basin at speeds of roughly 0.6 m/s (1.96 ft/sec), sufficient to transport fine grained beach sand in the 120- to 210-micron size regime into the West Basin and beyond. A sluggish disorganized eddy persists in the south arm of the West Basin, while the middle portion is near stagnation, ideal conditions for fine sand to settle and form sand bars of beach grade sand (Jenkins and Wasyl 2010).

Sedimentation

Following completion of the Batiquitos Lagoon Enhancement project in 1997, ocean swells propagating into the lagoon through the entrance channel created a dynamic swell environment within the small West Basin (Merkel and Associates 2009). The pulsing action from these ocean swells immediately began to erode the unconsolidated steep sand shoreline of the W-2 snowy plover nesting site on the western bank of the West Basin. During periods of both high swell and high tide, breaking waves were generated that impacted against the abandoned railroad spur that remained standing on the east bank of West Basin after construction. Winter storms of 1997-1998 further cut the railroad spur to a vertical, highly reflective and erosive scarp. By 1999, the railroad spur was cut all the way through, leaving only a small portion of the spur that was armored by rock and treated wood timbers. The erosion of the remaining portions of the eroded spur continued in subsequent years and now the armored tip is supported by only a few remaining timbers. Wave reflection off of the steep banks of the spur further exacerbated erosion of the W-2 nesting site across the main channel of West Basin from the spur.

Over the 10-year monitoring period (1997 to 2006) following completion of the Batiquitos Lagoon Enhancement Project, sedimentation, presumably from major storm events, filled the eastern end of the East Basin and lagoon depths there were decreased by 2 to 4 feet (from the as-built depth of -8 feet MLLW) (Figure 3). The Central and West basins restoration as-built depths generally extended to -8 feet as well, with some deeper pools at the I-5 crossing. Soon after restoration (in 2000), flood shoals began to develop in these basins from tidal action, decreasing depth in portions of these two basins by 2 feet or more. From 1996 to 2008, sediment accumulation was estimated at 78,995 cubic yards, with erosion accounting for the loss of 18,641 cubic yards and maintenance dredging accounting for removal of 31,026 cubic yards of sand, resulting in net accumulation of 29,328 cubic yards of sediment over this 13-year period (Merkel and Associates 2009).

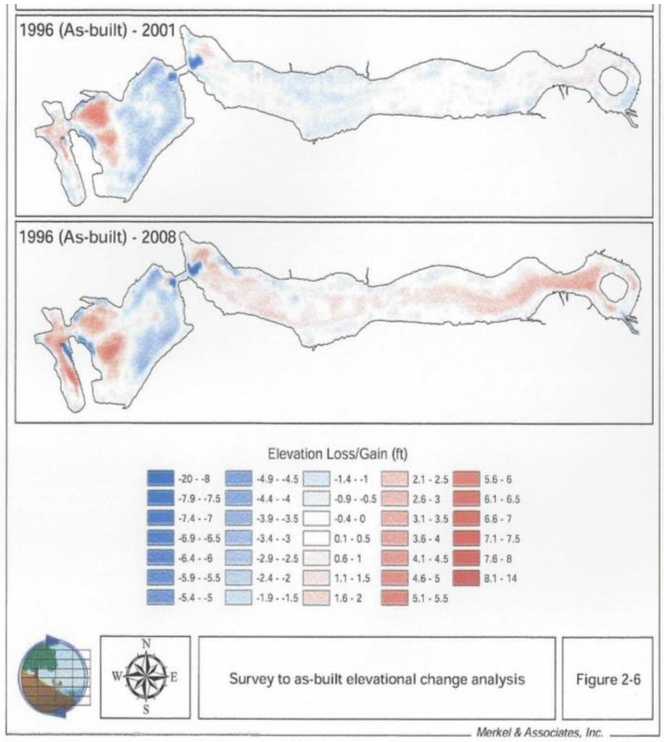


Figure 3. Elevational changes in Batiquitos Lagoon between 1996 (as-built) and 2008 (from Merkel and Associates 2009).

As the shoals built within the effective flow areas of the basins, they influenced the wave environment and tidal currents in proximity to the shoals. The altered course of waves in the West Basin contributed to shoreline erosion and sand accumulation in the north cove of the West Basin and in the southern arm of the basin. As the shoal built up within the widened reach of the main channel, greater restriction of flows occurred along narrow routes at the shoal margins. This led to erosion of the banks of the western shores of the central portion of the basin as tidal flows formed deep narrow channels that migrated into the marshlands. The channel migration resulted in losses of approximately 1.5 acres of pickleweed marsh.

Several episodic events between 1997 and 2008 contributed to sediment loading within Batiquitos Lagoon (Merkel and Associates 2009). The first was the restoration of tidal influence to the lagoon, which resulted in the development of extreme drainage gradients at the outflow delta of San Marcos Creek and led to littoral sand capture and deposition within the flood shoals in the West and Central Basins, as well as bluff erosion near the lagoon entrance. During 1997, scouring by the San Marcos Creek outflow began to form a new channel across the sediment fan where it joins the lagoon. In 1998, this channel was further eroded by storm flow discharges from San Marcos Creek and Encinitas Creek. A second major event was the heavy rainfall during the 1997-1998 El Niño. The season resulted in a rainfall yield with a regional probabilistic recurrence frequency of once every 17.4 years and ranked as the ninth wettest year in the 158- year regional rainfall history of the area. Exacerbating the high seasonal rainfall during 1998 was the fact that the rainfall accumulation pattern was made up of a number of very large, late season storms that led to heavy flooding and high sediment and debris flows being generated from local watersheds. A third large potential contributor of sediment into the lagoon was the record rainfall in the 2004-2005 winter season which likely accounted for the bulk of the sedimentation observed in the East Basin after 2001. The 2004-2005 water-year was the third wettest year in the regional rainfall history. At 22.49 inches, the year was only 3.48 inches behind the highest rainfall season of 1883-1884.

Maintenance dredging has not occurred frequently enough to prevent flood shoal accumulation well above the quantities envisioned by the original design (Merkel and Associates 2009). This resulted in a deteriorating tidal circulation pattern, with the lower end of the tidal range being truncated, increasing low tide lag behind the ocean tides, and a greater degree of distinction between the tidal patterns for the lagoon basins. The continued tidal muting of the lagoon by flood shoal accumulation combined with sediment infill at mid-tide elevation ranges resulted in reduction of the lagoon’s tidal prism (Figure 4).

Several conditions exist that may increase the risk of mouth closure for Batiquitos Lagoon (Merkel and Associates 2009). First, there was a large accumulation of sand within the West and Central basin flood shoals following completion of the lagoon restoration project. This large accumulation of sand created relatively circuitous flow patterns during the low flood and ebb tide conditions and would provide a considerable source of sand for potential closure events. Second, the West Basin was known to contain a fairly substantial amount of cobble material, which could add to the potential for accumulation of a stable inlet bar. Third, tidal flow constrictions at the I-5 bridge and railroad trestle extend the hydrograph for the lagoon, thus lowering the velocity generated in flooding and ebbing tides. Finally, shoaling within the West Basin nearly closed off the southern arm of this area in the ten years following completion of the restoration project. The West

Figure 4. Shoal conditions in the West Basin and East Basin in 2008 (from Merkel and Associates 2009).

Basin constituted only approximately 6% to that of the overall lagoon; however, much of this area could be easily lost due to a single storm event. Two factors counteracting the conditions favoring mouth closure are the maintenance dredging that has been conducted periodically to remove shoals and the fact that Ponto Beach does not approach the ends of the entrance channel jetties.

Bathymetric data collected during the post-restoration lagoon evolution was limited but documented the observed or anticipated changes such as shoal accumulation, dredging to export accumulated sand, bed scouring erosion, shoreline erosion, and deeper channel deposition (Merkel and Associates 2009). Sediment inputs from multiple sources including littoral sand deposition within the flood shoals, fluvial erosion inputs from San Marcos Creek, small local drainages, and bluff erosion, resulted in the net input of approximately 140,000 cubic yards of sediment in the lagoon when comparing the as-built (1996) conditions to those existing in 2008, when the most recent bathymetric investigation was performed.

The reduced tidal prism associated with the buildup of the flood shoal may have contributed to the greater capture of fine sediments within the lagoon (Merkel and Associates 2009). It also appears that the same degree of sediment flushing that may have occurred early in the lagoon's history did not occur in later years after completion of the restoration project. Some storm deposited materials may be eventually flushed from the system; however, the prolonged residence of sediment results in increased consolidation and cohesiveness that resists subsequent suspension and transport out of the system. As a result, while limited erosion of the fine sediments in the East Basin could be anticipated in the future, it is unlikely that substantial export will occur without a rehabilitation dredging event to remove fine sediments from this area

Maintenance dredging of Batiquitos Lagoon has historically targeted the removal of portions of flood shoal volume that had accumulated above as-built bottom contours. The annual rate of shoal sand infill was estimated to be approximately 33,000 to 52,000 cubic yards per year, with the most recent estimate of annualized shoaling rate being approximately 35,000 cubic yards per year. Maintenance dredging performed from 1998 through 2007 removed 206,838 cubic yards of sandy sediments from the lagoon (Merkel and Associates 2009). The California Department of Fish and Wildlife (CDFW) maintenance dredging project removed 112,000 cubic yards of sand from the lagoon in 2011 and 140,000 cubic yards of sand in 2012; this material was placed on South Ponto Beach. CDFW dredged 118,000 cubic yards of sand between September 2019 and February 2020 and transferred the material via pipeline onto South Ponto State Beach north of Encinitas (California Coastal Commission 2017).

Stormwater Runoff

According to data presented in the Batiquitos Lagoon Enhancement project EIR/EIS (City of Carlsbad 1990), total average runoff for 6-hour storms for several return periods was estimated in 1989. The total runoff for 2-, 5- and 100-year return periods was estimated at 1,147, 1,428, and 2,423 cfs, respectively. The 100-year and 50-year peak stormflow rates for San Marcos Creek were estimated at 12,050 and 6,707 cfs, respectively; and those for Encinitas Creek were estimated at 4,520 and 2,511 cfs, respectively (Moffatt and Nichol 2012). Previous modeling results predicted that during a 100-year storm event, the water surface elevation would be raised by rainfall runoff by approximately 0.8 feet in the East Basin by the I-5 Bridge, by approximately 0.4 feet in the Central Basin by the Railroad Bridge, and by approximately 0.7 feet in the West Basin by Carlsbad Boulevard Bridges (Moffatt and Nichol 2012). The water surface elevations associated with a 50-year storm event would be much lower than those under a 100-year storm event.

In 2013, the San Diego Regional Water Quality Control Board renewed the National Pollutant Discharge Elimination System (NPDES) permit and waste discharge requirements for discharges from the municipal separate storm sewer systems (MS4s) draining the watersheds within the San Diego Region (Order No. R9-2013-0001, which subsequently was amended by Order No. R9-2015-0001 and Order No. R9-2015-0100. This NPDES permit was issued to 21 San Diego County Copermittees, including the City of Encinitas, as well as 13 Orange County Copermittees.

The NPDES permit requires the Copermittees to develop and incorporate numeric storm water action levels (SALs) (Table 1) into their Water Quality Improvement Plans to: 1) support the development and prioritization of water quality improvement strategies for reducing pollutants in storm water discharges from the MS4s, and 2) assess the effectiveness of the water quality improvement strategies toward reducing pollutants in storm water discharges.

Table 1. Storm water action levels for discharges from MS4s to receiving waters.

Parameter	Units	Action Level
Turbidity	NTU	126
Nitrate and nitrite (total)	mg/L	2.6
Phosphorus (total P)	mg/L	1.46
Cadmium (total Cd)	µg/L	3.0
Copper (total Cu)	µg/L	127
Lead (total Pb)	µg/L	250
Zinc (total Zn)	µg/L	976

The most common pollutants in runoff discharged from the MS4s include total suspended solids, sediment, pathogens (e.g., bacteria, viruses, protozoa), heavy metals (e.g., cadmium, copper, lead, and zinc), petroleum products and polynuclear aromatic hydrocarbons, synthetic organics (e.g., pesticides, herbicides, and PCBs), nutrients (e.g., nitrogen and phosphorus), oxygen-demanding substances (e.g., decaying vegetation, animal waste), detergents, and trash. As operators of the MS4s, the Copermittees cannot passively receive and discharge pollutants from third parties. By providing free and open access to an MS4 that conveys discharges to waters of the U.S., the operator essentially accepts responsibility for discharges into the MS4 that it does not prohibit or otherwise control. These discharges may cause or contribute to a condition of pollution or a violation of water quality standards.

Pollutants in runoff discharged from the MS4s can threaten and adversely affect human health and aquatic organisms. Adverse responses of organisms to chemicals or physical agents in runoff range from physiological responses such as impaired reproduction or growth anomalies to mortality. Increased volume, velocity, rate, and duration of storm water runoff greatly accelerate the erosion of downstream natural channels. This alters stream channels and habitats and can adversely affect aquatic and terrestrial organisms.

The NPDES permit requires Copermittees to monitor and assess the impact on the conditions of receiving waters caused by discharges from their MS4s under wet weather and dry weather conditions. The goal of the monitoring and assessment program is to inform the Copermittees and the Regional Board about the nexus between the health of receiving waters and the water quality condition of the discharges from their MS4s. This goal will be accomplished through monitoring and assessing the conditions of the receiving waters, discharges from the MS4s, pollutant sources and/or stressors, and effectiveness of the water quality improvement strategies implemented as part of the Water Quality Improvement Plans.

Waste and pollutants which are deposited and accumulate in MS4 drainage structures will be discharged from these structures to waters of the U.S. unless they are removed. These discharges may cause or contribute to, or threaten to cause or contribute to, a condition of pollution in receiving waters. For this reason, pollutants in storm water discharges from the MS4s can be and must be effectively reduced in runoff by the application of a combination of pollution prevention, source control, and treatment control Best Management Practices (BMPs). Pollution prevention is the reduction or elimination of pollutant generation at its source and is the best “first line of defense.” Source control BMPs (both structural and non-structural) minimize the contact between pollutants and runoff, therefore keeping pollutants onsite and out of receiving waters. Treatment control BMPs remove pollutants that have been mobilized by storm water or non-storm water flows.

The NPDES permit requires the development of Water Quality Improvement Plans that guide the Copermittees’ jurisdictional runoff management programs towards achieving the outcome of improved water quality in MS4 discharges and receiving waters. The goal of the Water Quality Improvement Plans is to further the Clean Water Act’s objective to protect, preserve, enhance, and restore the water quality and designated beneficial uses of waters of the state. This goal will be accomplished through an adaptive planning and management process that identifies the highest priority water quality conditions within a watershed and implements strategies through the jurisdictional runoff management programs to achieve improvements in the quality of discharges from the MS4s and receiving waters.

The San Diego Regional Board has defined the Carlsbad Watershed Management Area’s Hydrologic Unit (904.00) to include Loma Alta Slough, Buena Vista Lagoon, Agua Hedionda Lagoon, Batiquitos Lagoon, San Elijo Lagoon, and the Pacific Ocean. Responsible parties are: City of Carlsbad, City of Encinitas, City of Escondido, City of Oceanside, City of San Marcos, City of Solana Beach, City of Vista, and County of San Diego. The Carlsbad Watershed Management Area Water Quality Improvement Plan prepared for these eight agencies was finalized in June 2016 (MOE 2016).

The NPDES permit requires monitoring for conventional pollutants and nutrients, metals, pesticides, and indicator bacteria at each long-term receiving water station (Table 2). The permit also requires toxicity testing at each long-term monitoring station. Monitoring is required for a minimum of one dry weather event and two wet weather events, including the first wet weather event of each wet season (October 1 – April 30), and at least one wet weather monitoring event during a wet weather event that occurs after February 1st.

Table 2. Monitoring requirements for long-term receiving water stations stipulated in the MS4 NPDES permit.

Conventionals/Nutrients	Metals (Total and Dissolved)	Pesticides	Indicator Bacteria
Total Dissolved Solids	Arsenic	Organophosphate pesticides	Total coliform
Total Suspended Solids	Cadmium	Pyrethroid pesticides	Fecal coliform (*E. coli* may be substituted)
Turbidity	Chromium		*Enterococcus*
Total Hardness	Copper		
Total Organic Carbon	Iron		
Dissolved Organic Carbon	Lead		
Sulfate	Mercury		
Methylene Blue Active Substances (MBAS)	Nickel		
Total Phosphorus	Selenium		
Orthophosphate	Thallium		
Nitrite1	Zinc		
Nitrate1			
Total Kjeldhal Nitrogen			
Ammonia			

BIOLOGICAL RESOURCES OF BATIQUITOS LAGOON

Communities in coastal lagoons frequently experience seasonal variabilities in salinity compared to marine waters (Zedler 1982). In summer, hypersaline conditions can occur in coastal lagoons due to evaporation, especially in lagoons without freshwater input in summer when tidal circulation is blocked by a seasonal sand berm. In winter, salinities in these same lagoons can be reduced to values well below those found offshore due to rainfall and runoff. As a result, lagoon communities are able to tolerate variable salinities compared to species and communities that found typically offshore marine habitats.

Within the Batiquitos Lagoon system, tides are muted and the reduction in low tide drainage has had the effect of narrowing the tidal range in a manner that increases the frequency of inundation throughout all but the extreme high end of the intertidal zone (Merkel and Associates 2009). This change resulted in a compression of the classical intertidal estuary zonation patterns towards the higher end of the normal intertidal range, such that low marsh vegetation (typically extending to a low elevation near mean sea level) was shifted to a higher elevation on the shoreline and began to displace middle marsh vegetation occurring within normal elevation ranges. The middle marsh was then pushed upward as well and displaced some of the higher marsh vegetation. The higher marsh remained limited at the upper boundary by its restriction to areas with saline influences that prevents terrestrial vegetation from effectively competing with salt tolerant marsh plants. The effect of this compression of the marsh zones to higher shoreline elevations is the reduction of the total area of marshlands and the creation of a marsh habitat that is then subject to variable inundation frequency levels with maintenance dredging events.

The slowing of drainage at low tides, with a relatively normal return of water levels with ocean flood tides, also plays a role in limiting the exposure period for mudflats below the vegetated marsh zones (Merkel and Associates 2009). Under fully tidal conditions, water drops along the wetland shorelines exposing a continually broadening band of mudflat until such time as the tide turns and the mudflat gradually narrows as it is inundated again. With tidal muting, less mudflat is exposed overall and the duration of mudflat exposure is reduced. As a result, there is less temporal and spatial availability of mudflat for species dependent on exposed mudflats, such as foraging shorebirds.

Vegetation Types

The physical restoration of Batiquitos Lagoon produced elevations and a tidal prism suitable to support important habitat-forming species, including eelgrass (*Zostera marina*), Pacific cordgrass (*Spartina foliosa*) and pickleweed (*Salicornia pacifica*).

Eelgrass is a native marine vascular plant indigenous to the soft-bottom bays and estuaries of the Northern Hemisphere. It is tolerant of a wide range of salinities, with little difference in growth or production found when grown in salinities between 10 and 35 ppt (Nejrup and Pederson 2008). Eelgrass is a defining habitat-forming species for much of the shallow-subtidal elevations in southern California estuaries and shallow bays. Within the southern portion of its range, eelgrass growth is generally limited at the shore by desiccation stress at low tides. Throughout its range, eelgrass is generally limited along its deeper fringe by light reduction to a level below which photosynthesis is unable to meet the metabolic demands of the plant to sustain net growth. Eelgrass creates unique biological environments when it occurs in the form of submerged or intertidal aquatic beds or larger meadows.

Eelgrass plays many important roles in estuarine systems. It clarifies water through sediment trapping and stabilization (de Boer 2007). It also provides the benefits of nutrient transformation and water oxygenation (Yarbro and Carlson 2008). Eelgrass serves as a primary producer in detritus-based food webs (Thresher et al. 1992) and is further directly grazed upon by invertebrates, fish, and birds (Valentine and Heck 1999), thus contributing to eco-system health at multiple trophic levels. Additionally, it provides physical structure in the form of habitat to the community and supports epiphytic plants and animals, which are in turn grazed upon by other invertebrates, fish, and birds. Eelgrass is also a nursery area for many commercially and recreationally important finfish and shellfish (Heck et al. 2003), including both those that are resident within the bays and estuaries, as well as oceanic species that enter the estuaries to breed or spawn. Among recreationally important species, sand basses and lobster make use of eelgrass beds as habitat. Besides providing important habitat for fish, eelgrass and associated invertebrates provide important food resources, supporting migratory birds during critical life stages, including migratory periods.

Pacific cordgrass is a coastal salt marsh species native to California and northern Baja California (Hickman 1993). Pacific cordgrass exerts significant influence over biotic and abiotic factors within its canopy (Whitcraft and Levin 2007), providing habitat and resources for benthic and epibenthic communities. Cordgrasses are an important source of organic carbon for detritivores (Graca et al. 2000) and ultimately support a diverse and abundant array of invertebrates within salt marsh habitat (Levin et al. 1998).

Pacific cordgrass is part of an important transitional habitat between marine and upland habitats. Although it can survive low salinity environments, it is a poor competitor and exists within a salinity range that many terrestrial, high marsh, and freshwater marsh plants cannot tolerate. Thus, it exists within a narrow range along the shoreline where it is limited by competition at its upper boundary and by physical stress from inundation at its lower boundary. While its growth may be localized within narrow physical and biological limits, its influence extends to adjacent habitats. The carbon produced by cordgrass makes its way through detritus-based food webs and is ultimately transported to adjacent habitats where it provides energetic support for marine fishes and birds (Adam 1990).

Eight permanent vegetation sampling sites were established within Batiquitos Lagoon during pre- and post-construction monitoring surveys (Merkel and Associates 2009). At each site, a baseline transect was established perpendicular to the shoreline. Points were established along each baseline within each marsh zone (high, middle, and low). Transect 3 was established in the West Basin (Figure 5).

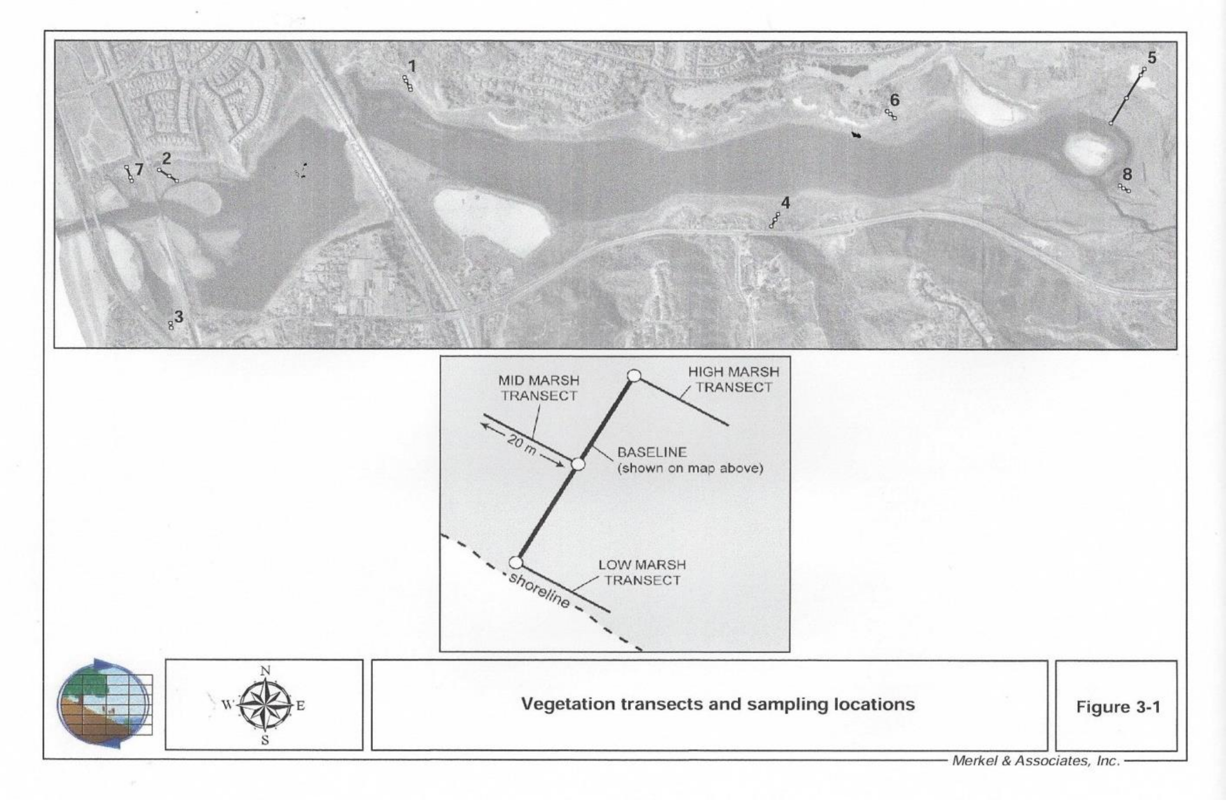
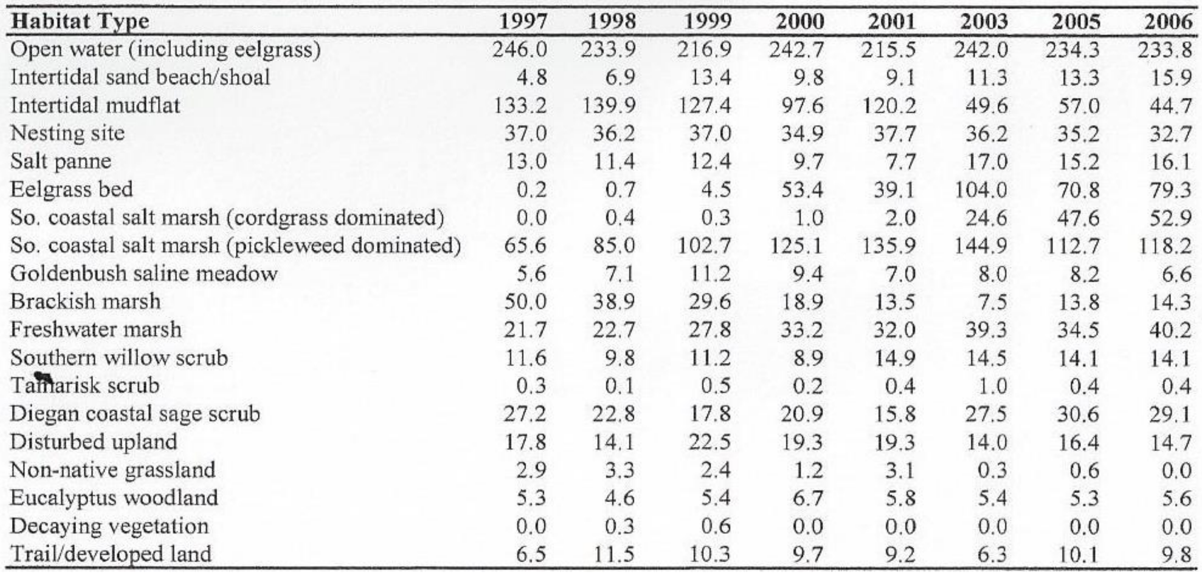


Figure 5. Vegetation transects monitored within Batiquitos Lagoon, 1997-2006 (from Merkel and Associates 2009).

Vegetation transect monitoring resulted in annual estimates of the acreages for 19 habitat types within Batiquitos Lagoon for 1997-2001, 2003, 2005 and 2006 (Table 3) (Merkel and Associates 2009). This included estimates of critical habitats such as eelgrass beds and southern coastal salt marsh (both cordgrass-dominated and pickleweed-dominated habitats). A substantial portion of the East Basin, and a smaller portion of the Central and West Basins, supported unvegetated intertidal mudflats. Expansion of salt marsh vegetation accounted for the majority of the approximately 65% reduction in mudflat habitat from 1997 to 2006 (Figure 6).

Table 3. Habitat acreages at Batiquitos Lagoon from 1997 to 2006 (from Merkel and Associates 2009).



Habitat Type	1997	1998	1999	2000	2001	2003	2005	2006
Open water (including eelgrass)	246.0	233.9	216.9	242.7	215.5	242.0	234.3	233.8
Intertidal sand beach/shoal	4.8	6.9	13.4	9.8	9.1	11.3	13.3	15.9
Intertidal mudflat	133.2	139.9	127.4	97.6	120.2	49.6	57.0	44.7
Nesting site	37.0	36.2	37.0	34.9	37.7	36.2	35.2	32.7
Salt panne	13.0	11.4	12.4	9.7	7.7	17.0	15.2	16.1
Eelgrass bed	0.2	0.7	4.5	53.4	39.1	104.0	70.8	79.3
So. coastal salt marsh (cordgrass dominated)	0.0	0.4	0.3	1.0	2.0	24.6	47.6	52.9
So. coastal salt marsh (pickleweed dominated)	65.6	85.0	102.7	125.1	135.9	144.9	112.7	118.2
Goldenbush saline meadow	5.6	7.1	11.2	9.4	7.0	8.0	8.2	6.6
Brackish marsh	50.0	38.9	29.6	18.9	13.5	7.5	13.8	14.3
Freshwater marsh	21.7	22.7	27.8	33.2	32.0	39.3	34.5	40.2
Southern willow scrub	11.6	9.8	11.2	8.9	14.9	14.5	14.1	14.1
Tamarisk scrub	0.3	0.1	0.5	0.2	0.4	1.0	0.4	0.4
Diegan coastal sage scrub	27.2	22.8	17.8	20.9	15.8	27.5	30.6	29.1
Disturbed upland	17.8	14.1	22.5	19.3	19.3	14.0	16.4	14.7
Non-native grassland	2.9	3.3	2.4	1.2	3.1	0.3	0.6	0.0
Eucalyptus woodland	5.3	4.6	5.4	6.7	5.8	5.4	5.3	5.6
Decaying vegetation	0.0	0.3	0.6	0.0	0.0	0.0	0.0	0.0
Trail/developed land	6.5	11.5	10.3	9.7	9.2	6.3	10.1	9.8

Most intertidal salt marshes of southern California are viewed as having three distinct zones: a low marsh that is inundated by nearly every high tide and is dominated by cordgrass; a middle marsh, inundated by higher high tides and dominated by pickleweed; and a high marsh, inundated only by high spring tides and dominated by one or more species including pickleweed, salt grass (*Distichlis spicata*), and alkali heath (*Frankenia salina*). At Batiquitos Lagoon, a recognizable zonation between the high and middle marsh zones had not become clearly established by year 10. The low and middle marsh zones were distinct, with cordgrass occupying the low marsh exclusively and pickleweed dominating the middle marsh (Merkel and Associates 2009). Freshwater flushing and heavy rainfall tend to increase productivity and areal extent of intertidal saltmarsh species, as long as prolonged low salinity conditions do not allow the marsh to be invaded by freshwater marsh species (Zedler 1982).

In the West Basin, eelgrass coverage increased from 0.09 acres in 1997 to 5.00 acres in 2006 (Figure 7), with a maximum extent of 5.44 acres in 2005 (Merkel and Associates 2009). Intruding sands that made much of the basin too shallow to support eelgrass apparently limited its distribution along the shoreline and within the entrance channel. Moreover, tidal current speeds were increased when the intruding sands filled the entrance channel. The increased current speeds may have prevented the growth of

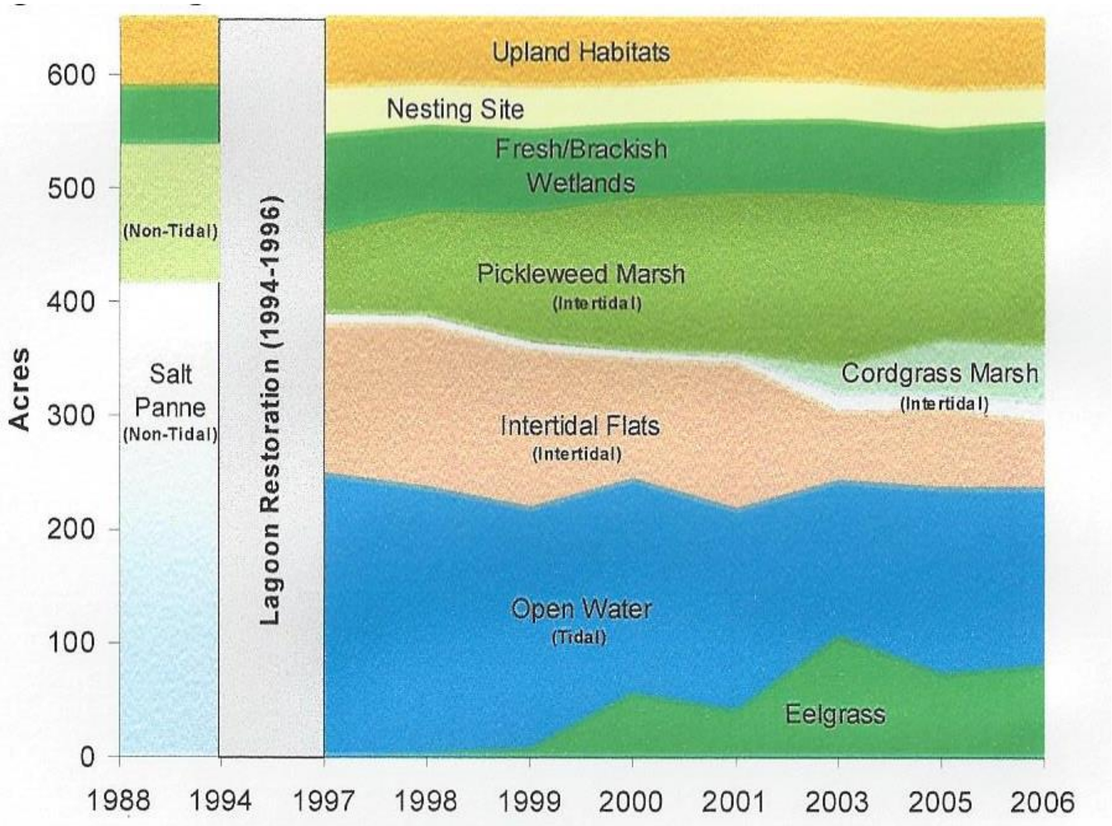


Figure 6. Development of habitats in Batiquitos Lagoon over time following restoration (from Merkel and Associates 2009).

eelgrass in and along the entrance channel. Additionally, the erosion of the railroad spur contributed to the deposition of sediments and the loss of eelgrass in the West Basin. Overall within Batiquitos Lagoon, eelgrass beds occurred between –5.5 feet and +1.0-foot MLLW.

There was relatively little cordgrass in the West Basin, likely due more to the shifting sand substrate than the availability of suitable elevations. Approximately 0.04 acres of cordgrass was present in 2006 (Figure 7), when 83% of the total cordgrass in the lagoon was found in the East Basin. Overall within Batiquitos Lagoon, cordgrass occurred between +2.5 feet to +6.0 feet MLLW.

The May 30, 2019 staff report prepared by the California Coastal Commission for the San Diego Association of Governments' Batiquitos Lagoon Double-Track Project cites a Biological Technical Report (November 2016) that describes the wetland habitat and resources present in the 107.9-acre biological study area (BSA) and the 42.3-acre project development footprint within the BSA. The Biological Technical Report and the Jurisdictional Delineation Report (November 2016) state that Coastal Act wetlands within the BSA include 15.58 acres of vegetated coastal wetlands (southern coastal salt marsh, coastal and valley freshwater marsh, herbaceous wetland, eelgrass, riparian scrub, mule fat scrub, tamarisk scrub, and arundo dominated riparian) and 20.33 acres of non-

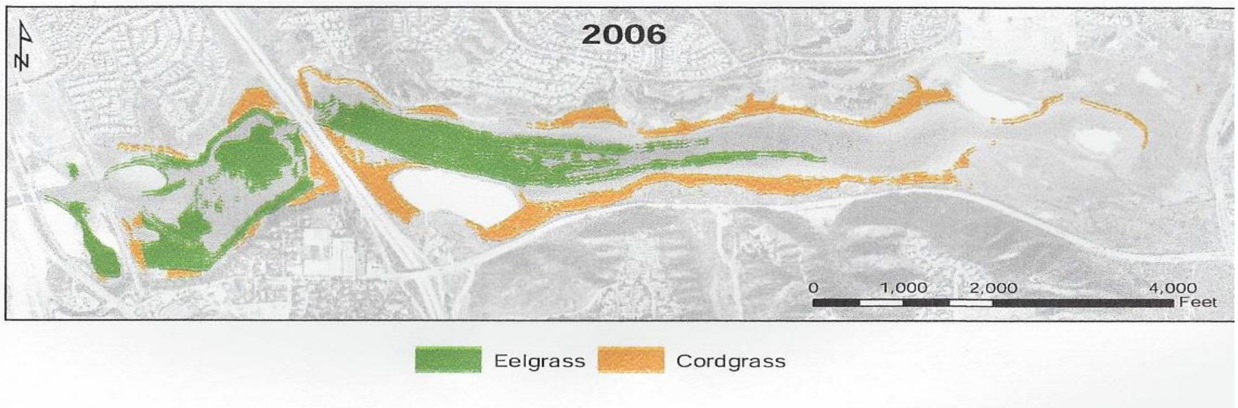


Figure 7. Eelgrass and cordgrass distribution in Batiquitos Lagoon in 2006 (from Merkel and Associates 2009).

vegetated coastal wetlands (open water, intertidal mudflat, shoal, drainage track ditch, and southern foredune).

MBC Aquatic Sciences conducted a reconnaissance survey of the West Basin of Batiquitos Lagoon at low tide on March 30, 2020. One objective of this survey was to map the areas in the West Basin that supported eelgrass and cordgrass habitats (Figure 8). Eelgrass beds (green stippling) were present in the water along much of the shoreline at the southern end of the West Basin and along a portion of the shoreline along the western side of the channel (adjacent to the Snowy Plover nesting site area). Cordgrass and pickleweed marsh areas (red cross-hatching) were observed along much of the shoreline at the southern end of the basin. Unvegetated intertidal mudflat habitat was observed along a small portion of the western side of the channel (to the north of the eelgrass habitat) and along a small portion of the eastern side of the channel.

Eelgrass was present throughout most of the West Basin in 2006 (Figure 7) but occurred within a smaller portion of the basin in 2020 (Figure 8). Cordgrass occupied a very small area of the West Basin in 2006 but was present over a more extensive area in 2020. Eelgrass and wetland vegetation (including cordgrass, pickleweed and other marsh plants) are considered to be sensitive biological resources by federal and state resource agencies.

Eelgrass warrants a strong protection strategy because of the important biological, physical, and economic values it provides, as well as its importance to managed species under the Magnuson Stevens Fishery Conservation and Management Act (MSA). Vegetated shallows that support eelgrass are also considered special aquatic sites under the 404(b)(1) guidelines of the Clean Water Act (40 C.F.R. § 230.43). The National Oceanic and Atmospheric Administration’s (NOAA) National Marine Fisheries Service (NMFS) developed the California Eelgrass Mitigation Policy to establish and support a goal of protecting this resource and its habitat functions, including spatial coverage and density of eelgrass habitats. The 1993 State of California Wetlands Conservation Policy established a framework and strategy to ensure no overall net loss and long-term gain in the quantity, quality, and permanence of wetlands acreage (which would include cordgrass, pickleweed and other marsh vegetation) and habitat values in California. The

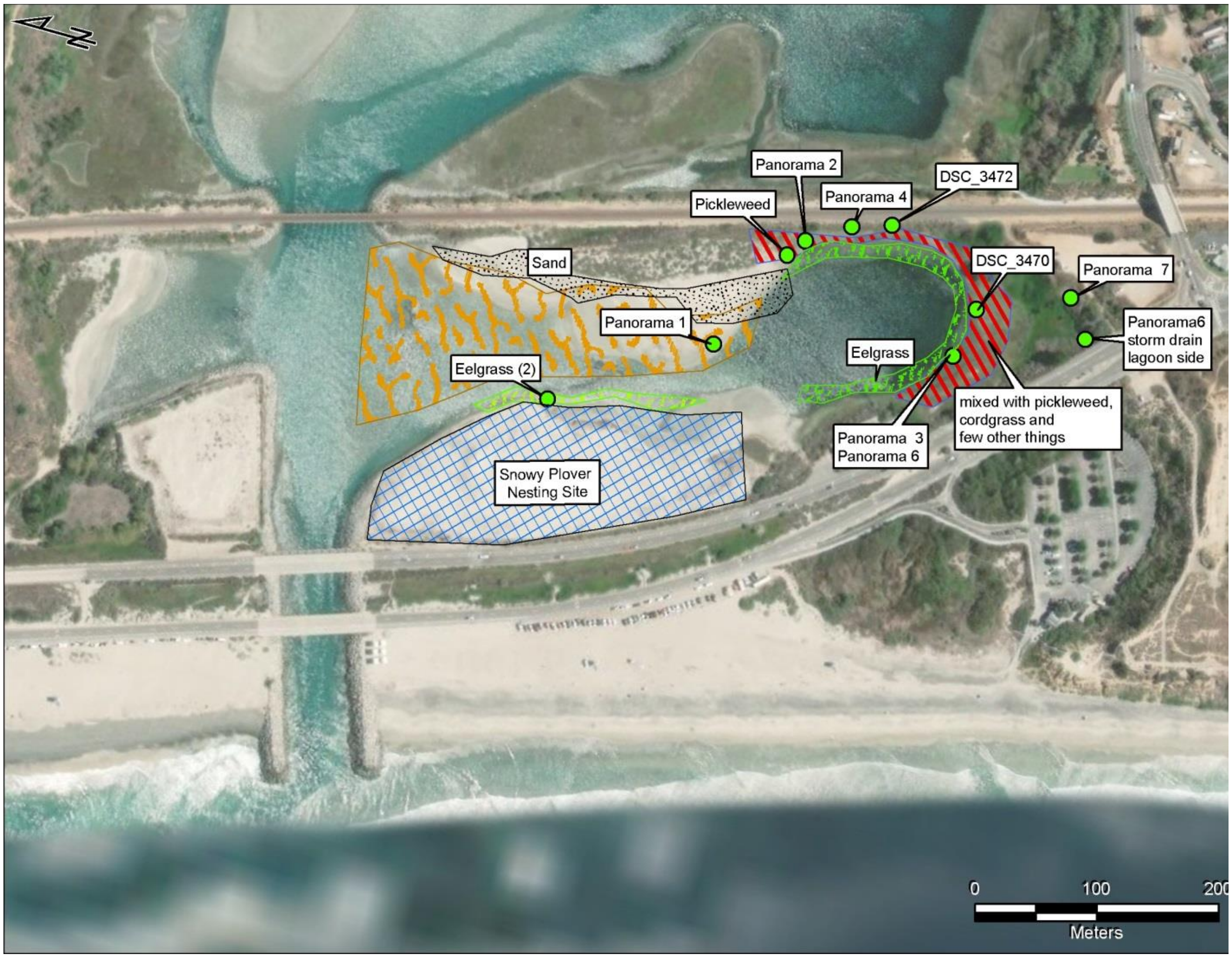


Figure 8. Map of habitat types present in the West Basin on March 30, 2020 (low tide) (prepared by MBC Aquatic Sciences based on field reconnaissance study).

State Water Resources Control Board adopted a State Wetland Definition and Procedures for Discharges of Dredged or Fill Material to Waters of the State in 2019 for inclusion in the forthcoming Water Quality Control Plan for Inland Surface Waters and Enclosed Bays and Estuaries and Ocean Waters of California to strengthen protection of waters of the state.

Avian Community

Over the course of 40 post-restoration surveys conducted from 1997 to 2006, a total of 168 species of birds were observed at Batiquitos Lagoon following the opening of the lagoon to the ocean (Merkel and Associates 2009). Species observed were divided into one of eight ecological guilds (small shorebirds, large shorebirds, wading/marshbirds, aerial fish foragers, waterfowl, gulls, raptors, and upland birds) based on foraging behavior, life history traits, and/or taxonomic affiliation.

Six study zones were established for the post-restoration avian surveys (Figure 9). These same areas were previously studied during the pre-restoration monitoring. Zone 1 was located along Encinitas Creek south of La Costa Avenue; this area was not included in

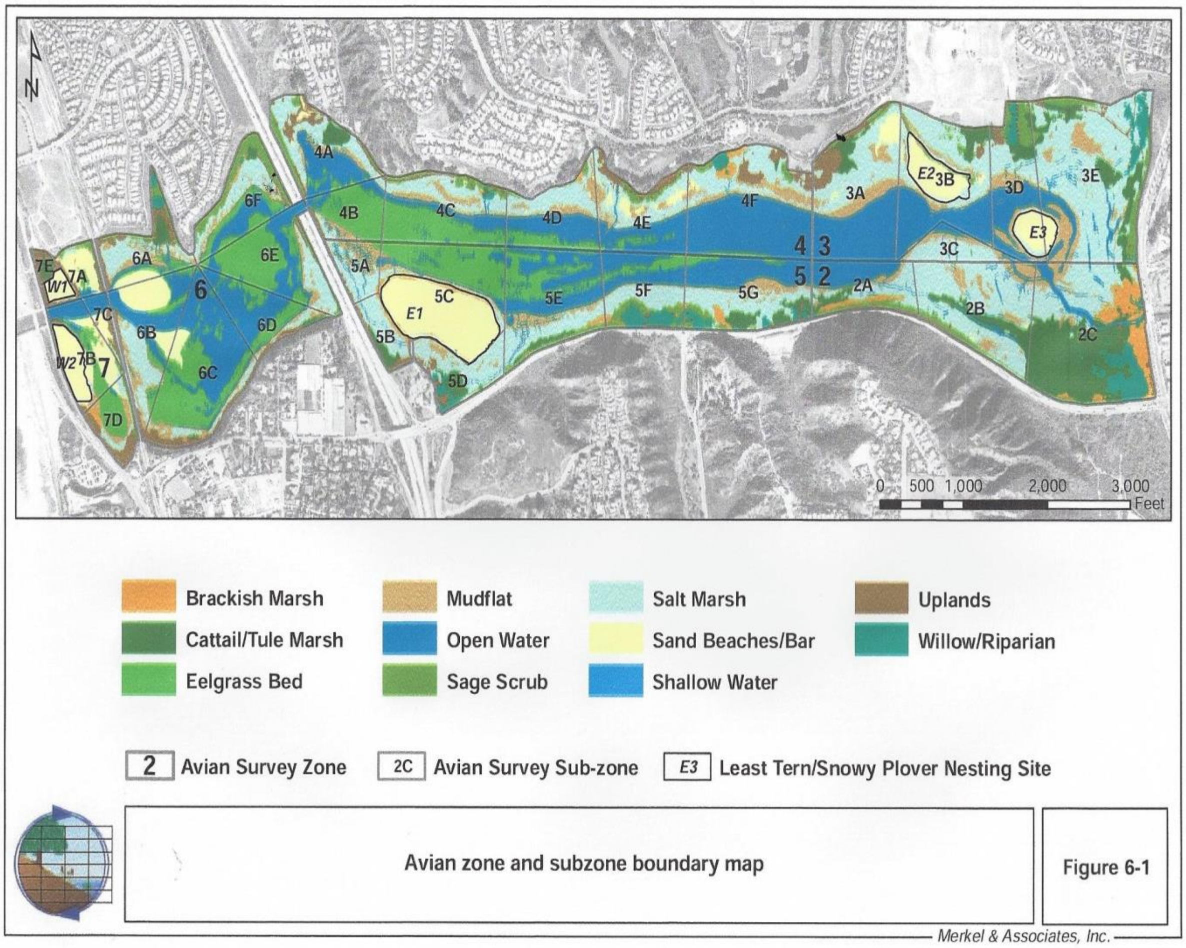


Figure 9. Avian survey zones and subzones in Batiquitos Lagoon, 1997-2006 (from Merkel and Associates 2009).

the post-restoration monitoring program, although it had been surveyed at times during pre-restoration monitoring. Zone 2 was located in the southeast quadrant of the East Basin of the lagoon. Zone 3 was located in the northeast quadrant of the East Basin. Zone 4 was located in the northwest quadrant of the East Basin, and Zone 5 was located in the southwest quadrant of the East Basin. Zone 6 consisted of the entire Central Basin of the lagoon, and Zone 7 represented the entire West Basin of the lagoon. Each zone was subdivided into three to seven subzones (31 total) so that the data collected could be used to generate density maps for small regions within the lagoon. Surveys were conducted quarterly in January, April, July, and October in years 1, 2, 3, 5, and 10 (1997, 1998, 1999, 2001, and 2006) following the completion of restoration (Merkel and Associates 2009).

Waterfowl

Post-restoration waterfowl were observed in the greatest numbers during January surveys each year, with the most counted immediately following the lagoon opening, then a reduced number in subsequent years, with a return to higher numbers in 2006 (Merkel and Associates 2009). During post-restoration surveys, the most abundant bird in the waterfowl group was American coot (a rail) (*Fulica americana*), which accounted for between 11% and 57% of the total waterfowl counted in all January, April, and October months. This species generally was absent in July each year, probably having moved to freshwater during the breeding season. Listed in order of decreasing abundance after American coot were ruddy duck (*Oxyura jamaicensis*), American wigeon (*Anas americana)*, northern pintail (*Anas acuta*), gadwall (*Anas strepera*), green-winged teal (*Anas crecca*), mallard (*Anas platyrhynchos*), redhead (*Aythya americana*), northern shoveler (*Anas clypeata*), and scaup (*Aythya* sp.). Present in regular, but lower, numbers were bufflehead (*Bucephala albeola*), cinnamon teal (*Anas cyanoptera*), canvasback (*Aythya valisineria*), surf scoter (*Melanitta perspicillata*), blue-winged teal (*Anas discors*), and ringnecked duck (*Aythya collaris*).

Small and Large Shorebirds

Shorebirds were divided into two guilds: small shorebirds, such as western sandpiper (*Calidris mauri*), and large shorebirds, such as marbled godwit (*Limosa fedoa*). Shorebirds trends did not show a clear annual pattern during post-restoration surveys. In some years, abundance peaked in January, while in others, October or April had the highest numbers, likely the result of survey timing in relation to seasonal and daily migratory events. In the July surveys of 1997, 1998, and 1999, there were considerable numbers of shorebirds present at the lagoon, with notably less in the July surveys of 2001 and 2006 (Merkel and Associates 2009).

During the post-restoration surveys, small shorebirds made up 82% of the total shorebirds observed. The most abundant small shorebirds were western sandpiper and least sandpiper (*Calidris minutilla*). The next most abundant small shorebird was semi-palmated plover (*Charadrius semipalmatus*), followed by killdeer (*Charadrius vociferous*), black-bellied plover (*Pluvialis squatarola*), sanderling (*Calidris alba*), western snowy plover (*Charadrius alexandrinus nivosus*), dunlin (*Calidris alpine*), and spotted sandpiper (*Actitis macularius*). The number of small shorebirds post-restoration was high in 1997, 1998, and 2006 and slightly lower in 2001 (Merkel and Associates 2009).

During post-restoration surveys, the most abundant large shorebirds were dowitchers, which were generally not broken out into long-billed (*Limnodromus scolopaceus*) and short-billed dowitcher (*Limnodromus griseus*) due again to the distance of the observers from the birds most of the time. Identification was possible in some cases where there was opportunity for close scrutiny. Also occurring in significant and regular numbers were willet (*Tringa semipalmata*), marbled godwit, American avocet (*Recurvirostra americana*), and black-necked stilt (*Himantopus himantopus*). Both willets and marbled godwits were present in low numbers initially, with an upward trend in numbers over the 10-year study period (Merkel and Associates 2009).

Wading/Marshbirds

This guild was represented by 12 species following the restoration, with snowy egret (*Egretta thula*), great egret (*Ardea alba*), and great blue heron (*Ardea herodias*) most abundant and present year-round. Present seasonally and regularly were green heron

(*Butorides virescens*), sora (*Porzana carolina*), and black-crowned night heron (*Nycticorax nycticorax*). Light-footed clapper rail (*Rallus longirostris levipes*) were first observed during the surveys in July 2001 in a planted patch of cordgrass in the Central Basin, although prior to this their presence was known in the East Basin from their calls heard outside of formal survey periods (Merkel and Associates 2009).

Raptors

Following restoration, the lagoon supported a diverse community of raptors, with four to nine species commonly observed during each survey (Merkel and Associates 2009). These included northern harrier (*Circus cyaneus*), red-shouldered hawk (*Buteo lineatus*), red-tailed hawk (*Buteo jamaicensis*), sharp-shinned hawk (*Accipiter striatus*), Cooper's hawk (*Accipiter cooperii*), merlin (*Falco columbarius*), American kestrel (*Falco sparverius*), peregrine falcon (*Falco peregrinus*), white-tailed kite (*Elanus leucurus*), osprey (*Pandion haliaetus*), and turkey vulture (*Cathartes aura*).

Aerial Fish Foragers

This guild included terns, belted kingfisher (*Megaceryl alcyon*), and California brown pelican (*Pelecanus occidentalis californicus*). Following restoration, seven species of tern were observed, with Forster's tern (*Sterna forsteri*) most abundant (Merkel and Associates 2009). California least tern (*Sterna antillarum browni*) numbers peaked during the first year of monitoring, then were greatly reduced but relatively consistent in the following survey years. Of note was the spike in numbers of elegant tern (*Thalasseus elegans*) in April 2006, when up to 630 individuals were observed loafing on the flood shoal in the Central Basin (Zone 6), and a peak in Forster's tern numbers in January 2006, when a large group was also loafing on the shoal.

Gulls

These were represented by nine species post-restoration, with ring-billed gull (*Larus delawarensis*) most abundant and occurring in high numbers in January surveys, followed by California gull (*Larus californicus*) and western gull (*Larus occidentalis*). The number of western gull increased throughout the post-restoration monitoring period. Much less common and irregular were Bonaparte's gull (*Chroicocephalus philadelpia*), Heermann's gull (*Larus heermanni*), mew gull (*Larus canus*), herring gull (*Larus argentatus*), glaucous-winged gull (*Larus glaucescens*), and Thayer's gull (*Larus thayeri*) (Merkel and Associates 2009).

Upland Birds

This was a large group that included 73 species post-restoration, such as sparrows, flycatchers, corvids, swallows, and others, all of which occur on the margins of the lagoon and, as a group, are not restricted to marsh habitats, though they may utilize marsh habitats heavily at Batiquitos Lagoon (Merkel and Associates 2009). Belding's Savannah sparrow (*Passerculus sandwichensis beldingi*) has been included in this guild with the other sparrows, though this race of Savannah sparrow generally occurs in non-upland marsh habitat. Excluding the Belding's Savannah sparrow, the most abundant upland birds were bushtit (*Psaltriparus minimus*), cliff swallow (*Petrochelidon pyrrhonota)*, house finch (*Carpodacus mexicanus*), common yellowthroat (*Geothlypis trichas*), marsh wren (*Cistothorus palustris*), mourning dove (*Zenaida macroura*), and Anna's hummingbird (*Calypte anna*).

West Basin Avian Communities

The West Basin (Zone 7) of Batiquitos Lagoon was relatively small, under full tidal influence, and had experienced dramatic physical changes between 1997 and 2006. Following the restoration, processes related to avian usage included the loss of most of the pickleweed marsh on the north side of the basin through erosion, the loss of coastal sage scrub through the erosion of the abandoned railroad spur, the development of a large eelgrass bed in the subtidal areas, and the accretion of sand on the eastern and western shores of the basin, which increased loafing areas and reduced open water. The most abundant species in this zone were western sandpiper, least tern, house finch, and mourning dove (Merkel and Associates 2009). General trends over the 10-year post-restoration period showed a decline in usage of the west basin by waterfowl and an increase by large shorebirds, corresponding to the loss of open water and increases in intertidal sandy areas for foraging large shorebirds. Brown pelicans and gulls frequently used the sand bar on the east shore of the basin for loafing. High numbers of California least tern were observed loafing and foraging in this basin in July 1997, with lower numbers in 1998, 1999, and 2001, and the lowest count in the 10-year period in 2006. Prior to restoration, much higher densities of birds were documented using this zone.

The number or diversity of birds using a particular habitat, however, is just one measure of the value of that habitat. The southern coastal salt marsh (including pickleweed and cordgrass dominated areas), which was the second most abundant habitat by the end of the monitoring program in 2006 (over 26% of total), was only used by 1.5% of the birds observed, but provided the specialized breeding habitat for the state endangered Belding's Savannah sparrow and the state and federally endangered light-footed clapper rail. Both species increased in abundance over the length of the post-restoration monitoring period, due in large part to the expansion of this habitat within the lagoon. More limited areas of upland, willow/riparian, freshwater marsh, and brackish marsh were used by fewer numbers of birds but increased the diversity of the avian community at Batiquitos Lagoon considerably, providing habitat for other migratory birds, upland species, and species preferring transitional freshwater/brackish conditions.

Sensitive Species

The restoration design of Batiquitos Lagoon included elements to promote the nesting of several sensitive avian species, including Belding's Savannah sparrow, western snowy plover, California least tern, and light-footed clapper rail. These elements included the creation of five nesting sites for least terns and snowy plovers and increasing areas of pickleweed-dominated salt marsh habitat for Belding's Savannah sparrows (Merkel and Associates 2009). The five nesting sites were created through placement of sand dredged during the restoration process and were designated as W-1 and W-2 in the west basin and E-1, E-2, and E-3 in the east basin (Figure 9). Site W-1 was completed in time for the 1994 nesting season, with sites W-2 and E-1 ready for the 1995 season, and sites E-2 and E-3 completed before the 1996 nesting season. The approximately 37.0 acres of sand nesting sites created was reduced over time as vegetation encroached on these five sites. Nesting sites W-1 and E-3 became vegetated by weedy species, while E-1 and E-2 became encircled by coastal salt marsh and brackish marsh vegetation. Nesting site W-2 was severely eroded along its eastern flank, and portions of this site were converted to intertidal sand beach. By 2006, available nesting site area had been reduced to 32.7 acres as a result of conversion to other coastal wetland and intertidal habitats. Additional salt marsh habitat was created through excavation of the lagoon basins to appropriate tidal elevations, limited transplants, and natural recruitment of pickleweed. To encourage occupation by light-footed clapper rails, cordgrass was transplanted onto the mudflats of the lagoon shortly after the restoration.

Post-restoration surveys for the state endangered Belding's Savannah sparrow were performed in April and June, the beginning and middle/end of the breeding season, in monitoring years 1, 2, 3, 5, and 10 (1997, 1998, 1999, 2001, and 2006) (Merkel and Associates 2009). Area 6 (A-6) was located along the southern edge of the West Basin and included small strips of salt marsh near the sewer pump station and in the median dividing west and east Carlsbad Boulevard. Breeding surveys and nest monitoring for the California least tern and western snowy plover sites within Batiquitos Lagoon were performed annually by CDFW. Population assessments for the light-footed clapper rail were conducted at Batiquitos Lagoon as part of statewide annual census efforts.

Belding’s Savannah Sparrow

Belding’s Savannah Sparrow is classified as endangered by the State of California. Belding's Savannah sparrows historically nested at Batiquitos Lagoon prior to the restoration effort. Approximately 20, 47, and 28 breeding territories were observed in 1977, 1987, and 1988, respectively, located primarily along the northern shoreline of the East Basin (CH2M Hill 1989). In 1991, prior to the restoration effort, 50 territories were located within the lagoon (Zembal et al. 2006). In 1996, after the completion of the restoration effort but prior to the opening of the mouth of the lagoon, 36 territories were observed (Zembal et al. 2006). In 2006, 142 breeding territories were recorded.

As the pickleweed dominated salt marsh habitat recovered from construction activities and began to expand post-restoration, usage by Belding's Savannah sparrows increased as well and population trends became more stable and less susceptible to climatic variability and closed lagoon ponding (Merkel and Associates 2009). With the increase in available nesting habitat, the transition of brackish marsh habitat to pickleweed-dominated coastal salt marsh, and the likely dispersal of young birds into the expanding habitats, the number of territories increased steadily.

Belding’s Savannah sparrow territories at Batiquitos Lagoon increased from an estimated 30-31 in 1997 to 142 in 2006 (Merkel and Associates 2009). The opening of the lagoon to tidal flow allowed pickleweed dominated salt marsh to expand into areas that were mudflats in 1997. There was also a large expansion of pickleweed in the eastern section of the lagoon where disturbed upland habitat became inundated with salt water. In 2005, the amount of pickleweed salt marsh at Batiquitos Lagoon had declined from 2003 due to conversion of some pickleweed at lower elevations into cordgrass marsh in relationship to increased inundation frequencies with increased tidal muting. Similar ratios of pickleweed to cordgrass were seen in 2006. It is not clear whether the pickleweed extent had reached a point of stabilization, although it was believed that with continued muting, cordgrass would expand shoreward, transitioning more pickleweed-dominated marsh to cordgrass-dominated marsh, rendering these areas unsuited to Belding's Savannah sparrows.

Area 6 (West Basin and the median between east and west Carlsbad Boulevard, just west of the West Basin) supported territories only in the median following the restoration, with no Belding's Savannah sparrow holding territories in the West Basin itself (Merkel and Associates 2009). The median had two to three territories from 1997 to 1999, with none detected in surveys in 2001 or 2006. The first observation of territorial Belding's Savannah sparrows in the West Basin since completion of the restoration was made in 2006. One singing male was observed flying between patches of pickleweed south of the W-2 nesting site to narrow strips of pickleweed below the railroad tracks and at the southern end of the west basin.

Western Snowy Plover

The western snowy plover is an endangered species that is federally listed as threatened. Prior to the creation of the nesting sites within the lagoon, western snowy plover nesting activity was limited. In 1978, no juveniles or nests were located at Batiquitos Lagoon (Merkel and Associates 2009). In 1983, two juveniles and one nest were located, and in 1988, no nests were located, but the presence of five juveniles indicated some nesting activity had occurred (CH2M Hill 1989, City of Carlsbad and U.S. Army Corps of Engineers 1990). In 1994, during the restoration, five nests were established on the north shore of the east basin. Following the creation of the sites in 1995 and 1996, snowy plover nesting was observed at the three nesting sites located in the East Basin (E-1, E-2, and E-3) and in low numbers at one of the two sites in the West Basin (W-2). Site W-1 has never been used by snowy plovers.

The population of nesting snowy plovers at Batiquitos Lagoon fluctuated over the period of the post-restoration monitoring (Merkel and Associates 2009). The numbers were very low in 1994, prior to the creation of the nesting sites, with only five nests located. Snowy plover nesting increased following the creation of the lagoon nesting sites, with the highest numbers of nests (39), eggs (113), eggs hatched (89), and fledglings (39) occurring in 1996, the first year the site was available. Nesting activity declined after the completion of construction, dropping to seven nests in 1999. No data are available for 2000. In 2001, plover nesting reversed the downward trend and rose through 2003 and then declined to 16 nests in 2006.

The hatch rate (percent of total eggs laid that survived to hatch) for the western snowy plover fluctuated over the years, ranging from between 29% in 2003 to 93% in 2006 (Merkel and Associates 2009). Generally, egg loss in snowy plovers is due to non-viable eggs, abandonment, or nest predation. The principal source of egg loss at Batiquitos Lagoon was probably due to nest predation though data to document this are not available. The fledge rate (percent of total hatched chicks that survived to fledge) was fairly high in 1995 (75%) but fluctuated between 21% and 45% in subsequent years (Table 7-2). These fluctuations in fledge rate are difficult to explain without data from the CDFG monitoring program, but they may be related to predation or isolation from foraging areas due to overgrowth of vegetation at the base of the nesting sites. The overall nest success (fledglings per nest) fluctuated from year to year, with the average being estimated at 0.69 fledglings per nest.

In area W-2 within the West Basin, no snowy plover nests were observed in 1996, 1997 or 1998, but nests were found each year through 2006 (no data in 2000), with a maximum of 4 nests in 2005 (Merkel and Associates 2009). The number of eggs laid ranged from 3 to 6 (maximum in 1998, 2003 and 2005) from 1998 through 2006, while the number of eggs hatched ranged from 1 to 6 (maximum in 1998). The number of fledglings ranged from 0 to 3 (maximum in 2005).

California Least Tern

The California least tern is listed as endangered under the Federal Endangered Species Act and the California Endangered Species Act, and also is protected under the multi-nation Migratory Bird Treaty. Following the construction of the five nesting sites (W-1 in 1994, W-2 and E-1 in 1995, and E-2 and E-3 in 1996), the total number of California least tern nests rose and leveled off at around 200 (range 172-298) each year, then increased dramatically again in 2003, remaining steady at around 600 (range 592-627) nests (Merkel and Associates 2009). The increased nests led to increased eggs laid and chicks (eggs hatched) and a modest increase in the number of fledglings. The hatch rate (percent of total eggs laid that survived to hatch) for the California least tern remained relatively high from 1994 through 2003, at between 82% and 97%, with the exception of two years: 1998 at 68% and 1999 dropping to 35%. In 2005 and 2006, the hatch rate declined to a rate of 78% and 73%, respectively. In contrast, the number of chicks that survived to fledge was averaged at 54% from 1994 until 1997 and then dropped to an average of 20% from 1998 until 2006. The lowest fledgling production was observed in 1999, when the hatch rate dropped to 35% and the fledge rate (percent of total hatched chicks that survived to fledge) was only 9%. The low hatch rate was attributed to nest abandonment at W-2 and the loss of all nests at E-2 to nest predation. The overall nest success (fledglings per nest) averaged 0.96 from 1994 to 1997 then dropped to an average of 0.25 fledglings per nest from 1998 to 2006.

In area W-2 within the West Basin, the number of least tern nests increased from a low of 3 in 1995 (pre-restoration) to a high of 409 in 2006 (Merkel and Associates 2009). The number of eggs laid also increased, from a low of 5 in 1995 (pre-restoration) to a high of 671 in 2006, while the number of eggs hatched increased from 4 to 481 over that period. The number of fledglings increased from 3, 0 and 0 in 1995, 1996, and 1997, respectively, to 176 in 2006.

Light-footed Clapper Rail

The light-footed clapper rail is listed as endangered under the Federal Endangered Species Act and the California Endangered Species Act. Light-footed clapper rails were absent from Batiquitos Lagoon through 1992. In 1993 and 1994, one pair of clapper rails was detected, no pairs in 1995, then two pairs in 1996 (Merkel and Associates 2009). After the lagoon was opened, while appropriate clapper rail habitat was still minimal, a few breeding pairs were detected in 1997, 1998, 1999, 2000, 2001. The number of pairs continued to increase as the transplants of the preferred habitat of light-footed clapper rails, Pacific cordgrass, also began to expand. Between 2001 and 2003, the acreage of cordgrass habitat expanded from 2 to 25 acres, with breeding pairs of clapper rails going from three in 2001 and 2002 up to five in 2003. The abundance of high-quality cordgrass habitat that resulted from the restoration project prompted the release of a total of 16 captive-bred clapper rails in 2004 and 2005. This release of captive-bred rails successfully assisted in the expansion of rail populations to 19 pairs by 2006.

Fish Community

The Batiquitos Lagoon restoration project was designed to create a stable, fully tidal system capable of supporting a diverse variety of fish species through increased habitat availability, while maintaining an open connection to the ocean. Five sampling stations, with an onshore and offshore component, were established within the lagoon for post-restoration monitoring of the fish community. Three stations were located in the East Basin (Stations 1, 2, and 3), one in the Central Basin (Station 4), and one in the West Basin (Station 5) (Figure 10). Five types of sampling equipment were utilized at each of the five nearshore and offshore stations. These included a large beach seine, small beach seine, square enclosure, otter trawl, and purse seine.

A total of 75 fish species from 35 families were captured over the duration of the post-restoration monitoring (1997-1999, 2001, 2003, 2005, and 2006). For the five stations in Batiquitos Lagoon, over 81% of the total catch was represented by one of three species: topsmelt (*Atherinops affinis*) (47.0% of the total catch), deepbody anchovy (*Anchoa compressa*) (23.8%), and California grunion (*Leuresthes tenuis*) (10.5%). It should be noted that 83% of all California grunion recorded were captured in July 2005. During all other sampling events, grunion made up only a small percentage of the total catch. Other species accounting for more than 1% of the catch were various goby species (4.4%), California killifish (*Fundulus parvipinnis*) (2.7%), shiner surfperch (*Cymatogaster aggregata*) (2.5%), slough anchovy (*Anchoa delicatissima*) (1.4%), northern anchovy (*Engraulis mordax*) (1.3%) and diamond turbot (*Hypsopsetta guttulata*) (1.3%).

The largest number of fish species generally was collected at Station 5 in the West Basin. Biomass also generally was highest at this location. Species richness was high, with 57 species collected by all sampling methods from 1997 to 2006. The total number of individuals captured also was high at this location over this time period. Generally, higher numbers of fish species and total numbers of individuals were observed during July and October samplings. The lowest numbers of individual fish were generally captured in January. This is probably due to seasonal influxes of some species into Batiquitos

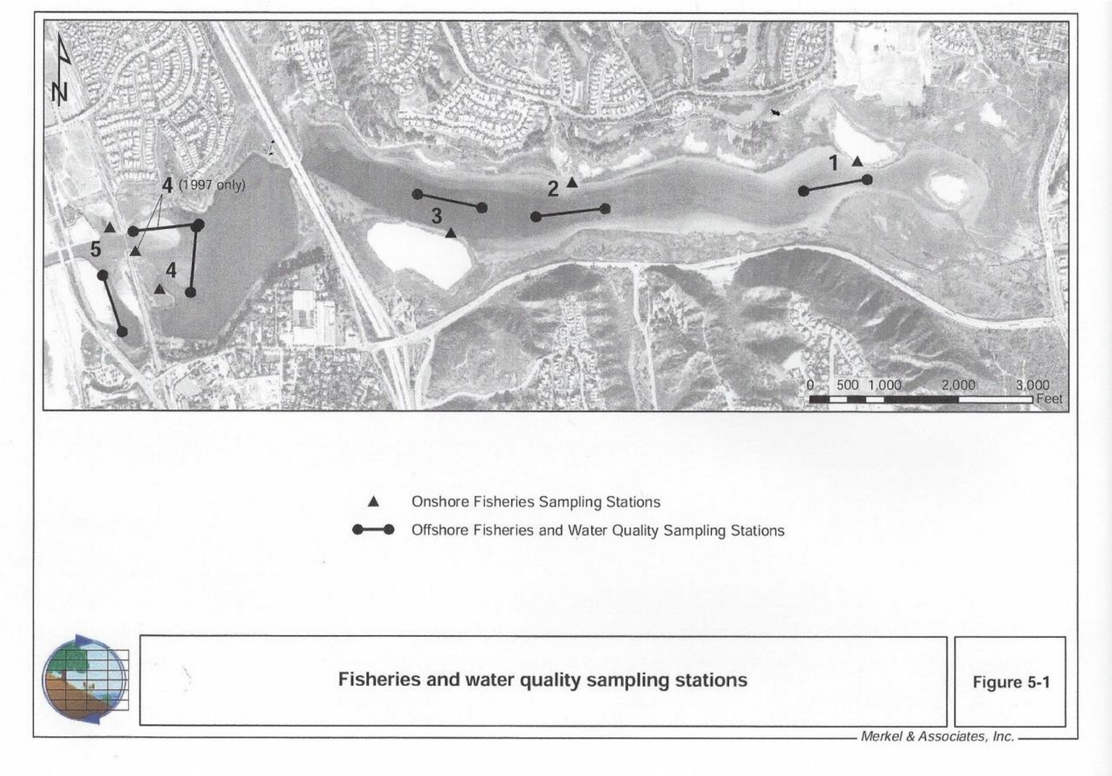


Figure 10. Fish and water quality sampling stations in Batiquitos Lagoon, 1998-2006 (from Merkel and Associates 2009).

Lagoon. Common species that were absent in some January of April samples but present in most July and October sampling events includes schooling pelagic fishes such as California grunion, California halfbeak (*Hyporhamphus rosae*), California needlefish (*Strongylura exilis*), California barracuda (*Sphryaena argentea*), salema (*Xenistius californiensis*), and sargo (*Anisotremus davidsonii*). Other fish species that were commonly collected in summer (warm water) months included queenfish (*Seriphus politus*), California butterfly ray *(Gymnura marmorata*), California corbina (*Menticirrhus undulatus*), and spotfin croaker (*Roncador stearnsii*).

Batiquitos Lagoon supports a relatively healthy assemblage of fish species and compares well with other southern California/San Diego County coastal embayment studies (PERL 1990, Zedler 1996, Allen et al. 2002, Miller et al. 2008). The 75 species collected in Batiquitos Lagoon over the 10-year monitoring program are similar to the 78 species collected over a 5-year study period in San Diego Bay by Allen et al. (2002).

Benthic Invertebrates

Post-restoration benthic surveys were conducted at five sampling stations throughout the lagoon, including Station 5 in the West Basin, which coincided with the stations established for fish community sampling (Figure 10). Sampling was conducted in January and October in years 1, 2, 3, 5, and 10 (1997, 1998, 1999, 2001, and 2006) following the completion of restoration (Merkel and Associates 2009).

During the 10-year post-restoration monitoring program, infauna from 12 phyla were collected (Merkel and Associates 2009). The abundance of organisms was highly variable between seasons and sampling years. Infauna were most abundant in the first-year post-restoration, when the gastropod *Tryonia imitator* was captured in very high densities (as dense as 51,642 per m^2 at Station 1 in January 1997) from the top of the sample cores. Overall infaunal densities were lower in years 2, 3, and 5, then slightly higher in year 10. Mollusks were consistently the most abundant phylum (43% of the total), followed closely by annelids (37%), then arthropods (15%), phoronids (2%), and nemerteans (1%). The other phyla made up less than 1% of the total individuals. Bivalves occurred in lower numbers than gastropods. They were dense in October of the first year, represented primarily by *Tellina* sp., *Lyonsia* sp, *Laevicardium substriatum, Diplodonta orbella,* and *Tegula* sp, then occurred in lower but consistent densities in the following years, represented by species such as *Chione californiensis*, *Tagelus* sp, *Tellina* sp, and *L. substriatum*. Annelids, comprised almost entirely of polychaetes, were nearly as abundant as mollusks. Annelid numbers were moderately high in years 1 and 2 (1997 and 1998), lower in years 3 and 5 (1999 and 2001), much higher in the beginning of year 10 (2006), and then dropped back down in the October 2006 sampling. The third most abundant infauna phylum, Arthropoda, was composed of amphipods (55% of all arthropods), insects (including dipterans) (19%), isopods (14%), mysids (5%), tanaids (4%), and ostracods (2%), with stomatopods, cumaceans, and decapods making up less than 1% of the total.

Of note was the rapid arrival of the highly invasive, non-native mussel *Musculista senhousia* in the lagoon (Merkel and Associates 2009). None were captured during the January 1997 sampling (one-month post-restoration), but by the second sampling in October 1997, *M. senhousia* were observed at all five stations, ranging in density from (57 to 453 individuals/m^2). It is not known if they were present prior to October; however, the individuals captured in the cores were large enough to have been present in the lagoon for at least several months. They were present in high numbers in 1998, 1999, and 2001, but were absent from infaunal collections from January and October 2006 (although some individuals were collected in April and July 2006 in the fish sampling gear).

Across the lagoon, there were trends with regard to the presence of benthic infaunal invertebrates. The two westernmost stations contained 71% fewer invertebrates on average relative to the three easternmost stations in the East Basin. The East Basin is characterized by muddy sediments high in organic content, while the West Basin sediments were almost entirely sand (Merkel and Associates 2009). Muddy sediments can support large numbers of small opportunistic species (Pearson and Rosenberg 1978) if the species present are not impacted by other physical parameters.

WATER QUALITY IN BATIQUITOS LAGOON

During each fisheries monitoring event during the post-restoration evaluation (1997-2006), water quality data were collected at each of the offshore fish stations, including three located in the East Basin (Stations 1, 2, and 3), one in the Central Basin (Station 4), and one in the West Basin (Station 5) (Figure 10). A Hydrolab® multi-probe water quality instrument, calibrated in accordance with manufacturer specifications, was utilized to collect temperature, salinity, pH, dissolved oxygen (DO), and turbidity data. Readings were taken near the bottom and surface of the water column at each station. Secchi depths, to the full depth of disappearance, were also determined at each station. Surface water grab samples were collected in years 1, 2, 3, and 5 (1997, 1998, 1999, and 2003) at each station and analyzed for nitrate, orthophosphate, and chlorophyll *a*.

Post-restoration monitoring demonstrated that mean water temperature within Batiquitos Lagoon varied seasonally, with generally higher temperatures observed in summer (July with an average temperature of 23.6^{o}C) and the lowest temperatures observed in winter (January with an average temperature of 14.4^{o}C) (Merkel and Associates 2009). Small-scale variations in water temperature were apparent (*e.g.*, temperature usually increased from west to east, day versus night, after storm events); however, water temperature within the lagoon closely mirrored oceanic conditions and any large-scale episodic events, such as the El Niño or La Niña, influenced temperatures within the lagoon.

Post-restoration monitoring indicated that DO measurements ranged from 3.1 to 12.1 mg/L, with a mean of 7.4 mg/L. DO concentrations generally did not vary substantially between surface and bottom waters at any station and were not consistently higher or lower at the surface, suggesting a well-mixed waterbody. Following opening of the lagoon to tidal action, lower nutrient levels and plankton production were observed within the system. DO levels were therefore likely being driven predominantly by temperature, sediment oxygen demand, and the presence of eelgrass. Cooler, oxygen-rich oceanic waters dominated the West Basin, while warmer waters with a lower DO saturation capacity occur within the East Basin.

Salinity recorded during post-restoration monitoring ranged from 17.7 parts per thousand (ppt) (April 1998) to 35.3 ppt (January 1998), with a mean of 32.7 mg/L. Salinity was generally highest at the mouth of the lagoon and decreased moving eastward. Salinity was typically highest in July at all stations and at the surface. Low salinity was recorded when monitoring occurred shortly after some rainfall events.

Turbidity during post-restoration monitoring was generally low in the West and Central basins and increased across the eastern stations. Turbidity was generally lower at the surface than the bottom, indicative of sediment re-suspension or, in some cases, tidal influxes of higher turbidity oceanic waters. Surface turbidity that exceeded bottom turbidity was frequently associated with phytoplankton blooms, sediment inputs from the watershed during periods of significant freshwater flows, or tidal water displacement of turbid bottom waters.

Post-restoration, chlorophyll *a* levels dropped significantly, ranging between 0 and 7.4 milligrams per cubic meter (mg/m^3) in year 1 (1997), representing approximately 4% of pre-construction levels. For all other monitoring events and stations, chlorophyll *a* ranged between 0.5 and 12.0 mg/m^3.

Nitrate in surface waters in year 1 (1997) ranged from 0.1 to 0.7 milligrams per liter (mg/L), and from below detection to 0.1 in 1998 and 1999. Higher values were seen in 2001, ranging from 0.1 to 0.7 mg/L. In 2006, nitrate was undetectable at all stations. In years 1, 2, and 3 post-restoration, orthophosphate levels ranged from non-detectable levels to 0.10 mg/L. In year 5 (2001) orthophosphate was undetected at Stations 4 and 5, and only occasionally at Stations 1, 2, and 3, with a high of 0.13 mg/L at Station 1 in April. In 2006, orthophosphate was not detected at Station 4, but reached the highest recorded concentration at Station 2 in July.

The Water Quality Control Plan for the San Diego Basin (Basin Plan) designates beneficial uses associated with Batiquitos Lagoon. These are Contact Water Recreation (REC-1), Non-contact Water Recreation (REC-2), Preservation of Biological Habitats of Special Significance (BIOL), Estuarine Habitat (EST), Wildlife Habitat (WILD), Rare, Threatened and Endangered Species (RARE), Marine Habitat (MAR), Migration of Aquatic Organisms (MIGR), and Spawning, Reproduction and/or Early Development (SPWN). The Basin Plan defines water quality objectives for ocean waters as those contained in the State Board’s Water Quality Control Plan for Ocean Waters of California (Ocean Plan). These objectives could be applied to Batiquitos Lagoon, but the Basin Plan does not contain any water quality objectives that are specific to the lagoon.

Batiquitos Lagoon has been designated as a State Marine Park by the California Legislature and as an Ecological Reserve by the California Department of Fish and Game. Batiquitos Lagoon was listed as impaired by the San Diego Regional Board in the 2014 and 2016 Integrated Report (303(d) List/305(b) Report) for toxicity (sediment). This was based on 5 of 8 sediment samples that displayed toxicity (data from 2003, 2004, 2005 and 2008). Data were evaluated for 2014 and 2016 Integrated Report and the San Diego Regional Board made the decision “Do Not List” for several chemical contaminants (2-methylnaphthalene, antimony, arsenic, benzo(a)anthracene, cadmium, chlordane, chromium, chrysene, copper, dibenz[a,h]anthracene, endrin, lead, lindane/gamma hexachlorocyclohexane (gamma-HCH), mercury, PAHs (polycyclic aromatic hydrocarbons), PCBs (polychlorinated biphenyls), phenanthrene, pyrene, silver, and zinc).

POTENTIAL IMPACTS TO BIOLOGICAL RESOURCES ASSOCIATED WITH STORMWATER IMPROVEMENT PROJECT

In the past, an existing 24-inch storm drain (La Costa Drain) discharged stormwater collected from the La Costa Interchange into the southern end of the West Basin of Batiquitos Lagoon. Currently, storm drain improvements are underway in connection with the Encinitas Beach Resort development. Modelling was performed by Hale Engineering to document peak flow (100-year storm event) discharging into the West Basin under pre-project and post-beach resort development conditions (Hale 2017). Modelling was performed to calculate predicted peak discharges into the West Basin under pre-project and post-beach resort development conditions for 2-, 5-, 10-, 50-and 100-year storm events (MBI 2020), The predicted peak discharges into the West Basin upon completion of the beach resort development would be 16 to 18% higher than peak discharges prior to this development for the range of storm events modelled (Table 4).

Table 4. Predicted peak discharge rates from stormwater outfall into the West Basin of Batiquitos Lagoon prior to and following completion of the Encinitas Beach Resort development project (MBI 2020).

Storm Event	**Pre-Beach Resort Project Discharge (Peak Flow)** (cubic feet per second)	**Post-Beach Resort Project Discharge (Peak Flow)** (cubic feet per second)
2-year storm	6.4	7.5
5-year storm	7.5	8.8
10-year storm	8.6	10.0
50-year storm	10.7	12.6
100-year storm	13.4	15.7

Modelling was performed by Michael Baker International (MBI) to calculate predicted peak discharges, peak velocities, and total volume into the West Basin following completion of the proposed Encinitas Flow Improvement Project for 2-, 5-, 10-, 50-, and 100-year storm events. (MBI 2020) During a 2-year storm event, modelling predicts that the peak flow rate of the stormwater discharge into the West Basin following completion of the project would decrease by approximately 83% compared to the pre-project (post-beach resort project completion) condition. During a 5-year storm event, the peak flow rate is predicted to increase by approximately 12%. During a 10-, 50-, or 100-year storm event, the peak flow rates would increase by 175% (nearly tripling) to 264% (nearly quadrupling (Table 5). Modelling predicts that peak velocities of the stormwater discharge into the West Basin would range from 4.3 feet per second during a 2-year storm event to 16.8 feet per second during a 100-year storm event. The total volume of stormwater runoff discharged into the West Basin would range from 7,966 cubic feet during a 2-year storm to 295,455 cubic feet during a 100-year event (Table 5).

Table 5. Predicted peak discharge rates, maximum velocities, and total volumes from stormwater outfall into the West Basin of Batiquitos Lagoon following completion of the North Coast Highway 101 Streetscape Storm Drain Improvement Project (MBI 2020).

Storm Event	**Peak Flow Rate** (cubic feet per second)	**Peak Velocity** (feet per second)	**Total Volume** (cubic feet)
2-year storm	1.3	4.3	7,966
5-year storm	9.9	8.5	19,470
10-year storm	27.5	11.8	62,820
50-year storm	45.9	16.1	218,017
100-year storm	48.2	16.8	295,455

The peak runoff and volumes for the "first flush" was evaluated (MBI 2020, Appendix B). The first flush has been identified by the Regional Water Quality Control Board as the flow containing the highest concentration of potential pollutants, As documented by Water Environment Federation, flows higher than the 85-percentile/24-hour storm sharply decline in composition of pollutant concentration. Due to project design, the 85th percentile from the Project Area discharges entirely at the west-101 outfall. The Batiquitos Lagoon, at east-101 outfall, will not receive any of the 85th percentile runoff (first flush) from the Project Area. Runoff from Local Area (the intersection of N. Coast Highway 101 and La Costa Avenue at the Encinitas Beach Resort), including the local 85th percentile, will continue to discharge to the Lagoon at the east-101 outfall, consistent with pre-development conditions.

Potential Adverse Impacts to Biological Resources

Following a review of the biological communities and physiography of the West Basin of Batiquitos, four areas of potential impact from the project to the biological resources were identified:

- Erosion Impacts – including erosion of terrestrial, intertidal mud and sand, and basin sediments and habitats,
- Dilution and Salinity Depression Impacts – including potential for extended salinity reductions in the West Basin
- Sedimentation Impacts – including potential for burying eelgrass and benthic species, and reduction in depth in the West Basin.
- Increased pollutant load transported to West Basin by runoff as a result of the project.

To further evaluate these potential impacts, a finite element hydrodynamic model was used to assess potential impacts to Batiquitos Lagoon as a result of incremental net additions of new storm water discharges associated with infrastructure improvements along North Coast Highway 101 within the City of Encinitas (MBI 2020, Appendix A). The analysis focused on the largest of these improvements, the East-101 Storm Drain Outfall with its associated dissipator structure. Discharges from this storm drain will run off across vegetated habitats and into the south arm of the West Basin of Batiquitos Lagoon.

The analysis focused on potential water quality impacts associated with dilution and salinity depression, potential erosion impacts associated with high velocity discharges, and potential sedimentation impacts associated with deposition of material transported by runoff. The modeling utilized updated bathymetry provided by Merkel and Associates, (2008) and latest updates to Scripps Pier NOAA tides for the 1983-2001 tidal epoch. The model was calibrated to within 0.1-foot accuracy in predicted lagoon water levels.

Findings for Potential Erosion Impacts

During flood tide, a sluggish disorganized eddy persists in the south arm of the West Basin in which velocities range from 0.02-0.04 m/s (0.06 – 0.13 ft/s), far below the threshold of motion of the native West Basin sands. Scour of these lagoon sands occurs at speeds of 0.8 ft/sec (0.24 m/sec) (MBI 2020, Appendix A). Similarly, on ebb tide, the south-arm currents in the West Basin do not exceed -0.1 m/sec (-0.3 ft/sec), or 2.4 times smaller than threshold scour speed. Scour across the vegetated habitats of the West Basin (eelgrass, cordgrass, pickleweed, and other plants) from the discharges of the East-101 Storm Drain Outfall are also equally unlikely since the dissipator is designed to lower discharge velocities below 1 ft/s (the threshold scour speed of the sandy soils across the vegetated habitats) for all storm event scenarios (MBI 2020). No adverse impacts to wetlands or other vegetated habitats would be expected to occur as a result of the increased stormwater discharge into the West Basin.

Findings for Dilution and Potential Salinity Depression Impacts

Discharges into the West Basin of Batiquitos Lagoon from the storm drain due to runoff from the 100-yr storm are calculated to yield 295,455 ft3 (6.78 acre-ft) in a 28.74-hour period (1.16 diurnal tide cycles) (MBI 2020, Appendix A). The average volume of sea water stored in the West Basin over one diurnal tide cycle is 108-acre ft. Using the definition of dilution factor Dm under the California Ocean Plan (Dm = parts seawater per parts effluent), the storm runoff discharged by the East-101 Storm Drain Outfall during a 100-yr event could not be any less than Dm = 15.9 to 1, assuming all of the storm water remained contained in the West Basin. In that case the salinity in the West Basin would be depressed by -1.98 ppt from 33.52 ppt for ambient seawater, down to 31.54 ppt. However, that amount of salinity depression would be a short-lived occurrence. After 1.9 days following cessation of runoff from the East-101 Storm Drain Outfall (equivalent to West Basin residence time) the dilution factor would increase to no less than Dm= 796 to 1. Consequently, salinity in the West Basin would increase to 33.48 ppt, a mere -0.4 ppt below ambient sea water.

Communities in coastal lagoons frequently experience variable salinities and are able to tolerate reduced salinities for longer periods than expected in the West Basin even during very large storm events. No adverse impacts to eelgrass or other wetland vegetation, fish and benthic invertebrate communities, or avian communities, including special status species, would be expected to occur due to the minor and short duration salinity depression caused by the increased discharge of stormwater runoff into the West Basin.

Findings for Potential Sedimentation Impacts

The 100-yr event runoff event from the East-101 Storm Drain Outfall are calculated to yield 0.13 cm of deposition of partially consolidated mud in the West Basin of Batiquitos Lagoon (MBI 2020, Appendix A). This is considered a *di minimis* amount of post-storm deposition, especially considering it is based on worst case assumptions that all storm water discharged from the East-101 Storm Drain Outfall remains confined within the West Basin over a 1.9-day period. No adverse impacts to eelgrass or other wetland vegetation, fish and benthic invertebrate communities, or avian communities, including special status species, would be expected to occur due to the minor increase in sedimentation caused by the increased discharge of stormwater runoff into the West Basin.

Findings for Increased Pollutant Load

The Q3 study (MBI 2020, Appendix B) evaluated the peak runoff and volumes for the “first flush” or the industry standard 85-percentile/24-hour storm event. The first flush has been identified by the Regional Water Quality Control Board as the flow containing the highest concentration of potential pollutants. As documented by Water Environment Federation, flows higher than the 85-percentile/24-hour storm sharply decline in composition of pollutant concentration. As documented in Q3’s analysis, the 85th percentile from the Project Area discharges entirely at the west- 101 outfall. The Batiquitos Lagoon, at east-101 outfall, will not receive any of the 85th percentile runoff (first flush) from the Project Area. Runoff from Local Area (the intersection of N. Coast Highway 101 and La Costa Avenue at the Encinitas Beach Resort), including the local 85th percentile, will continue to discharge to the Lagoon at the east-101 outfall, consistent with pre-development conditions.

Contaminant inputs in the West Basin of the Batiquitos Lagoon will not substantially increase above current levels as a result of the Project. No adverse impacts to eelgrass or other wetland vegetation, fish and benthic invertebrate communities, or avian communities, including special status species, would be expected to occur as a result of increased contaminant inputs from stormwater runoff into the West Basin.

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