Natural Treatment Wetlands at Ballona Southeast:

A Better Solution for Urban Runoff in the Ballona Watershed

Prepared by the Ballona Wetlands Land Trust

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Introduction

The Ballona Watershed encompasses a 128 square mile area, stretching from the ridgeline of the Santa Monica Mountains to Inglewood, from the eastern edge of Silverlake to Marina del Rey. Storm and dry-weather urban runoff accumulated in this large urbanized area drains from subsidiary streams into Ballona Creek and thence into the Pacific Ocean. Because this runoff is untreated, Ballona Creek has become the largest source of pollution in Santa Monica Bay. Anticipated growth and continued development in the watershed will continue to exacerbate this problem in the foreseeable future.

Under the auspices of the Federal Clean Water Act, local agencies including the City and County of Los Angeles have been directed by California's Regional Water Quality Control Board ("Regional Board") to make drastic near-term improvements in the quality of runoff entering the bay. Failure to comply will be grounds for severe financial liabilities. Impairments in water quality are numerous and include heavy metals, toxic chemical pollutants, and pathogens such as fecal coliform bacteria. Abatement of these pollutants will be difficult given the limited open space available in the lower watershed. The proposed Integrated Resource Plan provides a source reduction approach consisting of cisterns and permeability improvements at parks, schools and government facilities. This approach is costly and unlikely to provide the abatements necessary for Clean Water Act compliance. A second approach is the construction of end-of-pipe mechanical treatment plants. This approach is also costly, energy-intensive, and hobbled by a lack of viable sites.

The most cost-effective and environmentally-friendly regional solution is the construction of Natural Treatment Wetlands. Natural

Treatment Wetlands are designed and constructed to improve water quality by taking advantage of natural processes that occur in otherwise natural wetlands. Natural Treatment Wetlands have been constructed in hundreds of successful programs in the United States in recent decades, including projects here in Southern California, and have even been cited as preferable options by the City and County of Los Angeles as well as the Regional Board.

The EPA states that "the treatment of wastewater or stormwater by constructed wetlands can be a low-cost, low-energy process requiring minimal operational attention." Constructed treatment wetlands would provide habitat for threatened species and would serve dual function as needed park space in a city with the lowest ratio of open space per capita of any large city in the U.S. Adoption would be a keystone of Mayor Antonio Villaraigosa's stated intent to transform Los Angeles into "the greenest big city in America," and is an alternative to energy-intensive, greenhouse gas-emitting treatment plants. Jobs provided by the establishment of a natural treatment wetland would train disadvantaged Los Angeles residents for a career in the new "green economy."

Unfortunately, availability of appropriate sites for natural treatment wetlands is limited. An engineered treatment system would not be appropriate in land already protected as a Wildlife Reserve at Ballona, as fragile local ecosystems would be irreparably displaced. The 111 acres at "Ballona Southeast" (located east of Lincoln Boulevard and south of Jefferson Boulevard and the current proposed site for development of Playa Vista Phase 2) comprise the last remaining viable site for a natural treatment system of significant capacity in the lower Ballona basin. As historical wetlands adjacent to permanently preserved wetland habitat, these acres provide an ideal opportunity for the establishment of a "green corridor", an aesthetically pleasing and ecologically sound alternative to further development. Located in close proximity to Centinela and Ballona Creeks, a constructed Natural Treatment Wetland at this site could draw upon existing storm drain infrastructure. There are no other sites of comparable opportunity in the region.

A Natural Treatment Wetland at "Ballona Southeast" is a feasible, cost-effective, environmentally sound alternative for treating dry weather runoff and small storm events. The use of natural ecosystems to sequester and remove contaminants that would otherwise wind up in Santa Monica Bay is preferable to the construction of costly and energy-intensive new mechanical treatment plants. At the same time, only a constructed Natural Treatment Wetland will provide neighborhood open space and preserve critical wildlife habitat for the enjoyment of future generations.

Summary:

- The Regional Board demands drastic near-term reductions in pollutants reaching Ballona Creek and Santa Monica Bay, and will impose severe liabilities on the City and County of Los Angeles for continued noncompliance with the Federal Clean Water Act.
- The City and County have not produced stormwater pollution mitigation plans that adequately address the scope of the problem.
- Natural Treatment Wetlands reduce pollutant loads by tested and proven methods, using natural processes at much lower cost than energy-intensive mechanical treatment plants, saving taxpayer money.
- The 111 acres slated for development at Ballona Southeast comprise the only viable site in the lower watershed for a Natural Treatment Wetland of significant capacity.
- A Treatment Wetland at Ballona Southeast would renew the land's historic role in the greater Ballona Wetlands ecosystem, providing wildlife habitat and neighborhood park space, and is preferred by the local community to massive development and its attendant costs in traffic, pollution and real estate value on the West Side.
- Construction of a Treatment Wetland would provide local residents with valuable training for jobs in the growing "green economy."
- Funding for a Natural Treatment Wetland remains available via state and local bond acts passed by California voters in pursuance of cost-effective water quality initiatives.

I

The Ballona Watershed

I.1 Features of the Ballona Watershed

The Ballona watershed is one of the most urbanized watersheds in the country. Its land use consists of 64% residential, 8% commercial, 4% industrial, and 17% open space. Open space is almost entirely confined to the Santa Monica Mountains and Baldwin Hills. The population of the watershed is greater than 1.6 million. Runoff from the entire 128 square mile watershed collects in Ballona Creek before draining into the Santa Monica Bay, and is currently the largest source of pollution in the bay.

Development in the Ballona watershed has induced severely limited ground permeability. Historically, Ballona Creek emerged from the Santa Monica Mountains and meandered towards the Pacific Ocean. Because of the depth of alluvium (eroded material that is deposited in lowlands) on the coastal plain, much of the water in the creek and its tributaries disappeared into sand and gravel and replenished groundwater, resulting in various marshes, swamps and springs. At locations where surface water was present or groundwater was near the surface, willows and other native trees, roses, grapes, and other flowering shrubs were plentiful.

Wetlands, marshes, and springs dotted the landscape. At other locations, surface water was scarce and the vegetation was sparse and dominated by grasses and prickly pear cactus. The wide variety of habitats and available water supplies supported several settlements of indigenous peoples, including the Tongva (or Gabrielino) tribes. Spanish settlers in the

18th century were the first to attempt wholesale reengineering of the hydrology and ecology of the watershed for conversion to farm and grazing land.

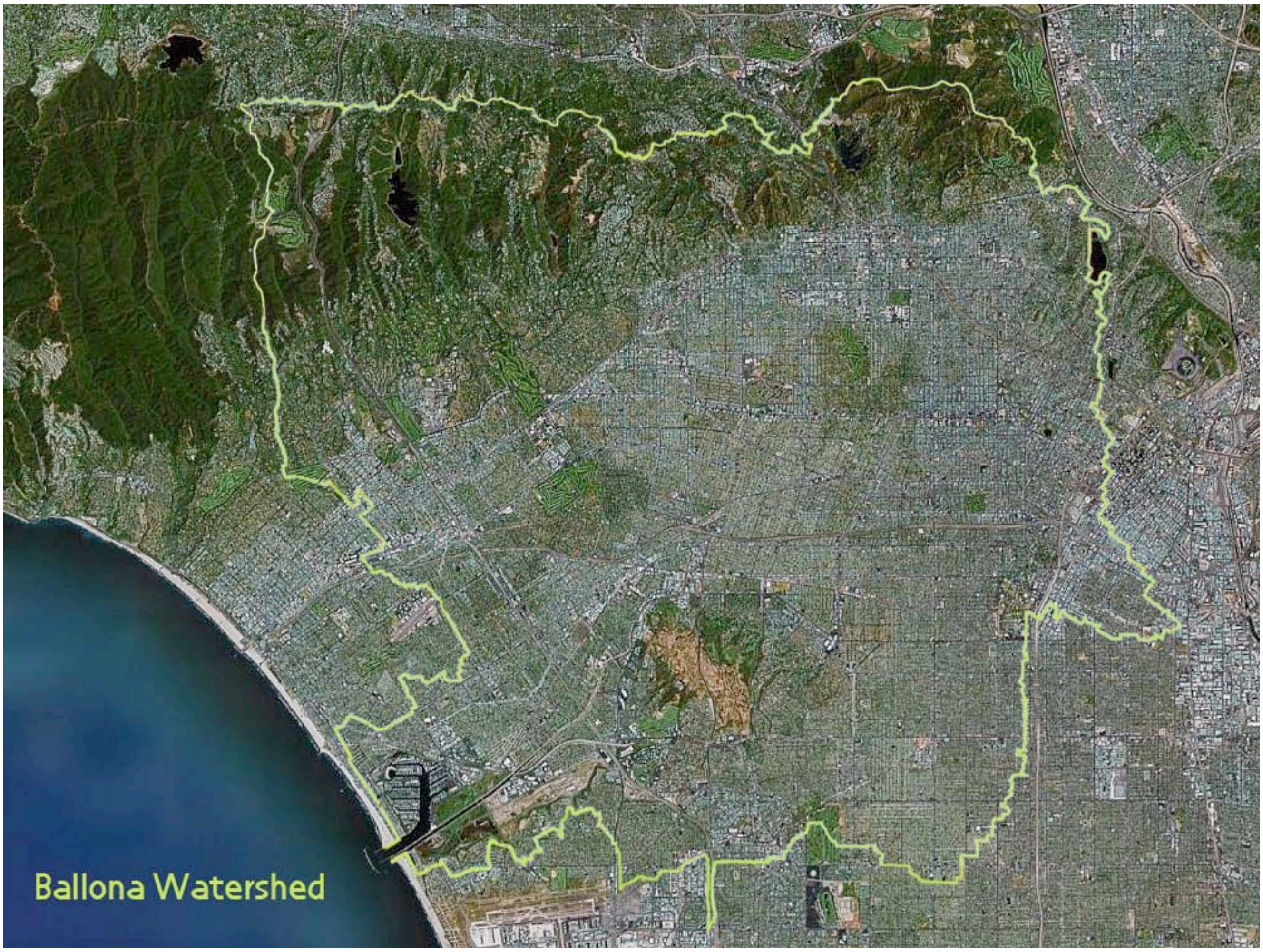

Figure 1: Extent of the Ballona Watershed

The transformation of the watershed from farmland to urban metropolis over the last two centuries exposed large populations to danger from floods. After two significant floods in the 1930s, the federal government worked with the Los Angeles County Flood Control District to implement a flood control plan to (1) channelize, straighten, and deepen Ballona

Creek; (2) install debris basins in the foothills to protect against debris flows during storm events; and (3) convert tributary streams to flood control channels, most in underground tunnels that erased traces of the extensive network of natural tributaries.

To provide recreational boating opportunities, the County of Los Angeles developed Marina del Rey in the late 1950s and early 1960s, transforming a large area of former coastal dunes and Ballona wetlands into a major small craft marina. The entrance channel to Marina del Rey was constructed immediately north of the Ballona Creek Channel, with a breakwater constructed at the mouth of the creek.

Ballona Creek has been greatly altered by human engineering. The Creek flows as an open channel for just under 10 miles from Los Angeles (south of Hancock Park) through Culver City, reaching the Pacific Ocean at Playa del Rey. It is almost entirely lined in concrete, with a sandy natural bottom west of Centinela Avenue, and is fed by a complex underground network of storm drains, which reaches north to Beverly Hills and West Hollywood. Tributaries of the Creek and Estuary include Centinela Creek, Sepulveda Canyon Channel, Benedict Canyon Channel, and numerous other storm drains. The creek meets Ballona Estuary at Centinela Avenue, and flows into the Santa Monica Bay at the site of engineered jetties and breakwater.

I.2 Polluted Runoff in the Ballona Watershed

The concretization of hydrologic pathways in the Ballona Watershed have been successful in their stated purpose of flood loss minimization, but have had the unintended consequence of subverting the natural cleansing processes of riparian habitat. High-flow concrete channels preclude the sequestration and absorption of pollutants and the recharging of ground aquifers. Lack of permeability ensures that pollutants spilled in the watershed are dumped into Santa Monica Bay at high concentrations.

Sources of pollution in the Ballona Watershed include, but are not limited to, automobiles, industry, fertilizers, pets, leaking tanks, legacy pollutants, and illegal dumping. These pollutant sources collect into storm drains and concretized creeks and result in high measured content of heavy metals, toxic chemicals and bacterial and viral pathogens in Ballona Creek and the Ballona Creek Estuary. Concentrations of these pollutants require drastic reductions to come into compliance with the Federal Clean Water Act.

Ballona Creek is designed to discharge to Santa Monica Bay approximately 71,400 cubic feet per second from a 50-year frequency storm event. In dry weather, flows in Ballona Creek are estimated to be 14 cubic feet per second.

I.3 Coming Into Compliance with the Clean Water Act

The Clean Water Act ("CWA") requires the establishment of limits on the amount of pollutants that can be discharged to Santa Monica Bay. Section 303(d)(1)(A) of the CWA requires each state to conduct a biennial assessment of its waters, and identify those waters that are not achieving water quality standards. The resulting list is referred to as the 303(d) list, otherwise known as "pollution-impaired waters." The CWA also requires states to establish a priority ranking for waters on the 303(d) list of impaired waters and to develop and implement limits on pollutants for these waters. These limits are called Total Maximum Daily Loads, or "TMDLs."

I.3.1 Assessment of Impairments in Ballona Creek

The most recent 303(d) assessment was in 2002 and identified 16 state impairments in Ballona Creek (Table 1). The most recent assessment localized to the Ballona Creek Estuary was in 1998 and found 10 state impairments (Table 2). These lists are not exhaustive, but indicate that impairments in water quality in Ballona Creek are most pressing in the areas of metals, toxic chemicals, and bacterial and viral pathogens.

Table 1: 303(d) Listed Impairments in Ballona Creek

State Impairment	Parent Impairment	Priority
CHEMA	OTHER CAUSE	HIGH
CHLORDANE (FISH TISSUE)	PESTICIDES	HIGH
CONTAMINATED SEDIMENTS (CADMIUM)	METALS (OTHER THAN MERCURY)	HIGH
CONTAMINATED SEDIMENTS (SILVER)	METALS (OTHER THAN MERCURY)	LOW
COPPER	METALS (OTHER THAN MERCURY)	HIGH
DDT	PESTICIDES	HIGH
DIELDRIN	PESTICIDES	HIGH
ENTERIC VIRUSES	PATHOGENS	HIGH
HIGH COLIFORM COUNT	PATHOGENS	HIGH
LEAD	METALS (OTHER THAN MERCURY)	HIGH
PCBS	PCBS	HIGH
PH	PH	LOW
SEDIMENT TOXICITY	TOTAL TOXICITY	HIGH
SELENIUM	METALS (OTHER THAN MERCURY)	LOW
TOXICITY	TOTAL TOXICITY	HIGH
ZINC	METALS (OTHER THAN MERCURY)	LOW

Table 2: 303(d) Listed Impairments in Ballona Creek Estuary

State Impairment	Parent Impairment	Priority
AROCHLOR	PCBS	HIGH
CHLORDANE	PESTICIDES	HIGH
DDT	PESTICIDES	HIGH
HIGH COLIFORM COUNT	PATHOGENS	HIGH
LEAD	METALS (OTHER THAN MERCURY)	LOW
PAHS	TOXIC ORGANICS	HIGH
PCBS	PCBS	HIGH
SEDIMENT TOXICITY	TOTAL TOXICITY	MEDIUM
SHELLFISH HARVESTING ADVISORY	FISH CONSUMPTION ADVISORY – POLLUTANT UNSPECIFIED	MEDIUM
ZINC	METALS (OTHER THAN MERCURY)	LOW

I.3.2 Meeting the Goals of the TMDLs

The Los Angeles Regional Water Quality Control Board, vested with the responsibility of enforcing the federal Clean Water Act in the Los Angeles region, is in process of establishing TMDLs to address all water quality impairments. To date, the following TMDLs have been established:

- For Ballona Creek: Trash (2002), Copper (2005), Lead (2005), Selenium (2005), Zinc (2005), and Bacteria (2007).
- For Ballona Creek Estuary: Cadmium (2005), Chlordane (2005), Copper (2005), Lead (2005), Silver (2005), DDT (2005), PAH (2005), PCBs (2005), Zinc (2005), and Bacteria (2007).

These regulations require reductions of as much as 70 percent in measured effluent pollutant content. Additional TMDLs for the other stated impairments are being drafted and are expected to be adopted in the coming years.

The regulatory mechanism used to implement the TMDL is the National Pollutant Discharge Elimination System (NPDES) permit program. The NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Under the NPDES storm water program, operators of large, medium and regulated small municipal separate storm sewer systems (MS4s), as well as industrial point polluters, require authorization to discharge pollutants. Parameters for the permit authorization process are informed by enacted TMDLs and are evaluated on rolling 5-year compliance schedules.

Permits granted by the Regional Board whose compliance targets will become more stringent include the Los Angeles County Municipal Storm Water NPDES Permit (MS4), the State of California Department of Transportation (Caltrans) Storm Water Permit, as well as minor and general NPDES permits for industry and construction. According to a schedule laid out in the Basin Plan and its amendments, by 2016 bacterial targets and metals targets for dry-weather must be fully met, and wet-weather metals targets must be met for 50 percent of the drainage area served by the MS4 system.

On March 4, 2008, the Regional Water Quality Control Board issued long-awaited violation notices to 20 cities and Los Angeles County. The Regional Board is requiring municipal violators to provide documentation of the causes of the violations, and detailed descriptions of remedial actions already attempted and planned for the future. The cities and counties face fines of $10,000 a day for noncompliance. The Regional Board may also ask the state Attorney General's office to seek civil liabilities in court of up to $25,000 a day for each day a violation occurs.

Meeting the TMDL goals and avoiding liability will require major pollution-abatement efforts by all NPDES permit-holders, including the City and County of Los Angeles. Proposed abatement plans have failed to fully account for the reductions mandated by the Regional Board. The Integrated Resource Plan promulgated by the City of Los Angeles proposes to install cisterns and permeability improvements at parks, schools and government facilities. This approach is costly, and unlikely to provide the abatements necessary for compliance. A second favored approach by the City is the construction of end-of-pipe treatment plants that would use costly and energy-intensive means of filtering runoff. As has been shown by respondents to the plan, there is a marked deficiency of viable sites for treatment plants. The cleanest and most cost-effective means of achieving compliance with the TMDLs mandated by the Clean Water Act is the establishment of Natural Treatment Wetlands in the lower Ballona watershed, which would use natural processes to sequester runoff and filter pollutants from dry- and wet-weather runoff before it reaches Santa Monica Bay.

II
Natural Treatment Wetlands

II.1 What is a Natural Treatment Wetland?

Wetlands are commonly known as biological filters, providing protection for water resources, including lakes, estuaries, ground water, and coastal shorelines. Although wetlands have always served this purpose, research and development of wetland treatment technology is a relatively recent phenomenon. In the United States, wastewater-to-wetlands research began in the late 1960s, and increased dramatically in scope during the 1970s. As a result, the use of wetlands for stormwater and wastewater treatment has gained considerable popularity worldwide. Currently, more than one thousand wetland treatment systems are in use in North America. This relatively new technology for water quality management is attractive because in many cases it provides the most cost-effective method for complying with the pollution abatement mandate of the Clean Water Act.

The goal of wastewater treatment is the removal of contaminants from the water in order to decrease the possibility of detrimental impacts on humans and the rest of the ecosystem. Many contaminants, including a wide variety of organic compounds and metals, are toxic to humans and other organisms. Other types of contaminants are not toxic, but nevertheless pose an indirect threat to our well-being. For example, loading of nutrients (e.g., nitrogen and phosphorus) to waterways can result in excessive growth of algae and unwanted vegetation, diminishing the value of lakes, bays and streams. The sequestration of polluted waters in a treatment wetland allows natural processes to proceed. These include sedimentation, chemical precipitation and adsorption, uptake and transformation by plants and microorganisms, and prolonged UV exposure.

Figure 2: Diagram of Treatment Wetland System in the San Diego Creek Watershed

Wetlands have proven effective in treating municipal wastewater (sewage), agricultural wastewater and runoff, industrial wastewater, and stormwater runoff from urban, suburban and rural areas. Wetland treatment systems vary greatly in size and scope, from single-residence backyard wetlands to regional-scale systems such as the 1200-acre Iron Bridge treatment wetland in central Florida. In Southern California, a number of Natural Treatment Systems have been proposed and built. These include the ambitious implementation of an integrated treatment system in the San Diego Creek watershed. Under the auspices of the Irvine Ranch Water District, Orange County, and the city governments within the watershed, the conversion of at least 31 sites to treatment wetlands is under way at modest cost ($41 million in the most recent estimate).

II.2 How does a Natural Treatment Wetland work?

A number of physical, chemical and biological processes operate concurrently in constructed and natural wetlands to provide contaminant removal. Knowledge of the essential features of wetlands is helpful in the consideration of a constructed natural treatment system.

II.2.1 Features of Wetlands

The term "wetlands" encompasses a broad range of wet environments, including marshes, bogs, swamps, wet meadows, tidal wetlands, floodplains, and ribbon (riparian) wetlands along stream channels. All wetlands - natural or constructed, freshwater or salt - have one characteristic in common: the presence of surface or near-surface water, at least periodically. In most wetlands, hydrologic conditions are such that the substrate is saturated long enough during the growing season to create oxygen-poor conditions in the substrate. The lack of oxygen creates reducing (oxygen-poor) conditions within the substrate and limits the vegetation to those species that are adapted to low-oxygen environments.

The hydrology of wetlands is generally one of slow flows and either shallow waters or saturated substrates. The slow flows and shallow water depths allow sediments to settle as the water passes through the wetland. The slow flows also provide prolonged contact times between the water and the surfaces within the wetland. The complex mass of organic and inorganic materials and the diverse opportunities for gas/water interchanges foster a diverse community of microorganisms that break down or transform a wide variety of substances. Most wetlands support a dense growth of vascular plants adapted to saturated conditions. This vegetation slows the water, creates microenvironments within the water column, and provides attachment sites for the microbial community. The litter that accumulates as plants die creates additional material and exchange sites, and provides a source of carbon, nitrogen, and phosphorous to fuel microbial processes.

Many chemical and biological (especially microbial) transformations take place within the substrates. The accumulation of litter increases the amount of organic matter in the wetland and provides storage for many contaminants. Organic matter provides sites for material exchange and microbial attachment. The physical and chemical characteristics of soils and other substrates are altered when they are flooded. In a saturated substrate, water replaces the atmospheric gases in the pore spaces and microbial metabolism consumes the available oxygen. Since oxygen is consumed more rapidly than it can be replaced (by diffusion from the atmosphere), substrates become anoxic (without oxygen). This reducing environment is important in the removal of pollutants such as nitrogen and metals.

Wetlands may be classified in three types; surface flow wetlands, subsurface flow wetlands, and hybrid systems. Surface flow wetlands sustain a water level above the ground surface. Waterflow is primarily above ground. In subsurface flow wetlands, water level remains below the ground surface. Water flows through a sand or gravel bed; vascular plant roots anchor to the bottom of the bed. In order to maximize treatment yields in a site of variable flow, a hybrid system may be maintained. Hybrid systems also confer the possibility for multistage treatment systems in which differing chemical processes are maximized.

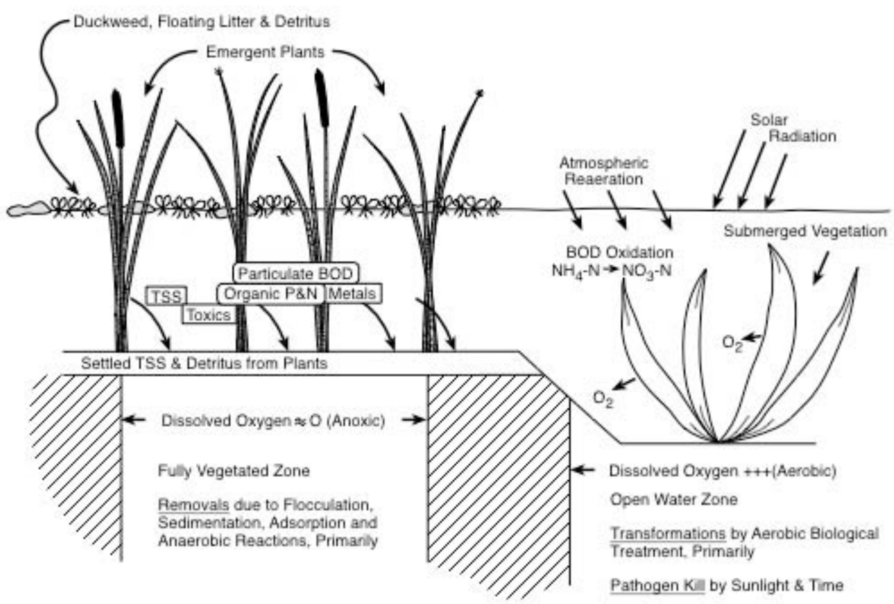

Figure 3: Selected Chemical Processes in a Wetland Ecosystem

II.2.2 Ecology of Wetlands

Wetlands are typically sites of high concentrations of biological diversity. Common to all wetlands is the presence of vascular plants, non-vascular plants (algae), microorganisms, and animals. These are highly adapted to saturated, oxygen-poor conditions. Decay of plant matter fuels high concentrations of microorganisms, which propel a diverse food web of vertebrate fauna.

II.2.3 How Wetlands Improve Water Quality

Wetlands are commonly referred to as the "kidneys" of the hydrologic cycle. The complex interaction of water, substrate, plants, plant litter, algae, microorganisms and invertebrates in a wetlands ecosystem improves water quality by a variety of mechanisms, including:

- sedimentation of suspended particulate matter
- filtration and chemical precipitation through contact of the water with the substrate and plant litter
- chemical transformation
- adsorption and ion exchange on the surfaces of plants, substrate, sediment, and litter
- breakdown, transformation and volatilization of pollutants by microorganisms and plants
- uptake and transformation of nutrients by microorganisms and plants
- predation and natural die-off of pathogens.
- prolonged exposure of sequestered materials to UV radiation

In most systems, a detention period of 10-14 days is the standard for optimum treatment.

II.2.4 Mechanisms for Specific Pollutant Removal

Treatment of specific pollutants in a wetland occurs by a varied set of interrelated processes (Table 3). Design of wetland systems may be configured for maximum benefit to local pollutant loads.

Table 3: Pollutant Removal Mechanisms in Treatment Wetlands

POLLUTANT	REMOVAL MECHANISMS
Suspend solids	• Sedimentation and filtration
Nitrogen	• Nitrification and denitrification • Plant uptake • Volatilization
Phosphorus	• Sedimentation • Adsorption
Pathogens	• Sedimentation and filtration • Natural die-off / predation • UV radiation
Toxic chemicals	• Adsorption • Degradation by bacteria • Volatilization
Selenium	• Adsorption in permanently anoxic conditions • Volatilization
Dissolved metals	• Adsorption • Precipitation

Sediment

Gravitational settling (sedimentation) is the predominant removal mechanism for suspended solids. Sedimentation of larger particles occurs in shallow areas designed as sediment traps, where finer particles can settle out over extended periods. Some solids will also be removed by vegetation through electrostatic adsorption and by filtering through trapped organic debris and sands.

Nitrogen

Nitrogen removal in treatment wetlands occurs by several complex mechanisms, collectively referred to as the nitrogen cycle. Bacteria present in the sediments facilitate important removal mechanisms. Bacteria convert ammonia to nitrate in the presence of oxygen, and convert nitrate to nitrogen gas in the absence of oxygen. These processes are affected by temperature, occurring more rapidly during warmer seasons when microbial activity is highest. Nitrate is also a readily available form of nitrogen for growth and uptake by wetland vegetation.

Phosphorus

Phosphorus removal occurs by sedimentation of particulate forms of phosphorus. Plant uptake of soluble phosphorus by adsorption is a secondary removal mechanism.

Pathogens

Pathogen removal in natural treatment wetlands occurs by filtration/interception, predation by nematodes and microorganisms, and natural die-off. Ultraviolet radiation (UV) from sunlight also reduces pathogen populations in systems with open water areas. The waters of the lower Ballona watershed are listed for enteric viruses and also for high coliform count. The coliform count is employed as an indicator of total bacterial load. Natural treatment systems have proven especially effective in reducing bacteria (see Figure 4), and a treatment wetland at Ballona would be expected to contribute significantly to meeting the goals of the TMDL. Reported data from functioning treatment wetlands systems on the reduction of viral loads is minimal and less conclusive.

Pesticides and Organics

Toxic organic compounds that are potentially present in urban runoff include a wide variety of hydrocarbons, solvents, and pesticides. Removal processes for organic compounds in natural treatment wetlands are highly compound-specific and include volatilization, sedimentation, adsorption, and microbial degradation. In the lower Ballona watershed, toxic compounds of concern include Chlordane, DDT, Dieldrin, Arochlor and PCBs. For these compounds, moderate uptake by adsorption to soil sediments and by biodegradation may be expected.

Selenium

Selenium removal is dependant upon low- oxygen (anoxic) conditions. A permanently anoxic environment promotes the biologically mediated conversion of selenium to reduced forms that will readily adhere to soil particles. Other removal/degradation mechanisms include bacterial and phyto methylation. During methylation, inorganic selenium is converted to volatile dimethylselenide (DMSe) by bacteria and plants. DMSe is substantially less toxic than inorganic forms of selenium (i.e. selenate and selenite) and will readily be transferred to the environment through volatilization. Selenium is listed as a low priority impairment for Ballona Creek, and recent studies of selenium removal in surface flow wetlands have shown that selenium volatilization is a significant removal pathway.

Metals

Removal of trace metals occurs by several mechanisms including adsorption, sedimentation, precipitation as insoluble salts, and uptake by plants and microorganisms. Adsorption and sedimentation are key to the removal of heavy metals. High concentrations of Cadmium, Copper, Lead, Silver and Zinc in the lower Ballona watershed can expect to see significant abatement by adsorption and sedimentation. High levels of sedimentation of these metals may require infrequent dredging and removal.

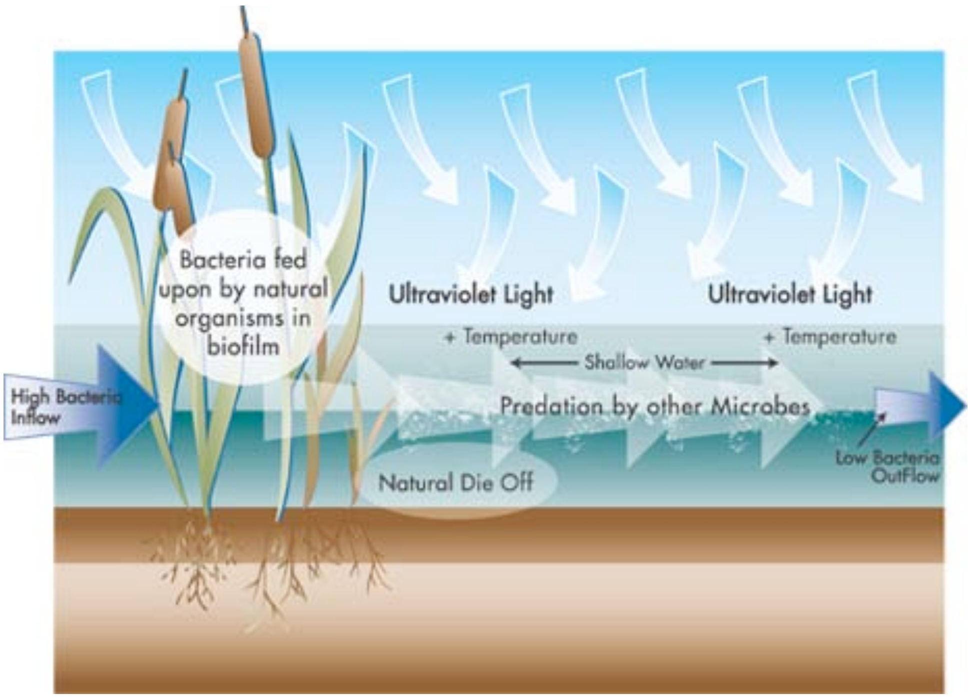

Figure 4: Bacterial Removal Mechanisms

II.3 Elements of Treatment Wetlands Design

Natural treatment systems incorporate various elements to achieve specific design objectives. While most natural treatment facilities share common design features, design of treatment wetlands must be tailored to local conditions and constraints in order to maximize removal of local pollutants, accommodate endemic species, and provide necessary flood control for large storm events.

Cells

Wetlands can be constructed by excavating basins or by building up earth embankments (dikes), or by a combination of the two. A gradual slope keeps the water velocity low, which promotes more effective treatment in the wetlands and limits stress on the vegetation that could be caused by high water velocities. The design of wetland cells should accommodate a retention period of maximum effectiveness, usually no less than 10-14 days. Finger dikes may be employed to create controlled, serpentine flow paths through varied treatment zones.

Flow Control Structures

Water levels should be maintained by simple and easily-adjustable low maintenance flow control structures. Inlet structures are designed to dissipate energy at the inflow, reducing the potential for erosion and damage to wetland plants. Important elements of inlet and outlet design include even flow distribution, elevation to prevent blockage by silt buildup, facilitation of water quality monitoring, devices for trash catchment, and structures such as sluice gates for containment and drainage of the system.

Figure 5: Constructed Treatment Wetland in the Las Vegas Wash

Hydrologic and Vegetative Design

Natural treatment systems may incorporate varied water depths to facilitate maximum treatment. Shallow water, 1-2 feet in depth, supports emergent plants such as cattails and bulrushes, which provide frictional resistance to slow the velocity of the inlet waters, promoting sedimentation and increasing the time for pollutant removal. Cattails and other shallow-water vegetation provide a physical substrate for filtering bacteria, and some removal of soluble phosphate. Bulrushes provide a good long-lasting peat source for anoxic degradation of organic pollutants such as pesticides and petroleum products. Deeper, open water areas, approximately four to six feet deep, provide favorable environments for fish and also provide sites for ultraviolet degradation of complex organics and pathogens. The coexistence of emergent, aquatic, and woody plants in a treatment system, each of which have different preferred water depths, promotes both biodiversity and variable treatment zones. Riparian and upland vegetation adjacent to the wetlands can serve important habitat functions, including the production of detritus critical to the wetland food chain.

Stormwater Flooding

The use of levees around the perimeter of the wetlands provides contingency for high-flow storms. Runoff from the largest storm events will require diversion structures. Maximum capacity of a treatment wetlands varies greatly based on the design of mitigation structures.

Monitoring Devices

Monitoring devices for automatic flow measurement and water quality sampling are typically installed near the inlets and outlets to measure influent and effluent pollutant concentrations.

Maintenance

Maintenance of natural treatment systems is generally minimal. Required service may include cleaning and maintaining inlet and outlet structures, valving, and monitoring devices, and inspecting embankments and structures for damage. Harvesting of plants generally is not required, but annual removal or thinning of vegetation or replanting of vegetation may be needed to maintain flow patterns and treatment functions.

II.4 Treatment Wetlands Are More Economical Than Mechanical Treatment Facilities, Saving Millions in Taxpayer Funds

The City of Los Angeles has proposed an Integrated Resources Program ("IRP") which outlines a plan for catching and treating urban runoff as mandated by the Clean Water Act. The plan relies on two approaches: source reduction and mechanical treatment. Significant source reduction is proposed via catchment at government-owned facilities such as schools and parks, and a requirement that new development incorporate on-site catchment. While source reduction is a worthwhile and necessary goal, the IRP does not quantify the expected benefits, which are expected to fall far short of what's needed to meet the goals of the TMDLs.

In order to meet those goals, the IRP suggests the construction of conventional end-of-pipe treatment plants. Unfortunately, the costs of mechanical treatment of the City's urban runoff would far exceed the IRP's $1 billion estimate inclusive of all runoff treatment approaches. Meeting the mandated targets would require a network of up to 24 plants at a cost upwards of $9 billion. Not only are construction and operational costs high, but there is a marked lack of viable publicly-owned sites for such plants. Mechanical treatment plants are also energy-intensive, producing greenhouse gas emissions, and rate a poor investment at a time when energy costs are escalating. Mechanical treatment of runoff is a costly and inefficient boondoggle that fails to meet the multiple benefit goals of an integrated approach that enhances the value and livability of city neighborhoods.

The construction of treatment wetlands is a far more economical approach. Construction and operational costs are low, and auxiliary benefits to the value of local communities are high. Even when factoring the cost of acquisition of property, a large-capacity treatment wetland is a regional solution that will ultimately pay for itself, saving billions of taxpayer dollars over the alternative.

III

Natural Treatment Wetlands in the Lower Ballona Watershed

III.1 Natural Treatment Wetland Site Opportunity

There currently stands a large undeveloped tract of cleared land in close proximity to the confluence of Centinela and Ballona Creeks. Historic wetlands, part of the wetlands ecosystem that once stretched from Venice to El Segundo on the coast and inland towards what is now Culver City, 1000 acres of land was purchased by Howard Hughes in the 1940's, about 300 acres of which was built for use as an aircraft factory and airstrip at the eastern end of the property. Many other acres were drained, cleared and farmed. The western-most portion of Hughes' land remained functional salt and freshwater marsh. After Hughes' death, the land was transferred to a development company who proposed a mammoth development for the 1000 acres called "Playa Vista." Objections to the destruction of the last remaining coastal wetlands in Los Angeles County held up the project for nearly 25 years. In 2000, Playa Vista began constructing its first phase of development, approximately 250 acres. In 2003, the Ballona Wetlands Land Trust, working in conjunction with other environmental groups, convinced the State of California to purchase approximately 600 acres of the Ballona Wetlands for permanent protection. The remaining 111 acres is currently undeveloped, and unpreserved property known as "Ballona Southeast" and threatened with development by Playa Vista's proposed "Phase 2."

The landowner's proposal for the 111 acre undeveloped site calls for a 99.3 acre "Urban Development Component" and an 11.7 acre "Habitat Creation/Restoration Component" in the form of restoration of the riparian corridor in the historical path of Centinela Creek. The proposal calls for 2,600 dwelling units, 175,000 square feet of office space and 150,000 square feet of retail space.

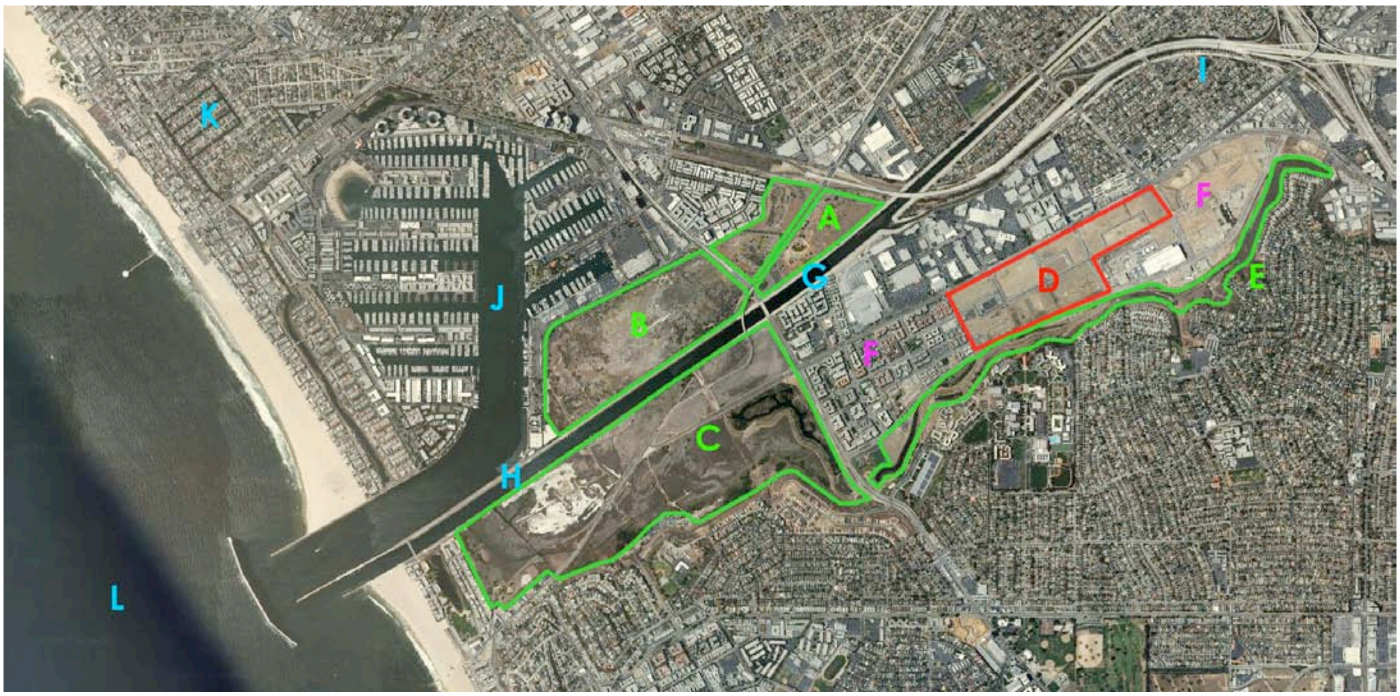

Figure 6: The Lower Ballona Watershed

A, B, C: Permanently Protected Wetlands

D: Natural Treatment Wetland Site Opportunity at Ballona Southeast ("Playa Vista Phase II")

E: Riparian Corridor in Historic Path of Centinela Creek

F: Playa Vista Phase I Residential and Commercial Development

G: Ballona Creek

H: Ballona Creek Estuary

I: Centinela Creek

J: Marina del Rey

K: Venice Canals

L: Santa Monica Bay

The California Second District Court of Appeal halted development on the site in October 2007, ruling that the Los Angeles City Council violated the California Environmental Quality Act when it approved Playa Vista's development expansion in 2005. The developers' Environmental Impact Report was deemed "deficient in its analysis of land use impacts, mitigation of impacts on historical archaeological resources, and wastewater impacts."

Development of the site would not only have unavoidable adverse impacts on the environment by increasing traffic and wastewater and the emission of greenhouse gases and toxic pollutants, but would despoil an ideal site for collected stormwater treatment, the last available site of significant capacity in the lower Ballona watershed. Deployment of an engineered Treatment System in the preserved Wildlife Reserve would not be appropriate, as fragile local ecosystems would be forever lost. However, a Treatment Wetland at Ballona Southeast would provide valuable upland habitat for protected species, enhancing the habitat value of the adjacent Wildlife Reserve.

Figure 7:
Collected Stormwater at Ballona Southeast ("Playa Vista Phase II") site

Topography of the site is flat and low-lying, ranging from approximately 7 to 24 feet above mean sea level. The soil consists of Holocene Alluvium deposited within the last 11,000 years overlain by recent fill. The alluvium ranges from 40 to 120 feet thick and comprises compressible soft silty clay and clay with layers of silt and sand. The presence of impermeable clay indicates that compaction of soil would provide sufficient liner for the creation of a natural treatment wetland on the site.

A natural treatment wetlands system at Ballona Southeast would be able to draw upon existing hydrologic infrastructure. Already, a tributary area of approximately 1,056 acres drains to the property. According to the current landowner, the site currently "provide[s] for temporary stormwater detention." A county stormwater drainage pipe runs parallel to the site along Jefferson Boulevard, and could supply additional surface water. The path of the concretized Centinela Creek runs less than a kilometer from the site to the east, and bends to within 400 meters of the site to the north. Drainage pipes could divert runoff from the creek back towards the creek's original pathway, where it could be treated in a freshwater wetland. Outflow from the treatment wetlands could replenish the riparian corridor and the wetlands west of Lincoln Boulevard or be diverted to Ballona Creek west of its confluence with Centinela Creek.

Ballona Southeast presents a tremendous opportunity for the enhancement of capacity for treatment of polluted runoff. It is the only site of comparable size and value in the lower Ballona watershed and is uniquely recommended by its placement near the confluence of Centinela and Ballona Creeks, by its elevation and soil constituents, and by its historical role as wetlands and its proximity to preserved wetlands habitat. State and local agencies would be well advised to consider acquisition of this land to create a cost-effective means of treating regional polluted runoff with beneficial consequences for the environmental health of the lower Ballona watershed and Santa Monica Bay.

Figure 8: Possible Inflow/Outflow Paths at Ballona Southeast

III.2 Auxiliary Benefits of a Natural Treatment Wetland at Ballona Southeast: Wildlife Habitat, Recreation, Increased Property Values, Green Jobs

At least 90 percent of historic coastal wetlands in California have been lost due to filling, dredging, flood control and intensive development. In Los Angeles County, over 98 percent of wetlands have been lost. The wetlands that remain at Ballona have been degraded by trash and legacy pollutants as well as invasive species. Key native species remain, however, and rely on the Ballona wetlands for survival.

Federal and State Endangered California Least Tern photographed at the Ballona Wetlands

Many of the bird species native to Los Angeles have been extirpated. Of those that remain, the red-tailed hawk, least tern (endangered), yellow-headed blackbird, American coot, cinnamon teal, snowy egret, white-faced Ibis, red-winged blackbird, and great blue heron are among the visitors to the Ballona Wetlands area. Tanagers, wrens, finches, towhees, phoebes, phainopeplas, and owls are common native birds in the upland areas. Some of these are migratory visitors to Los Angeles. A restoration of wetlands habitat at Ballona Southeast could attract listed species such as the least Bell's vireo and the coastal California gnatcatcher. Recently Osprey (listed as sensitive by the California Department of Fish and Game) have been spotted frequenting standing water on the site of the proposed treatment wetland.

Known and Documented to Use the Ballona Wetlands:

- **American Peregrine Falcon** (Falco peregrinus) State Endangered
- **Brown Pelican** (Pelecanus occidentalis) State and Federal Endangered
- **California Least Tern** (Serna antillarum browni) State and Federal Endangered
- **Belding Savannah Sparrow** (Passerculus sandwichensis beldingi) State Endangered

Known Historic or Occasional Use of Ballona Wetlands:

- **Light-footed Clapper Rail** (Rallus longirostris levipes) State and Federal Endangered
- **Western Snowy Plover** (Charadrius alexandrinus nivosus) Federal Threatened

Possible Historic Use or Potential Future Use of Ballona Wetlands:

- **Coastal California Gnatcatcher** (Polioptila californica californica) Federal Threatened
- **Least Bell's Vireo** (Vireo bellii pusillus) State and Federal Endangered
- **Southwestern Willow Flycatcher** (Empidonax traillii extimus) Federal Endangered
- **California Red-legged Frog** (Rana aurora draytonii) Federal Threatened
- **Pacific Pocket Mouse** (Perognatus longimembris pacificus) State and Federal Endangered
- **Unarmored Threespine Stickleback** (Gasterosteus aculatus williamsoni) State and Federal Endangered
- **Arroyo Southwestern Toad** (Bufo microscaphus californicus) Federal Endangered
- **El Segundo Blue Butterfly** (Euphilotes battoides allyni) Federal Endangered
- **San Diego Fairy Shrimp** (Branchinecta sendiegoensis) Federal Endangered
- **Quino Checkerspot Butterfly** (Euphydryas editha quino) Federal Endangered
- **Tidewater Goby** (Eucyclogobius newberryi) Endangered
- **Saltmarsh Bird's Beak** (Cordylanthus maritimus) Endangered

In recent years, conservationists have stressed the importance of the maintenance of contiguous habitat areas for the preservation of diverse species. In the Ballona watershed, numerous groups advocate for the creation of a "Green Corridor" connecting a renewed natural ecosystem from Baldwin Hills to the Ballona Wetlands along a revitalized Ballona Creek. Preservation of the land at Ballona Southeast as a constructed treatment wetland would be a vital link in the greenway, connected to the rest of Ballona via Playa Vista's existing Riparian Corridor. The establishment of a contiguous wildlife corridor in Los Angeles would be a model demonstration of the viability of urban ecosystems.

Osprey photographed at Ballona Southeast (on proposed site) February 2008. The Osprey (Pandion haliaetus) is listed by the California Department of Fish and Game as a Species of Special Concern. Formerly a breeding bird throughout much of California, this species had declined by the 1940's and is now found mainly in a few areas in northern California.

A study of major metropolitan cities in the U.S. concluded that Los Angeles had the lowest amount of accessible park space per capita of any city of comparable size, and increased development will only exacerbate the deficit. A natural treatment wetland at Ballona Southeast would provide needed open space and could incorporate trails and recreational areas, as has been accomplished at natural treatment wetland sites around the country. One model to emulate is the Sepulveda Basin Wildlife Reserve established by the City of Los Angeles, where a protected wildlife reserve coexists with mixed-use community park space. The park doubles as stormwater and flood water management areas during the rainy winter months.

Numerous studies have shown beyond a doubt that parks and open space increase the value of neighboring residential property. A constructed natural treatment wetland would be a boon to residents of surrounding communities including Westchester, South Los Angeles, Mar Vista, Marina del Rey, Playa del Rey and El Segundo, as well as Playa Vista (Phase I), by providing accessible, aesthetically pleasing park space that enhances the value and diversity of their communities.

Construction of a Treatment Wetland at Ballona Southeast also presents the opportunity to create "green jobs" for disadvantaged local communities. These jobs would provide training in ecologically sensitive construction and hydraulic design, which would prove valuable expertise as Los Angeles revamps its private and public infrastructure to be more efficient and ecologically sustainable.

III.3 Fulfillment of Multiple Agency Goals and Objectives

In recent decades, the Los Angeles Regional Quality Control Board, the City of Los Angeles and the County of Los Angeles have promulgated a variety of interagency plans for improved hydrologic management in the Ballona Watershed. A Treatment Wetland at the Ballona Southeast site would significantly advance the goals of many of these plans.

SANTA MONICA BAY RESTORATION PLAN

In 1994, the Santa Monica Bay Restoration Project, the precursor organization to the Santa Monica Bay Restoration Commission, completed the Santa Monica Bay Restoration Plan ("Restoration Plan"), which addresses all of the coastal watersheds that drain into Santa Monica Bay. The Restoration Plan identifies almost 250 actions that address critical problems such as stormwater and urban runoff pollution, habitat loss and degradation, and public health risks associated with seafood consumption and swimming near storm drain outlets. The Restoration Plan offers the following recommendations:

- "Evaluate and develop effective mechanisms to address small discharges of nonstorm or contaminated storm runoff within the Santa Monica Bay watershed."
- "Restore and enhance ecological diversity and productivity of degraded wetlands."
- "Acquire privately-owned wetlands."
- "Create new wetlands, where feasible."

LOS ANGELES BASIN WATER QUALITY CONTROL PLAN

In 1994, the Los Angeles Regional Water Quality Control Board updated its Water Quality Control Plan, Los Angeles Region: Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties ("Basin Plan"). The Basin Plan is designed to preserve and enhance water quality and protect the beneficial uses of all regional waters facing the Bay and principles including:

- "Reclaimed water will be used to preserve, restore or enhance instream beneficial uses which include, but are not limited to, fish, wildlife, recreation and esthetics associated with any surface water or wetlands."

CITY OF LOS ANGELES INTEGRATED PLAN FOR THE WASTEWATER PROGRAM

In 1999, the City of Los Angeles began work on an Integrated Plan for the Wastewater Program (IPWP) to address the interrelationships between water supply, wastewater, and stormwater. Based on a dual track approach of information gathering and stakeholder outreach, a list of policy recommendations was developed, which include development of new wastewater treatment facilities at "upstream" locations, expand use of recycled water, increase water conservation, increase the diversion of dry-weather urban runoff for treatment, and increase the amount of stormwater that can be captured and beneficially used. The IPWP is the first element of the Integrated Resource Plan (IRP) for the City of Los Angeles, which addresses wastewater, water supply, and stormwater runoff.

SOUTHERN CALIFORNIA WETLANDS REGIONAL RESTORATION STRATEGY

In 2001, the Board of Governors of the Southern California Wetlands Recovery Project, a partnership of public agencies working cooperatively to acquire, restore, and enhance coastal wetlands and watersheds between Point Conception and the International border with Mexico, adopted a Regional Restoration Strategy which identified specific wetland restoration objectives for each county in the Southern California region. Site-specific objectives for the Ballona Wetlands Complex include:

- "acquire coastal wetland and associated upland habitat"
- "develop and implement a restoration and long-term management plan for Ballona wetlands complex."

LOWER BALLONA CREEK RECONNAISSANCE STUDY

In 2002, the U.S. Army Corps of Engineers initiated the Lower Ballona Creek Ecosystem Restoration Los Angeles County 905(b) Reconnaissance Study. The study identifies issues and opportunities for restoration of drainage channels and natural areas in the lower Ballona Creek watershed. The General Opportunity Statement highlights the following:

- "Restore previously filled wetlands and improve the quality of remaining existing wetland remnants and riparian habitat."
- "Creating healthy wetland ecosystems will provide important coastal wetland habitat for threatened and endangered species and can also aid in enhancing Ballona Creek water quality."

BALLONA CREEK WATERSHED MANAGEMENT PLAN

The Ballona Creek Watershed Task Force is a stakeholder group convened by the County of Los Angeles, the City of Los Angeles, the Santa Monica Bay Restoration Commission, and Ballona Creek Renaissance. The task force articulated a broad goal for this Plan: "[Set] forth pollution control and habitat restoration actions to achieve ecological health." The Ballona Creek Watershed Management Plan was adopted in September 2004 and endorses the following goals:

- "Improve Quality of Surface Water and Groundwater"
- "Restore Natural Hydrologic Function to Ballona Creek and Tributaries Where Feasible"
- "Improve Aquatic, Estuarine and Riparian Habitat Quality and Quantity"
- "Improve Habitat Quality, Quantity and Connectivity"
- "Improve Access to Open Space and Recreation for All Communities"

GREEN LA: AN ACTION PLAN TO LEAD THE NATION IN FIGHTING GLOBAL WARMING

The Green LA Action Plan was produced by the office of Mayor Antonio Villaraigosa in May 2007. The plan endorses a goal of 35% reduction in greenhouse-gas emissions below 1990 levels by 2030, and outlines actions to be taken commensurate with that goal.

- "Unpave paradise by increasing green space"
- "Create 35 new city parks by 2010"
- "Identify and develop promising locations for stormwater infiltration to recharge groundwater aquifers."
- "An urban ecosystem approach recognizes and accounts for the intrinsic ability of ecosystems—through biological processes—to improve environmental quality and livability"

III.4 Funding Sources for Lower Ballona Regional Natural Treatment Wetland

California taxpayers have repeatedly demonstrated their willingness to fund bonds in order to achieve the goals of open space, wildlife protection and clean water. Funding for a Natural Treatment Wetland at Ballona Southeast is available under a number of city and state propositions.

PROP. 84

Proposition 84 was approved by California residents in 2006. The Act authorizes the issuance of $5.388 billion in general bonds to fund projects relating to safe drinking water, water quality and supply, flood control, waterway and natural resource protection, water pollution and contamination control, state and local park improvements, public access to natural resources, and conservation efforts. The Proposition states the following intentions:

- Provide grants and loans for safe drinking water and water pollution prevention projects.
- Protect the public from catastrophic floods by identifying and mapping the areas most at risk, inspecting and repairing levees and flood control facilities, and reducing the long-term costs of flood management, reducing future flood risk and maximizing public benefits by planning, designing and implementing multi-objective flood corridor projects.
- Protect the rivers, lakes and streams of the state from pollution, loss of water quality, and destruction of fish and wildlife habitat

• Protect the beaches, bays and coastal waters of the state for future generations.
• Revitalize our communities and make them more sustainable and livable by investing in sound land use planning, local parks and urban greening.

PROP. 1E

The Disaster Preparedness and Flood Prevention Bond Act was approved by California voters in 2006. The Act provides $4.09 billion in bonds – some of which are specified for use in the Central Valley and some of which are to be used outside of the Central Valley. The Act provides:
• $300 million to the Department of Water Resources for grants for stormwater flood management projects that: are designed to manage stormwater runoff to reduce flood damage, comply with regional water quality control plans, and are consistent with any applicable IRWMP.
• $500 million to provide funds to local governments for the state's share of costs for locally sponsored, federally authorized Flood Control Subventions.
• $290 million to protect, create, and enhance flood protection corridors, including flood control bypasses and setback levees; as well as for floodplain mapping.

PROP. O

On November 2, 2004, the voters of Los Angeles overwhelmingly passed Proposition O, authorizing the City of Los Angeles to issue $500 million in general bonds for projects to protect the City's water resources. The Proposition aimed to clean up pollution, including bacteria and trash, in response to the regulatory requirements of the Federal Clean Water Act, while funding improvements to protect groundwater, provide flood protection, and increase water conservation, habitat protection, and open space. Criteria for project approval include:

- Protect rivers, lakes, beaches, and the ocean
- Conserve and protect drinking water and other water sources
- Reduce flooding and use neighborhood parks to decrease polluted runoff
- Capture, clean up, and reuse stormwater

PROP. 50

California residents approved the $3.44 billion Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002 by a large margin. In addition to providing funds for protection of the water supply from terrorism, the act declares that it is necessary and in the public interest to:

- Establish and facilitate integrated regional water management systems and procedures to meet increasing water demands due to significant population growth that is straining local infrastructure and water supplies.
- Improve practices within watersheds to improve water quality, reduce pollution, capture additional storm water runoff, protect and manage groundwater better, and increase water use efficiency.

- Protect urban communities from drought, increase supplies of clean drinking water, reduce dependence on imported water, reduce pollution of rivers, lakes, streams, and coastal waters, and provide habitat for fish and wildlife.
- Protect, restore, and acquire beaches and coastal uplands, wetlands, and watershed lands along the coast and in San Francisco Bay to protect the quality of drinking water, to keep beaches and coastal waters safe from water pollution, and to provide the wildlife and plant habitat and riparian and wetlands areas needed to support functioning coastal and San Francisco Bay ecosystems for the benefit of the people of California.

Conclusions/Recommendations

The management of dry- and wet-weather urban runoff presents a major challenge to the infrastructure of large cities such as Los Angeles. The expansion of impermeable development over large swaths of the Ballona Watershed occurred before the consequences of polluted effluent were fully understood and before best practices for management of runoff were commonplace.

At the beginning of the 21st Century, opportunities for better land use practices that mitigate pollution are few. There is a marked lack of open space left in the Ballona Watershed, and particularly in the lower portion of the watershed where surface effluent will require treatment. To prevent further pollution of Santa Monica Bay, as required by State and Federal law, and to revitalize our beaches and expand our tourism economy, an integrated approach to source reduction and treatment of polluted runoff should be an urgent priority for policymakers.

As urban development and population growth continue, the problem will metastasize, and consequences of continued dumping of toxics and pathogens will further degrade ecosystems already expected to face severe strain from climate change. The Integrated Resource Plan offered by the City of Los Angeles does not adequately address the scope of the challenge. Installation of porous pavement and catchments at city-owned sites will not sufficiently mitigate downstream pollutants. Construction of treatment plants will be costly and energy-intensive, releasing tons of greenhouse gases, and there is a notable lack of available sites on which to build. It is for these reasons that state and local agencies are urged to consider the purchase of privately-held land at Ballona Southeast for the construction of a natural treatment wetland.

There are no sites of comparable promise left in the watershed, and a constructed wetland would restore the land's historic role in the lower Ballona ecosystem. Natural Treatment Wetlands throughout North America have proven effective in the sequestration and abatement of the very pollutants impairing the Ballona Watershed. Construction and maintenance costs are low, and auxiliary benefits to wildlife and to communities in need of vital park space are high.

Taxpayers in California have signaled their environmental priorities by approving multiple bond acts for the preservation of open space and the mitigation of pollution. Compliance with Federal and State law demands drastic and timely action by local agencies. A Natural Treatment Wetland at Ballona Southeast is the most attractive, cost-effective, "green" option, and should be given all due consideration as we attempt a more conscious stewardship of our ecological resources.

References

Ballona Creek Watershed Task Force. Ballona Creek Watershed Management Master Plan. December 2004. http://www.ladpw.com/wmd/watershed/bc/bcmp/masterplan.cfm

Ballona Wetlands Foundation. A Baseline Survey of the Ballona Outdoor Learning & Discovery (Bold) Area. John H. Dorsey and Sean Bergquist, editors. April 2007.

California Regional Quality Control Board, Los Angeles Region. Amendment to the Water Quality Control Plan – Los Angeles Region to incorporate the Ballona Creek Metals TMDL. September 2007.

California Regional Quality Control Board, Los Angeles Region. Amendment to the Water Quality Control Plan – Los Angeles Region to incorporate the TMDL for Bacterial Indicator Densities in Ballona Creek, Ballona Estuary, and Sepulveda Channel. June 2006.

California Regional Quality Control Board, Los Angeles Region. Amendments to the Water Quality Control Plan – Los Angeles Region for the Ballona Creek Trash TMDL. March 2004.

City of Los Angeles DPW and Bureau of Sanitation. Integrated Resources Plan for the Wastewater Program. 2004. http://www.lacitysan.org/irp/

City of Los Angeles Stormwater Management Division, DPW and Bureau of Sanitation. Reference Guide for Stormwater Best Management Practices. July 2000.

City of Los Angeles. Integrated Plan for the Wastewater Program. Summary Statement. 2001.

City of Los Angeles/Mayor Antonio Villaraigosa. Green LA: An Action Plan to Lead the Nation in Fighting Global Warming. May 2007.

DeBusk, William M. Wastewater Treatment Wetlands: Contaminant Removal Processes. University of Florida, Institute of Food and Agricultural Sciences. 1999. http://edis.ifas.ufl.edu/SS293

Frankel, Rex. Table of Santa Monica Bay Cleanup Scenarios. June 2006.

Frankel, Rex. Breaking the Bank for the Wrong Bay Cleanup Plan. June 2006. http://radio.weblogs.com/0138798/stories/2006/06/20/breakingTheBankForTheWrongBayCleanupPlan.html

Frankel, Rex. A Collection of Historical Ballona Stories... December 2007. http://ballona-news.blogspot.com/search/label/Ballona%20History

Irvine Ranch Water District/San Diego Creek Watershed. Natural Treatment Systems Master Plan. June 2005. http://www.naturaltreatmentsystem.org/MasterPlan.html

Irvine Ranch Water District/San Diego Creek Watershed. Natural Treatment Systems Design Guidelines. June 2005.
http://www.naturaltreatmentsystem.org/DesignGuidelines.html

Luise Davis, U.S.D.A.-Natural Resources Conservation Service and the U.S. Environmental Protection Agency-Region III. A Handbook of Constructed Wetlands.

Playa Capital Company, LLC. Draft Environmental Impact Report/Village at Playa Vista. City of Los Angeles/EIR No. ENV-2002-6129-EIR. 2003.

Santa Monica Bay Restoration Project. Santa Monica Bay Restoration Plan. 1994.

The Trust for Public Land. No Place to Play. San Francisco: 2002. http://www.tpl.org

The Trust for Public Land. The Benefits of Parks. San Francisco: 2006. http://www.tpl.org

U.S. Army Corps of Engineers. Lower Ballona Creek Ecosystem Restoration Los Angeles County 905(b) Reconnaissance Report. September 2002.

U.S. Environmental Protection Agency. Office of Research and Development. Manual: Constructed Wetlands/Treatment of Municipal Wastewaters. September 2000.

U.S. Environmental Protection Agency. Listed Water Information: Ballona Creek.
http://iaspub.epa.gov/tmdl/enviro.control?p_list_id=CA406.0050R%20BALLONA%20CREEK

Photo p. 27 available at http://nevada.usgs.gov/lmqw/backgroundinfo.htm

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