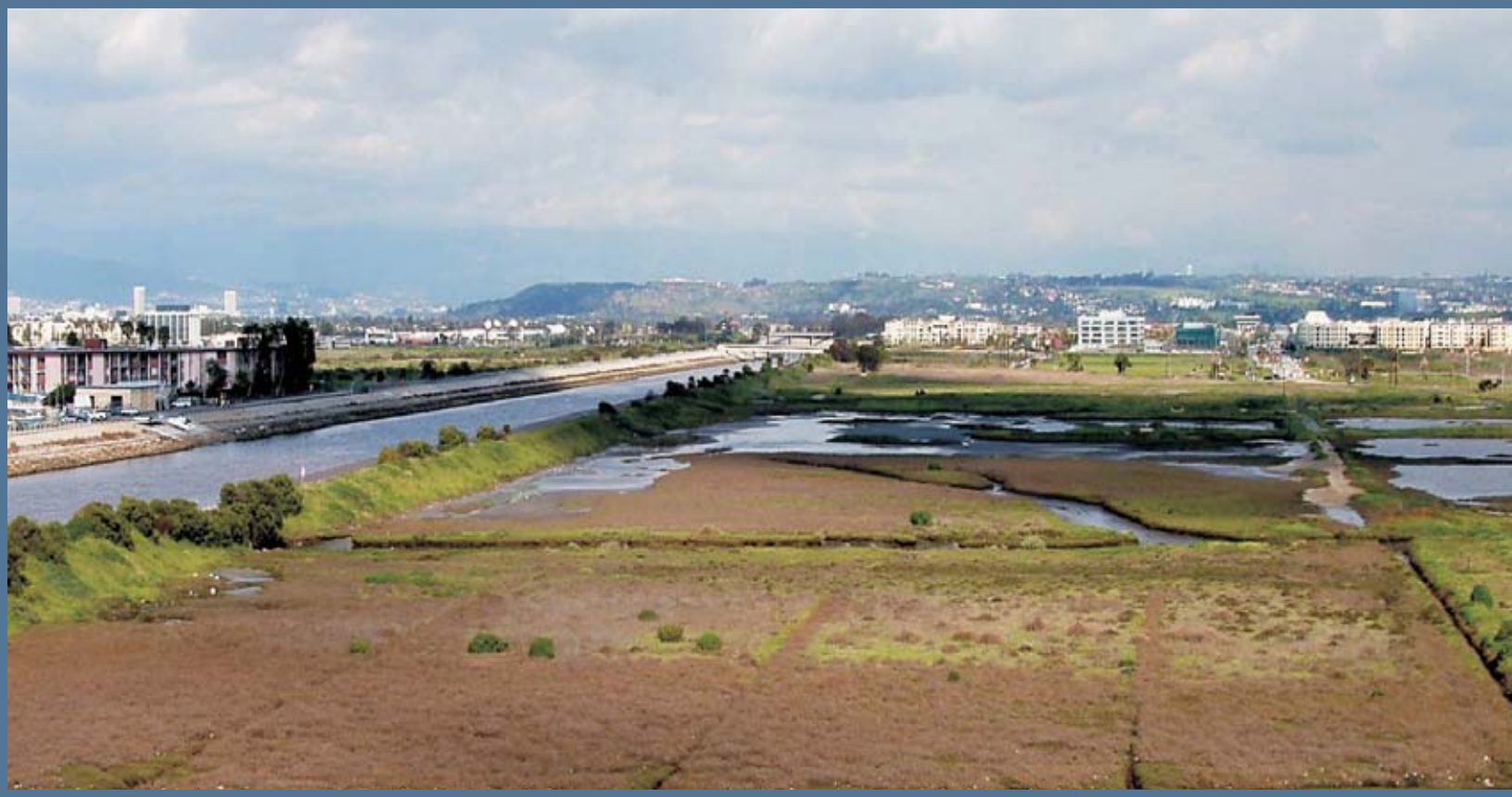
Ex 3: Fesibility Study and Science Advisory Committee Recommendations

September 2008

Ballona Wetland Feasibility Report

Prepared For *California State Coastal Conservancy*



Prepared By

Philip Williams & Associates, Ltd.

with

EDAW,
Nordby Biological Consulting,
Tierra Environmental, and
Weston Solutions

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PHILIP WILLIAMS & ASSOCIATES, LTD
ENVIRONMENTAL HYDROLOGY

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Ballona Wetlands Restoration
Feasibility Report

Prepared for

California State Coastal Conservancy

Prepared by

Santa Monica Bay Restoration Commission
Philip Williams & Associates, Ltd.

with

EDAW
Nordby Biological Consulting
Tierra Environmental
Weston Solutions

September 2008

PWA REF. # 1793.00

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1. INTRODUCTION

In 2004, the State of California took title to 600-acres of the remaining Ballona Wetlands in Los Angeles (Figure 1-1). The property is owned by two state agencies, the Department of Fish and Game (DFG) and the State Lands Commission. The State Coastal Conservancy (Conservancy) has funding for planning and restoring the property. Together, the three agencies are working with stakeholders, scientists and other agencies to develop a plan to restore this extraordinary resource. The Conservancy is providing funds for the planning effort and manages the work plan, budget, and schedule. DFG would be the applicant for any permits needed for the restoration project and the lead agency for purposes of CEQA. A restoration plan would be developed for all of the lands owned by the state. Planning is being conducted within the landscape and watershed context, incorporating adjacent and ecologically related resources.

This document characterizes the differences between five preliminary alternatives for the Ballona Wetlands Restoration Plan developed and refined by the Project Management Team (PMT), with the advice of the Ballona Wetlands Working Group, Science Advisory Committee, Agency Advisory Committee, and the consultant team. The aim is to provide a consistent set of information for each alternative using measures of change developed from the project's Goals and Objectives (Appendix A). These measures of change provide the ability to objectively determine how each alternative moves towards a specific project objective from the existing baseline conditions. The PMT would use this information to screen out infeasible or undesirable alternatives from advancing to the EIS/EIR process.

While the report is structured around five alternatives, they are discussed for each subarea within the Ballona Wetlands when appropriate, allowing the preferred alternative(s) to be developed from a combination of alternatives from different subareas. Area A refers to the portion of the Ballona Wetlands north of Ballona Creek to the west of Lincoln Boulevard. Area B refers to the portion south of Ballona Creek. Area C refers to the area north of Ballona Creek and east of Lincoln Boulevard.

Chapter 2 of the report provides an overview of the five alternatives, highlighting the changes from the existing conditions of the site, as well as the habitat restoration and public access objectives accomplished by each alternative. The alternatives encompass a reasonable range of options for restoring estuarine habitat within each of the different subareas (see Appendix B for habitat descriptions). These options include:

- Enhance existing habitat with minimal grading
- Muted tidal wetland restoration within existing constraints
- Full tidal wetland restoration, supporting all associated habitat types, and requiring significant site alteration

- Full tidal wetland and subtidal habitat restoration, providing a connection between these habitats with the project site, and requiring significant site alteration.
- Realignment of Ballona Creek, allowing interaction between the creek and wetland, and providing much more habitat and functional connectivity; and, requiring significant site alteration.

For each habitat restoration alternative, a public access alternative has been developed which includes trails, gateway entrances, overlooks and pullouts.

Chapter 3 applies information from existing sources, in particular the Existing Conditions Report and hydrodynamic modeling (Appendix C), to compare the potential effects of the restoration alternatives based on the measures of change. The main themes of the feasibility assessment are:

- Habitat Acreages
- Quality of Habitat
- Habitat Connectivity (Regional and Local)
- Biodiversity
- Hydrology (Tidal Circulation and Flood Protection)
- Sediment and Water Quality
- Sustainability
- Public Access, Recreation and Safety
- Phasing and Relative Costs

These themes are based on the goals and objectives for the project. Each theme is discussed in terms of how different site conditions might improve or effect desired characteristics of the theme. The evaluation is summarized in a Chapter 4 which describes the main characteristics of each alternative. The information provided in this section can then be used as an objective basis to determine how each of the alternatives accomplishes these project objectives. A summary is provided that compares the alternatives to each other based on a list of common, favorable characteristics. This summary also describes some of the trade-offs between the different approaches to restoration. A ranking of each alternative on a scale from 1 to 5 is given. These rankings are based on the best judgment of the Project Management Team, with input from the Science and Agency Advisory Committees.

1.1 SECTION 1 FIGURES

N

0 255 510 1,020 1,530 2,040 2,550 Feet

figure 1-1

Ballona Wetlands Restoration

Project Area

Proj. # 1793

PWA

2. DESCRIPTION OF ALTERNATIVES

2.1 ALTERNATIVE 1 - ENHANCE EXISTING HABITAT WITH MINIMAL GRADING

Alternative 1 (Figure 2-1) proposes minimal change relative to the existing conditions of the site. As such, this alternative emphasizes enhancement of existing upland habitats, in particular coastal sage scrub (CSS) and native grassland habitats, over creation or restoration of coastal wetland habitats. Alternative 1 would convert an area of freshwater marsh in the southeast portion of Area B to muted tidal marsh by replacing the existing Freshwater marsh culvert with a daylighted tidal channel that connects to Ballona Creek. This would provide one additional source of tidal influence to the project area. Existing tide gates would be modified to increase the muted tidal waters entering the southwest portion of Area B. Alternative 1 proposes little change to existing infrastructure such that the project area would remain fragmented and isolated by roads, Ballona Creek, berms and levees. Existing dune habitat, the constructed freshwater marsh and recreational facilities in Area C would be retained.

Area A would be managed to include seasonal wetland habitat, tidal low marsh and channel, transition zone and enhanced upland. The existing tidal connection to Berth H in Marina del Rey would not be changed.

Area B would remain similar to existing conditions with the following exceptions:

1. A small triangle of land located south of Culver Boulevard and west of proposed muted mid-marsh habitat that is currently mapped as non-tidal salt marsh/brackish marsh would be converted to CSS and transitional habitats.
2. The closing elevation of the tide gates that allow limited tidal influence in this area would be increased to admit lower high tides into the area. This would expand the area of muted tidal marsh.

Area C includes the highest elevations of the project area. Under Alternative 1, little excavation of this area is proposed. Instead, existing recreational facilities would be retained and enhanced CSS and native grassland habitat, and a small treatment wetland would be constructed.

In terms of Public Access (Figure 2-2), Area A would have a loop trail on the existing Gas Company access road, and a larger loop trail would provide access to the seasonal wetland area via a boardwalk. Gateway entrances, overlooks and a formal parking/staging area would be developed. For Area B, public access would include periphery trails, along Cabora Drive, and pedestrian crossings for a fully integrated trail network. Gateway entrances, overlooks and formal parking would be provided. Linkages between the east and west portions of Area B would be provided by two pedestrian crossings on Culver Boulevard. A pedestrian bridge located near the historic rail crossing would link Area B to Area A. Public access features in Area C would

include two loop trails originating from the gateway entrances at La Villa Marina and near the Little League fields. A parking area would continue to be located at the Little League fields.

2.2 ALTERNATIVE 2 - A SMALLER AREA TIDAL WETLAND RESTORATION

Alternative 2 (Figure 2-3) includes a departure from existing conditions through excavation of fill to create fully tidal channels, low marsh, and mid-high salt marsh. Alternative 2 would also convert an area of freshwater marsh in the southeast portion of Area B to muted tidal marsh by replacing the existing Freshwater Marsh culvert with a daylighted tidal channel that connects to Ballona Creek. This would provide one additional source of tidal influence to the project area. Existing connections would be modified by adjusting the setting of the existing tide gates to increase the muted tidal waters entering the southwest portion of Area B. The connection under Dock 52 to Marina del Rey would be enhanced, creating a full tidal marsh in Area A. Alternative 2 proposes little change to existing infrastructure such that the project area would remain fragmented and isolated by roads, Ballona Creek, and berms and levees. Existing dune habitat, constructed freshwater marsh and recreational facilities would be retained.

Area A would be modified to include fully tidal channels, low and mid-high marsh, and associated transition zone habitats. This would be accomplished by increasing the tidal connection under Dock 52 to create an open culvert with a cross-sectional area of 100 ft^2. The remainder of Area A would be converted to enhanced CSS and native grassland habitat.

The southeast portion of Area B (Area B southeast) would be modified to include fully tidal channels, low and mid-high marsh, and associated transition zone habitats. In Area B southwest, the degree of tidal influence would be increased through modification of the existing tide gates. A new culvert with a cross-section of 100 ft^2 would provide a new fully tidal connection to Area B southwest. Like Alternative 1, a small triangle of land located south of Culver Boulevard that is currently mapped as non-tidal salt marsh/brackish marsh would be converted to CSS and transition zone habitats

Alternative 2 would create a small, deeper extension of Fiji Ditch in Area C beneath Lincoln Boulevard resulting in an incremental increase in fully tidal channel, low and mid-high marsh habitats and transition zone habitat beyond that proposed in Alternative 1. The recreational facilities, CSS and native grassland habitat would be retained and small areas of seasonal wetland and treatment wetlands created.

In Area A, a loop trail on the existing Gas Company Road, and a perimeter trail, around the new wetlands, connecting the gateway entrance along Fiji Way to the Ballona Creek Bicycle trail along the north levee would be developed (Figure 2-4). Boardwalk spur trails at the Fiji Way and Fisherman's Village gateway entrances would provide access to overlooks. Public access features in Area B would be similar to Alternative 1. Public access features in Area C would include two loop trails originating from the gateway entrances at La Villa Marina and near the Little League

fields. A parking area would continue to be located at the Little League fields. An overlook would be located near the seasonal wetland area.

2.3 ALTERNATIVE 3 - A LARGER AREA TIDAL WETLAND RESTORATION

Alternative 3 (Figure 2-5) would create additional estuarine habitat relative to Alternative 2 resulting in further increases in fully tidal channel, low marsh and mid-high marsh habitats and associated transition zone habitat. Culver Boulevard, Jefferson Boulevard and the Gas Company road in Area B would be improved by raising the roads on levees or piles; these would provide greater hydraulic connectivity through larger culverts or between piles. Portions of the project area would remain fragmented and isolated by Ballona Creek and Jefferson Boulevard. Existing dune habitat, constructed freshwater marsh and recreational facilities would be retained.

Area A would be modified to include fully tidal channels, low marsh and mid-high marsh and associated transition zone habitats. This would be accomplished by increasing the tidal connection under Dock 52 to create an open culvert with a cross-sectional area of 160 ft^2. The remainder of Area A would be converted to enhanced CSS and native grassland habitat.

In Area B, Alternative 3 would increase the degree of tidal influence in the southwest wetland by replacing the SRT with a 100 foot wide breach. The alternative also includes extension of existing fully tidal channels and raising Culver Boulevard on pilings or levees and removal of the berm south of Culver Boulevard. Most available area would be converted to fully tidal habitats and transition zone habitat. The southeast wetland would be connected as in Alternative 2.

Alternative 3 would create a small, deeper extension of Fiji Ditch in Area C and excavation of a small tidal marsh resulting in an incremental increase in fully tidal channel habitat and an increase in transition zone habitat beyond that proposed in Alternative 2. The recreational facilities, CSS and native grassland habitat would be retained and two small areas of seasonal wetland would be created.

Key provisions for public access (Figure 2-6) in Area A are a looping perimeter trail along the banks of the restored wetland. This trail links gateway entrances along Fiji Way to those along the north levee. Gateway entrances would be located at the existing parking area near Fisherman's Village, along Fiji Way, and two along the Ballona Creek Bicycle Path. Boardwalk spur trails at the Fisherman's Village and Fiji Way gateway entrances would provide access to overlooks. These overlooks would provide both an easily accessible viewing point and a key location for interpretive and educational signage. A formal parking/staging area would be developed at the gateway entrance near Fisherman's Village. In Area B, roadside vehicular pullouts would be provided along Culver and Lincoln Boulevards. A link between the east and west portions of Area B would be provided by a pedestrian crossing located on Culver Blvd. A pedestrian bridge located near the historic rail crossing would link Area B to Area A. Formal parking areas would be located at the gateway entrance behind Gordon's Market and along Jefferson Blvd at the Freshwater Marsh. Public access features in Area C would include two loop

trails originating from the gateway entrances at La Villa Marina and near the Little League fields. A parking area would continue to be located at the Little League fields. Overlooks would be located at viewing points for the seasonal wetland area near the Little League fields and north of Culver Blvd at the restored estuarine wetland area.

2.4 ALTERNATIVE 4 - A LARGE AREA TIDAL WETLAND RESTORATION WITH SUBTIDAL COMPONENT

Alternative 4 (Figure 2-7) resembles Alternative 3 with the exception of a larger connection with Marina del Rey and creation of shallow subtidal and intertidal habitats in Area A. This increased excavation would create a shallow subtidal basin and increased intertidal mudflats, while shifting the excavation to the northwest edge of Area A would allow for the creation of a more diverse marsh plain. Culver Boulevard and the levee system south of Culver Boulevard would be improved by raising the road on piles or a levee, these would provide greater hydraulic connectivity through larger culverts or between piles. Portions of the project area would remain fragmented and isolated by Ballona Creek and Jefferson Boulevard. Existing dune habitat, constructed freshwater marsh and recreational facilities would be retained.

Area A would be modified to include a shallow subtidal embayment, tidal channels, intertidal mudflat, low salt marsh, mid-high marsh and associated transition zone habitats. This would be accomplished by increasing the tidal connection under Dock 52 to create an open culvert with a cross-sectional area of 500 ft^2. A narrow, linear strip adjacent to Ballona Creek would be converted to enhanced CSS habitat.

In Area A there would be a loop trail on the existing Gas Company Road, and a perimeter trail along the southern edge of the restored estuarine wetland, portions of which would be boardwalk (Figure 2-8). Gateway entrances would be located at the existing parking area near Fisherman's Village and along the Ballona Creek Bicycle Path. The loop and perimeter trails would link the gateway entrance near Fisherman's Village to the Ballona Creek trail located along the north levee and the two gateway entrances along Ballona Creek. Overlooks would be located near the Fisherman's Village gateway entrance and along the perimeter trail. A formal parking/staging area would be developed at the gateway entrance near Fisherman's Village. Public access features in Area B and C would be the same as Alternative 2.

2.5 ALTERNATIVE 5 - A REALIGNMENT OF BALLONA CREEK

Alternative 5 (Figure 2-9) proposes the greatest amount of change to the project area, including the greatest degree of fully tidal wetland creation. The most obvious change would be the removal of the Ballona Creek flood control channel levees and creation of a sinuous natural creek and associated tidal basins through the site. The site would be interconnected across all areas, with shallow subtidal and mudflats grading through all marsh habitats to higher wetland-upland transition habitat. The channel would be free to migrate across the tidal floodplain, limited where necessary by buried rock protection. The existing Ballona Creek channel would be filled where

necessary. The intersection of Culver and Jefferson Boulevards would be moved westward, closer to Lincoln. Culver and Lincoln Boulevard would be raised on pilings above the fully tidal marshlands. The gas/oil monitoring facilities in Area A and recreational facilities in Area C would be minimized and converted to fully-tidal channel, low, and. mid-high marsh, transition zone and enhanced CSS. The constructed freshwater marsh and existing dunes would be retained.

Phasing would be an important aspect of this alternative. Phase 1 would lower the levees and surface elevations and excavate the main channel in Area A; Phase 2 would extend the channel into Area B; Phase 3 would extend the channel into Area C following the raising of Lincoln Boulevard.

Areas A, B and C would be modified to include the reengineered fully-tidal Ballona Creek, two shallow tidal ponds, tidal channels, low salt marsh, mid-high marsh and associated transition zone habitats. The northern breakwater of Ballona Creek would be lowered to allow flood flows to spill into Marina Del Rey. Buried rock protection would be provided along the south east edge to prevent the channel meandering too far west. A narrow, linear strip in the north and west portions of the area would be converted to enhanced CSS habitat.

A perimeter trail would be constructed along Fiji Way and gateway entrances located at the existing parking area near Fisherman's Village and along Fiji Way (Figure 2-10). A boardwalk containing an overlook would link the two gateway entrances as well as overlooks located at both gateway entrances. A vehicular pullout would be located along Culver Blvd and would also provide an overlook. Linkages within Area A would be provided through two pedestrian crossings located along Lincoln Blvd. A formal parking/staging area would be developed at the gateway entrance near Fisherman's Village. Area B gateway entrances would be located behind Gordon's Market, along the southern bank of Ballona Creek, along Lincoln Blvd, and along Jefferson Blvd at the entrance to the Freshwater Marsh. Boardwalk spur trails leading to overlooks would be located along the Freshwater Marsh Trail and at a vehicular pullout along Culver Blvd. Overlooks would also be located at the existing Boy Scout Overlook Platform, at the gateway entrance along the south levee, and along the Cabora Drive trail at Pershing Drive. Linkages throughout Area B would be provided by three pedestrian crossings located on Culver Blvd. An upland area along Lincoln Boulevard provides for a possible visitor center location. Formal parking areas would be located at the gateway entrance behind Gordon's Market, at the visitor center, and along Jefferson Blvd at the Freshwater Marsh.

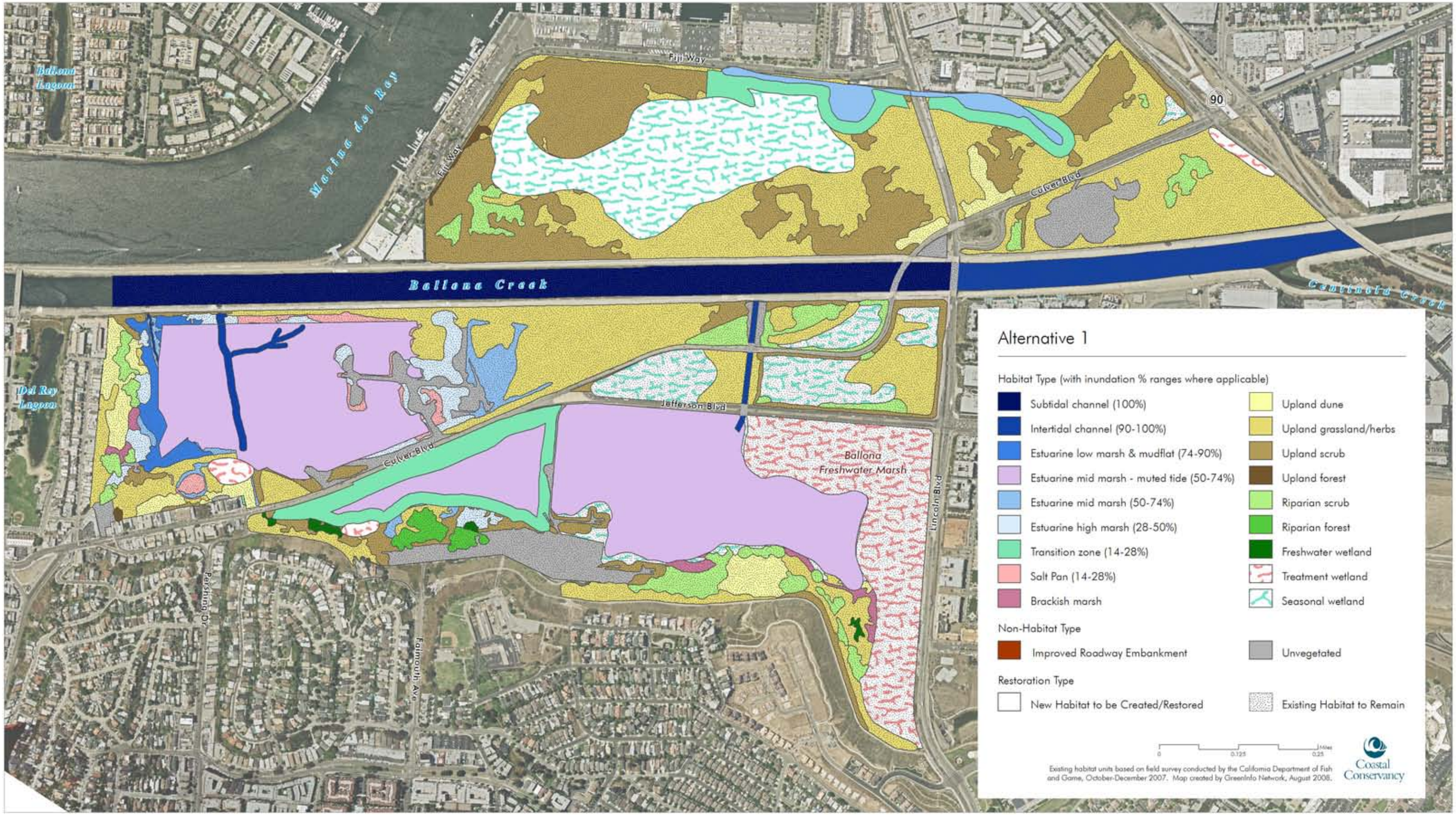
Public access features in Area C would include a perimeter trail from the La Villa Marina gateway entrance to the Lincoln Blvd pedestrian crossing to Area A. Regional trail connectivity would be preserved by connecting the Ballona Creek Bicycle Trail (previously located on the north levee) to a dual pedestrian and bicycle trail along the southern boundary of Area C. This trail would continue both to the north along Lincoln Blvd and to the south along Culver Blvd. Since both roads would be improved within this restoration alternative, improved bicycle lanes would facilitate this regional connectional. A pedestrian bridge would cross Ballona Creek

connecting this new trail alignment to the existing Ballona Creek Bicycle Trail. An overlook would be located at the La Villa Marina gateway entrance.

2.6 SECTION 2 FIGURES

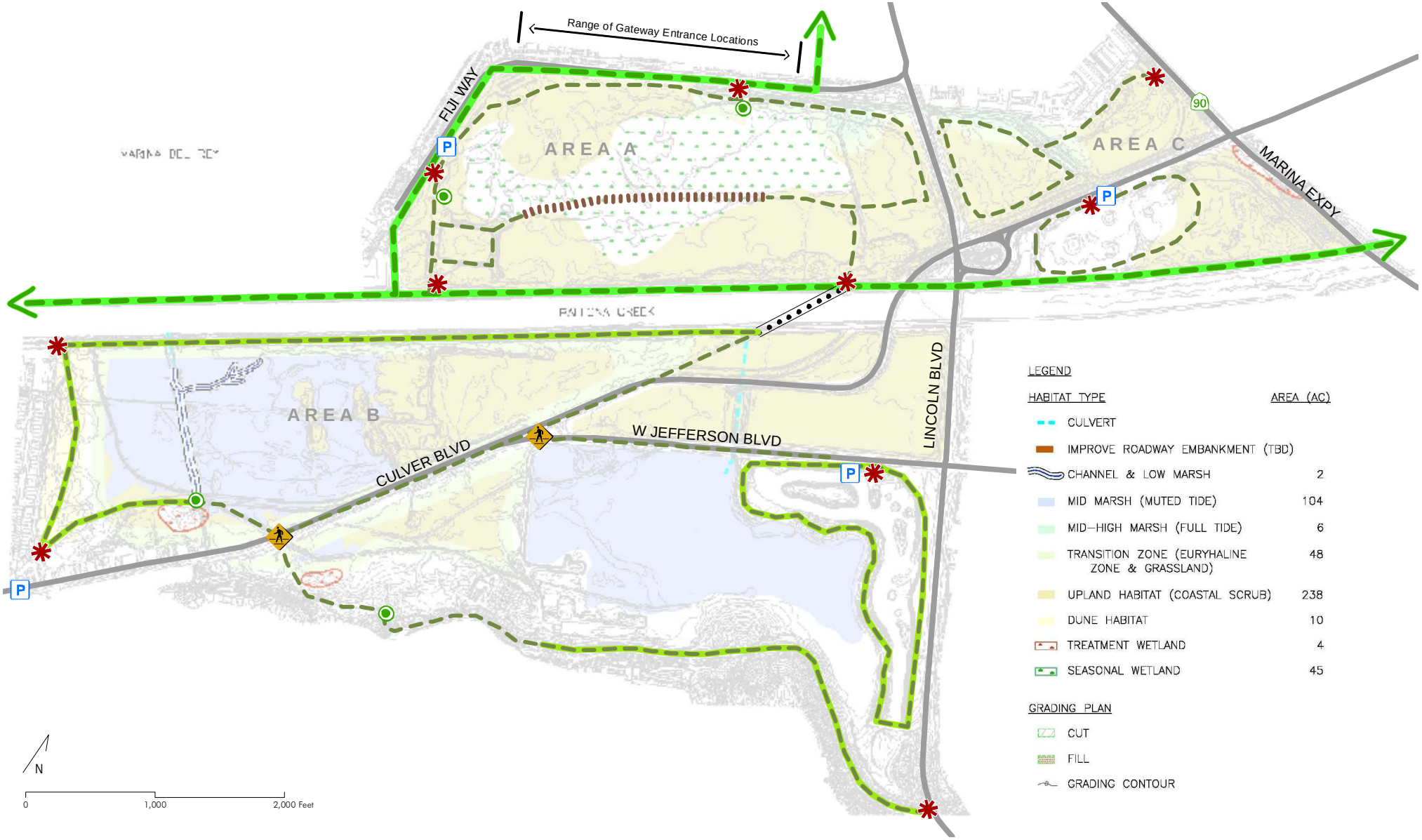
Ballona Wetlands
Restoration Project

Habitat Alternatives - Alternative 1



Ex 3: Fesibility Study and Science Advisory Committee Recommendations

Public Access Plan Alternative 1



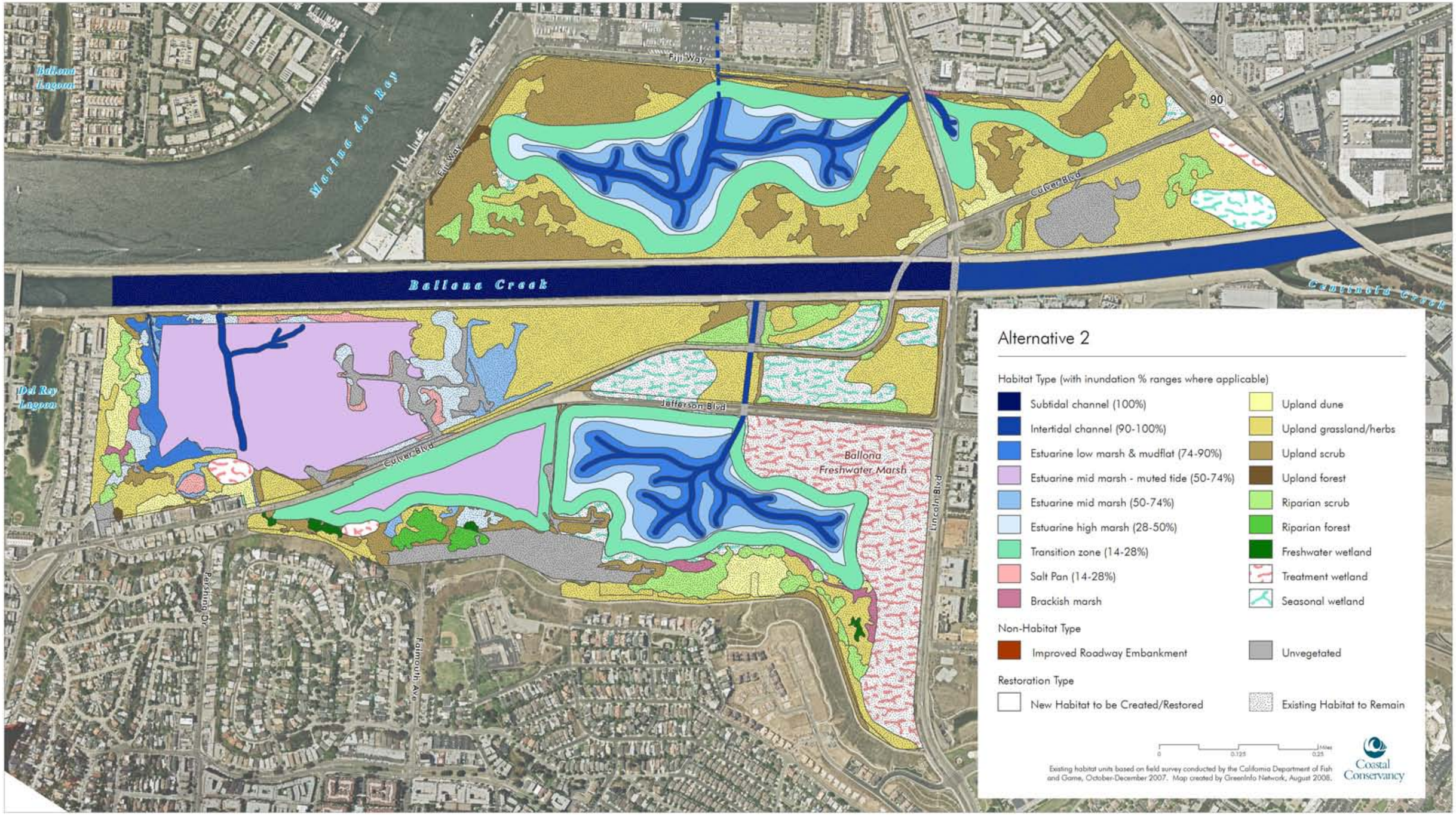
Gateway Entrance
Overlook
Parking Area
Pedestrian Crossing
Pedestrian Bridge
Boardwalk
Existing Regional Trail
Proposed Regional Trail
Existing Trail Network
Proposed Trail Network

Coastal Conservancy

Habitat concepts created by Philip Williams and Associates (PWA) and EDAW. Map created by GreenInfo Network and EDAW, June, 2008.

Ballona Wetlands
Restoration Project

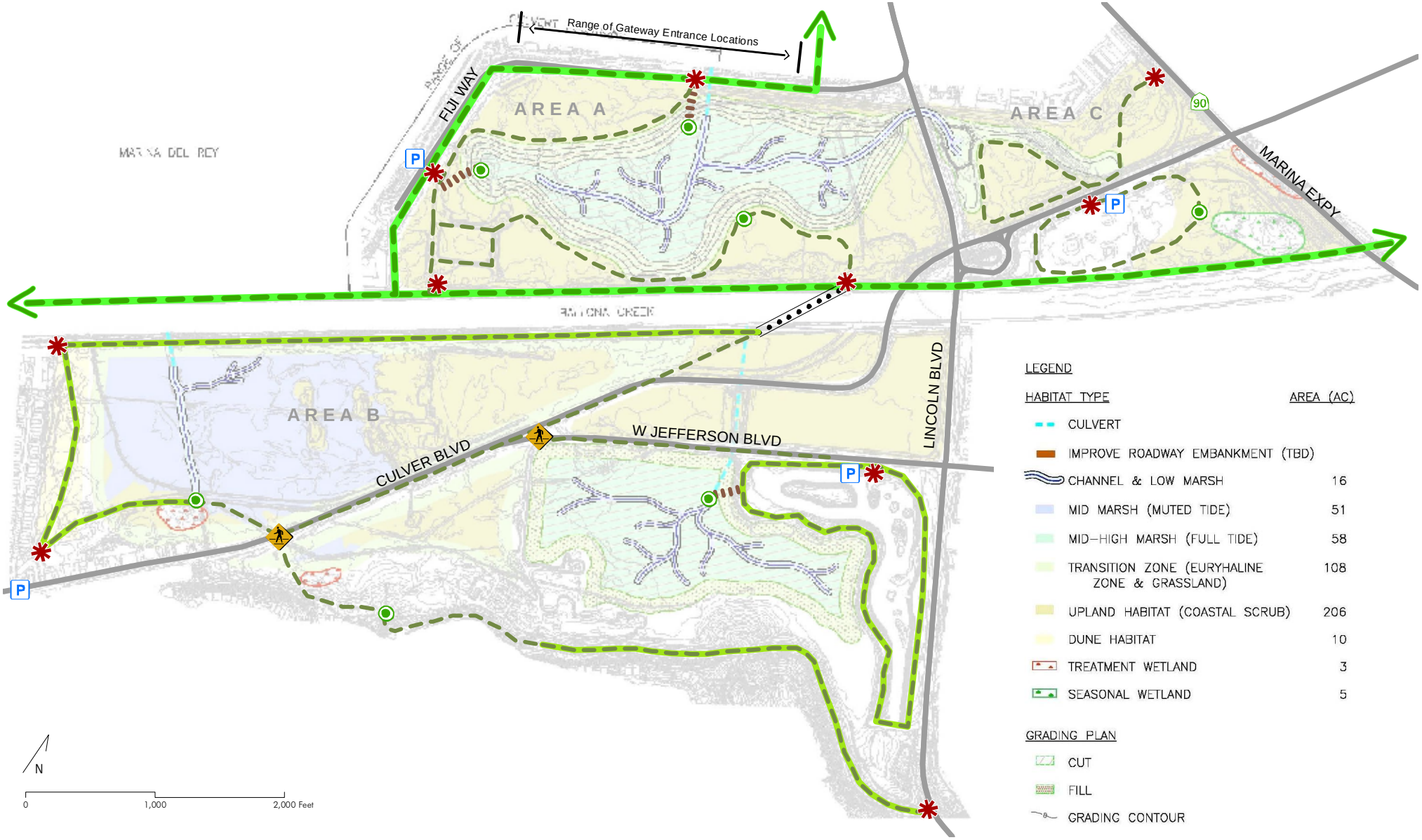
Habitat Alternatives - Alternative 2



Ballona Wetlands
Restoration Project

Ex 3: Fesibility Study and Science Advisory Committee Recommendations

Public Access Plan Alternative 2



Gateway Entrance
Overlook
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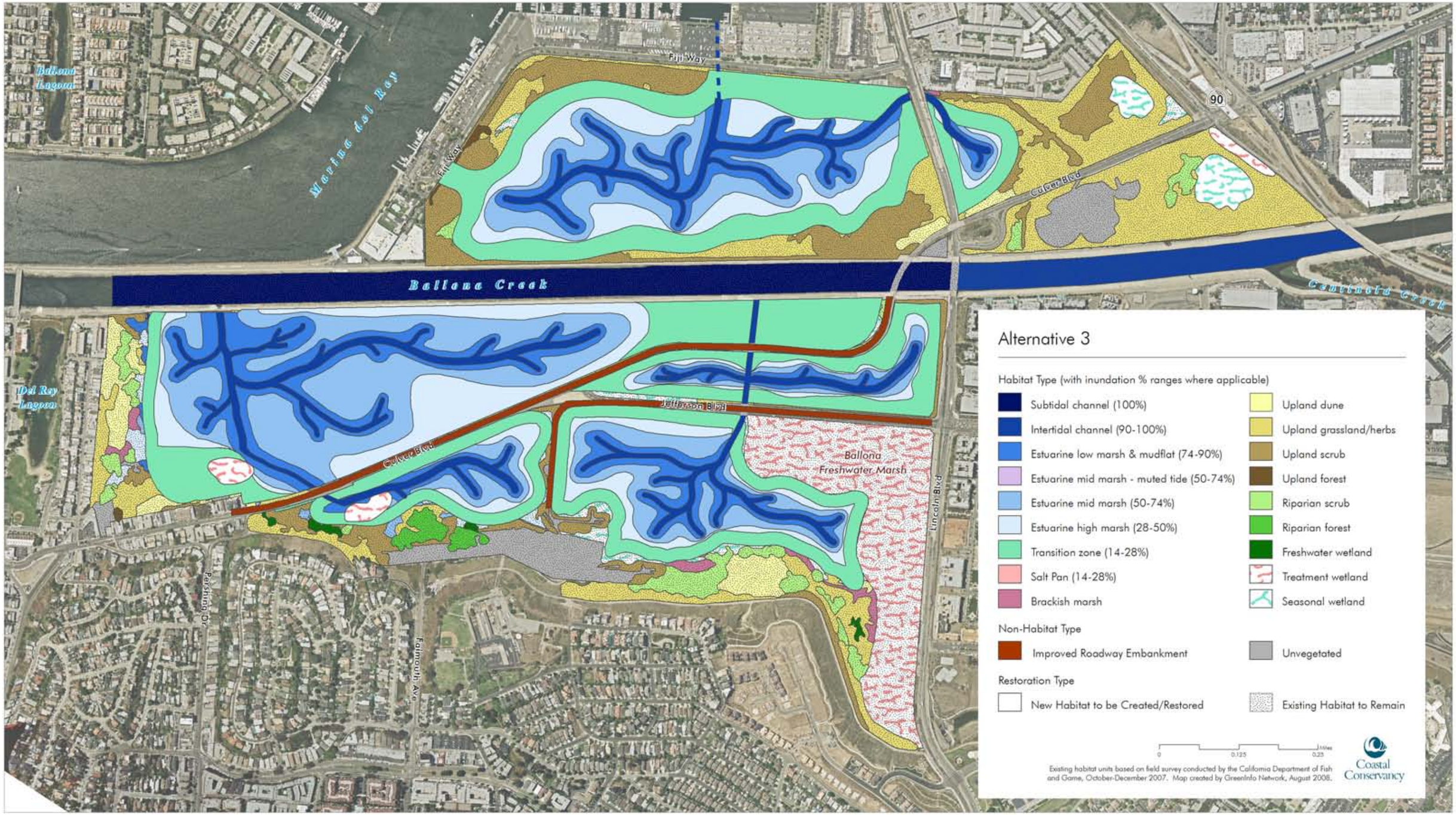
Coastal Conservancy

Habitat concepts created by Philip Williams and Associates (PWA) and EDAW. Map created by GreenInfo Network and EDAW, June, 2008.

Ballona Wetlands
Restoration Project

Habitat Alternatives - Alternative 3



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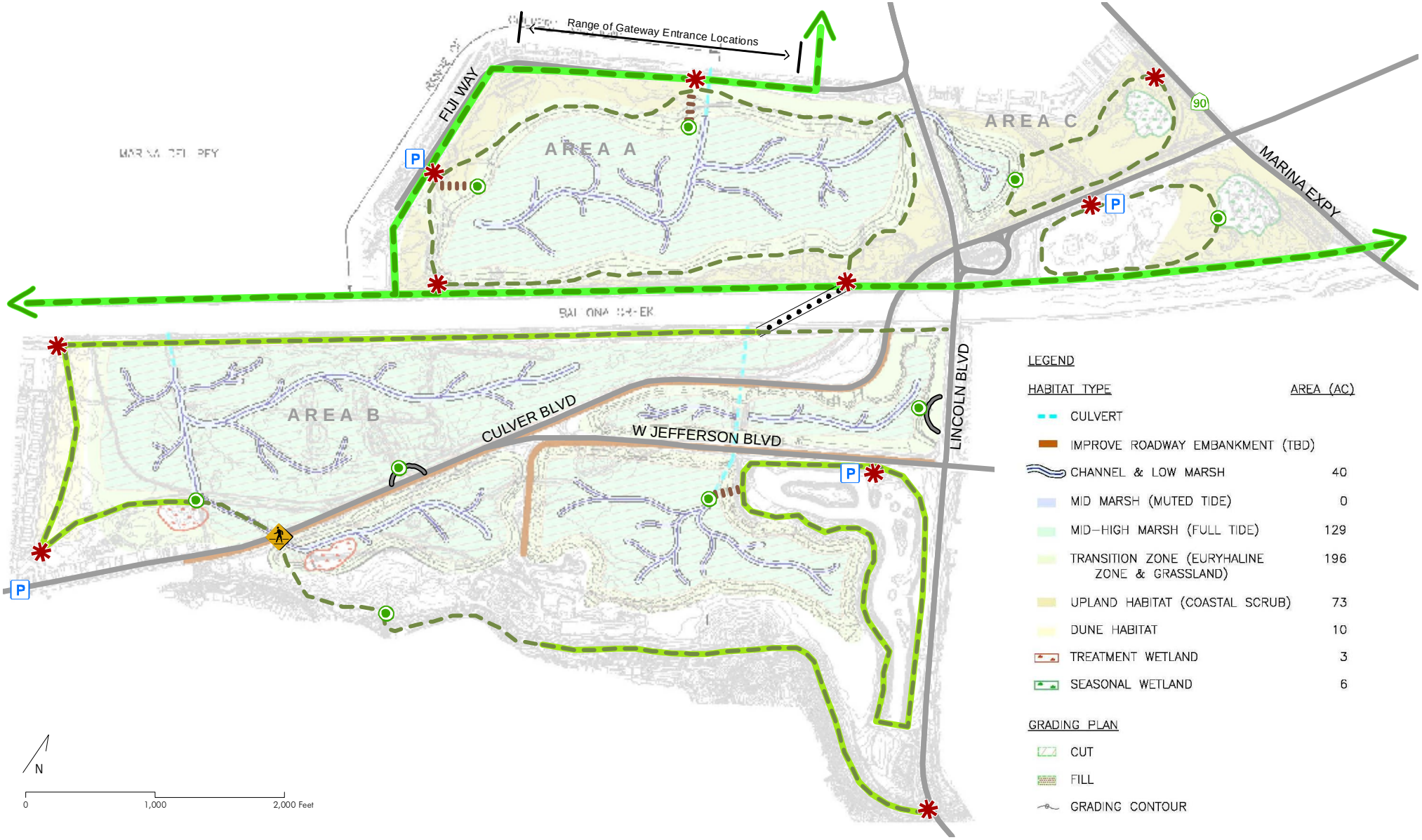
Public Access Plan Alternative 3



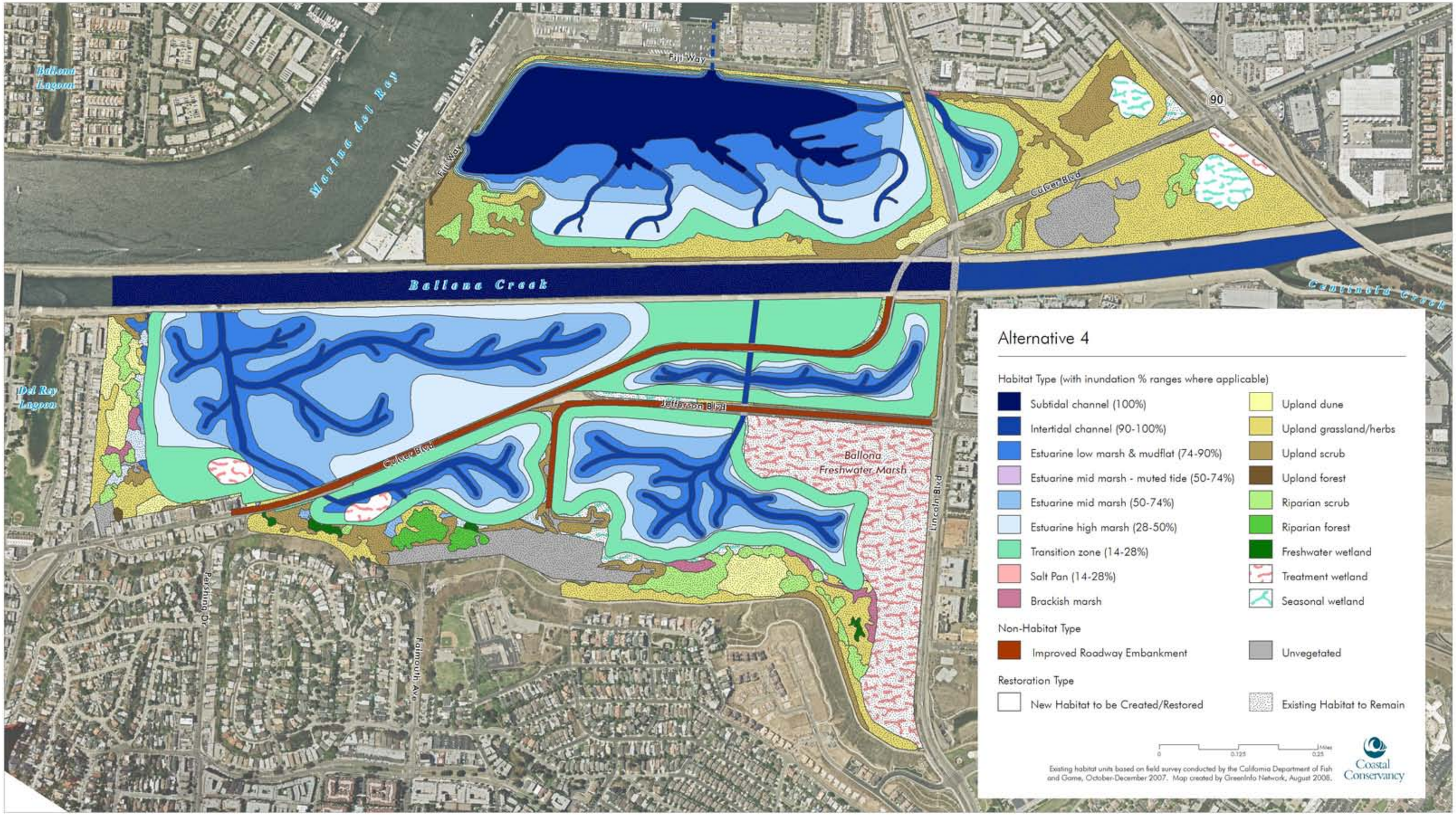
Gateway Entrance
Overlook
Parking Area
Pedestrian Crossing
Pedestrian Bridge
Boardwalk
Existing Regional Trail
Proposed Regional Trail
Existing Trail Network
Proposed Trail Network
Vehicular Pullout

Coastal Conservancy

Habitat concepts created by Philip Williams and Associates (PWA) and EDAW. Map created by GreenInfo Network and EDAW, June, 2008.

Ballona Wetlands
Restoration Project

Habitat Alternatives - Alternative 4



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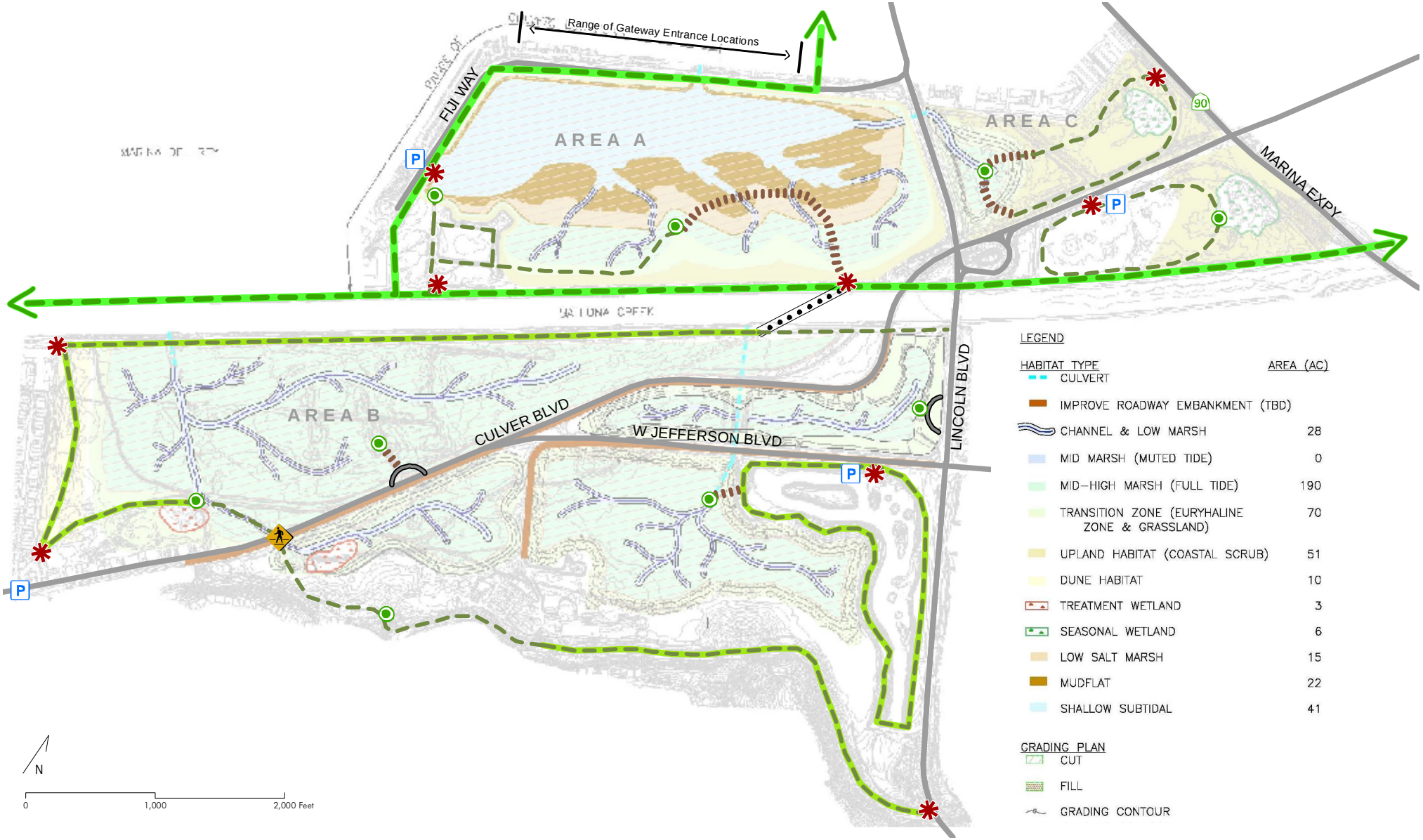
Public Access Plan Alternative 4



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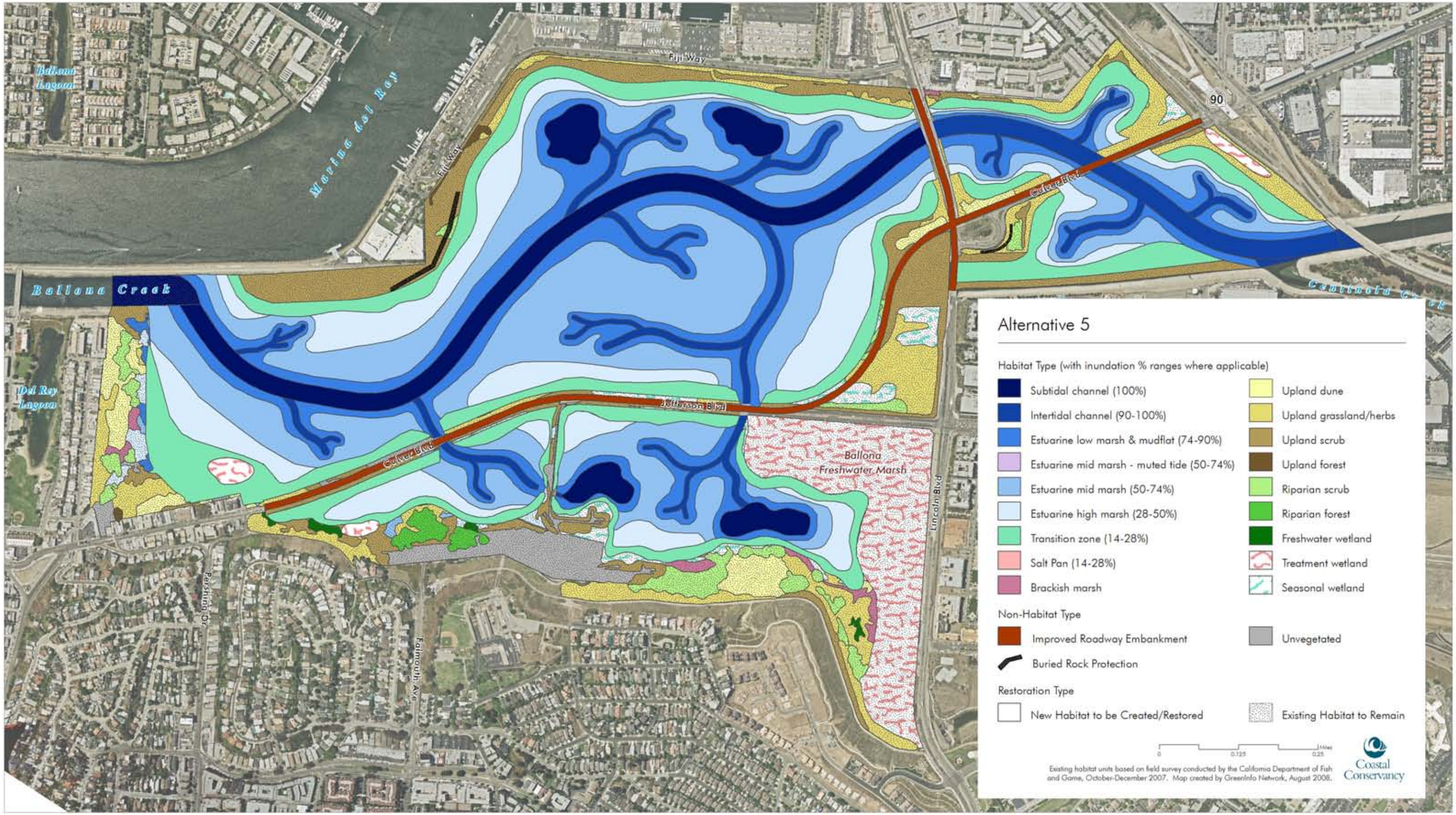
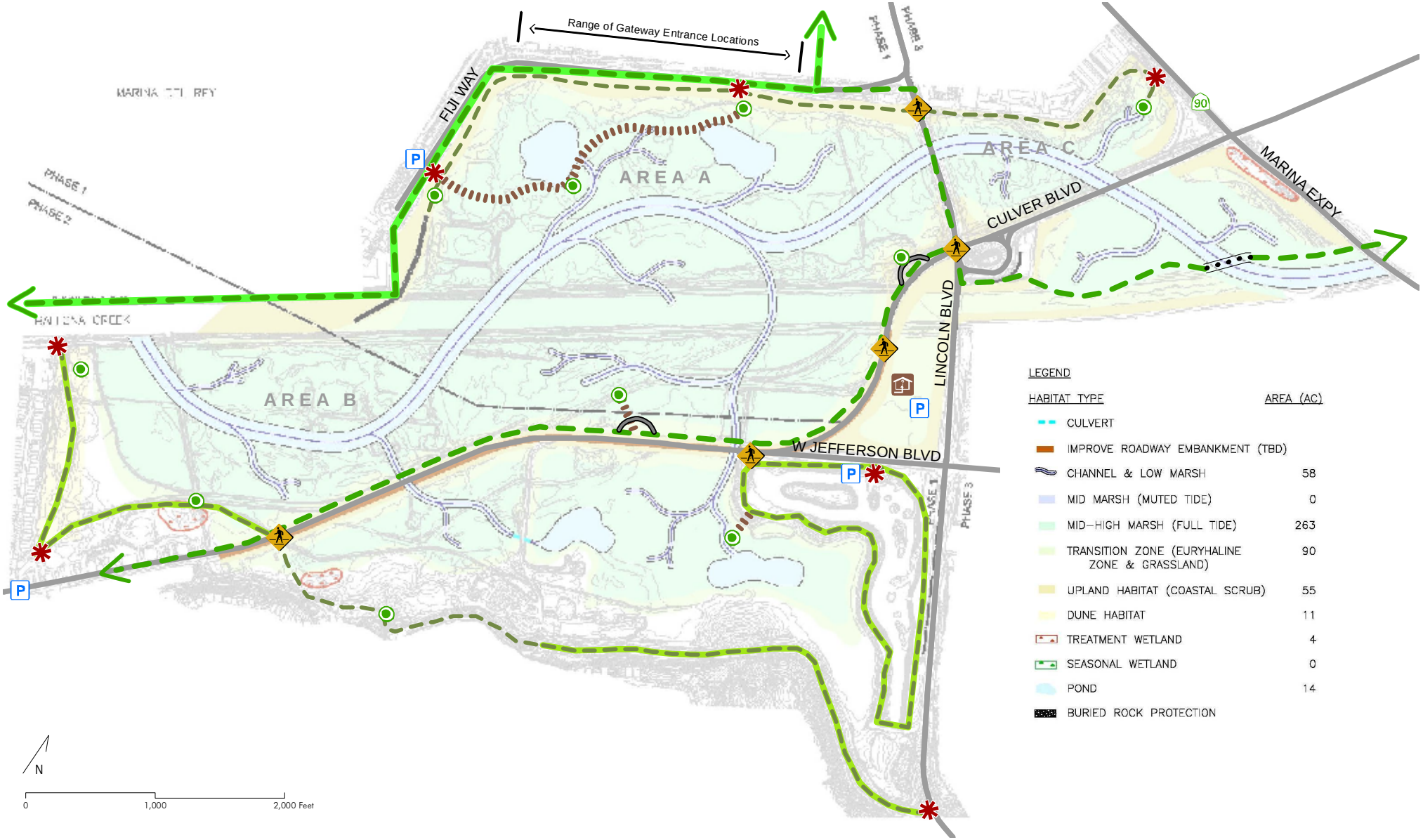
Habitat Alternatives - Alternative 5



Ballona Wetlands
Restoration Project

Ex 3: Fesibility Study and Science Advisory Committee Recommendations

Public Access Plan Alternative 5



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Coastal Conservancy

Habitat concepts created by Philip Williams and Associates (PWA) and EDAW. Map created by GreenInfo Network and EDAW, June, 2008.

3. MEASURES OF CHANGE

3.1 HABITAT

The Ballona Wetlands historically covered over 2000-acres and likely included a mix of fluvial, tidal, deltaic and dune habitat types. Today this wetland has been reduced to less than 170 acres within the project area and the hydrology of the watershed has been severely altered by extensive development. Remnant areas of the historic wetland complex include Del Rey Lagoon, Ballona Lagoon, Grand Canal, Oxford lagoon, Marina Del Rey, and the Venice Canals. Given the significant alteration, restoring Ballona Wetlands to its historic condition is infeasible; however, the opportunity to recreate a vibrant wetland system would still require consideration of the mix of habitat types that would benefit the ecological functioning.

This section provides a brief description of the different habitat types that would be restored under each of the alternatives (for more detail see Appendix B). A number of broad habitat types are identified in the alternatives: shallow subtidal and open water habitats, intertidal channels and mudflat habitats; low, mid and high marsh and salt pan habitats; wetland-upland transition habitat; brackish marsh; seasonal wetland habitat; freshwater marsh and riparian scrub habitats; and coastal dune, coastal sage scrub and native grassland habitats. Estuarine intertidal wetland habitat includes shallow subtidal, intertidal channels, mudflats, and low, middle and high marsh, salt pan, and transition zone habitats. Each component is necessary to recreate the Ballona Ecosystem and without each component the estuarine wetlands within the system would not function properly. Some components are currently absent from Ballona, and may be important additions in the restoration of Ballona Wetlands.

<u>Tidal Wetlands</u>

Given the estuarine location of the site, the degree of tidal inundation would be a major factor in influencing the habitat type. The period, depth, and frequency of inundation by tidal water are dependent upon the tidal range, density of soil, degree of slope, and ground elevation.

Shallow subtidal habitats include channels, embayments, basins and other features, which at extreme low water do not drain with the outgoing tides. This estuarine water regime results in permanently flooded habitats and permanent open water bodies. These habitats are generally considered truly aquatic systems and are adjacent to and downslope from tidal estuarine wetlands. Estuaries with extensive subtidal habitat areas often support extensive intertidal low marsh and mudflat habitats, providing refugia for fish during low tides, and feeding opportunities for wetland birds.

Intertidal channels and creeks play a critical role in salt marshes as they convey tidal waters and associated nutrients and dissolved gases. They also support a complex assemblage of plants and

animals. Estuarine channels and creeks are subjected to a wide variety of environmental conditions. Typically, tidal flushing is greatest at the tidal inlet and decreases with distance from the inlet. This general gradient, in turn influences, water movement, salinity, temperature, nutrients, and dissolved gases. These environmental factors influence the species composition, distribution, and population dynamics of the channel fauna.

Intertidal mudflats are situated low in the intertidal zone, between subtidal open water and vegetated salt marsh (low marsh), at the open water edge and along channel banks. Mudflats are inundated and exposed during most tide cycles. Mudflat habitat support invertebrate population and provides valuable foraging habitat, particularly for shorebirds.

Intertidal salt marsh ranges from low marsh, dominated by California cordgrass (*Spartina foliosa*), to a diverse mosaic of species that comprises the mid-marsh, to very high marsh species that transition to upland. Salt marsh vegetation changes gradually with elevation. Nearly every species has its peak occurrence at its unique elevational band and the vegetation forms a continuum rather than a set of zones. However, the presence of shrub-like succulents at the uppermost elevations and tall cordgrass at the lowest elevations helps to delineate low to high marsh.

Low salt marsh is regularly inundated by tides and is dominated by California cordgrass that forms dense monotypic stands. At its lower elevation, cordgrass intergrades with mudflat habitat; at its upper elevation it intergrades with a mosaic of mid-marsh species. This highly productive species decomposes to form the base of the detrital food chain that supports many lower order estuarine consumers. Many of the animals of the low marsh are adapted to periods of frequent inundation.

Intermediate elevations within the salt marsh are inundated irregularly by tides but at a greater frequency than are higher elevations. As a result, the plant species that inhabit this elevation are adapted to highly saline soil conditions due to long periods of exposure. The animals of the mid-marsh are abundant and diverse. Food is abundant in the form of algae and the epifaunal invertebrates and insects that feed on algae. In addition, when flooded by the tides, fish move into the marsh plain to forage on these abundant invertebrates. Several bird species such as the Beldings' savannah sparrow and light footed clapper rail also forage in this zone.

High marsh habitats are also irregularly to intermittently inundated by tidal water and generally range from saline to hypersaline conditions. The vegetation varies depending on the density of the soil (i.e. ratio of clay to sand), which often is correlated with salinity.

Salt pans form in the high marsh where drainage is poor. These higher elevation areas along the upland edge are only inundated during the highest spring tides and typically have no tidal channels. As a result, ponded areas are formed that become hypersaline as water evaporates, thereby inhibiting vegetation establishment. These salt pans provide habitat diversity and have habitat value for foraging and refugia.

The wetland transitional zone represents that area where the halophytic (salt-tolerant) and hydrophytic salt marsh vegetation overlaps with upland communities. Scrub-shrub plant species of the transition zone overlap with the highest of the salt marsh species. The animals at the higher elevations of the transition zone are primarily terrestrial species. The transitional zone may also include nontidal palustrine habitats both salt influenced and non-saline types. Seeps from perched water tables on deltas and the toe of slopes and along dune transitions often support a variety of palustrine emergent and scrub-shrub types. Seasonal wetlands also occur in this area, especially in low-gradient deltaic deposits and may include salt pans. Transitional zones provide refugia during extreme weather or tides, as well as foraging opportunities. These areas also support a unique set of plant species, which may only occur or coexist in the habitat conditions provided in these transition zones.

Muted tidal habitats are created by the installation of gate structures and flow restrictions, which typically reduce tidal flows and the tide range compared to a fully tidal wetland. Muted tidal wetlands may support subtidal, mudflat, and vegetated wetland habitats. Hydraulic control structures have proven to severely limit fish passage, decrease tidal flushing, and restrict the diversity of habitat of a restored tidal wetland. A muted tidal system typically limits the creation of upper marsh and transitional habitat.

Additional habitats, which either occur on the site or are included in the alternatives consist of, brackish marsh, seasonal wetlands, freshwater and riparian habitat, and upland habitats, including coastal dune, coastal sage scrub and native grassland habitats. Some of these additional habitats are important to the restoration of the tidal wetland system; they may provide buffers from human disturbances, refugia during extreme weather or tides, or complementary habitats. These habitat types may also be significantly impacted in the region due to limited range along the coast.

Brackish conditions, with intermediate salinities, occur where freshwater mixes with seawater. This phenomenon is less frequent in southern California where many estuaries are less influenced by runoff from rainfall than in more northerly latitudes. Local influence from seeps and springs and seasonally impounded stream and river-mouths can produce brackish environments that support emergent vegetation and aquatic bed species.

Non-tidal Wetlands

Seasonal wetlands are non-tidal wetlands and transitional habitats that are flooded to varying degrees by seasonal rainfall and runoff. If there are sufficient salts in the soil, the seasonal wetland may support plant species more typical of coastal salt marsh. If the soils do not contain salts, the seasonal wetlands may support freshwater marsh species and a mixture of weedy opportunists. “Vernal pools” and seasonal saline wetlands in transition zones can occur on alluvial and deltaic deposits adjacent to estuarine habitats and are known to support special-status plants and invertebrate animals. A majority of the existing seasonal wetlands at Ballona occur on saline dredge spoils from the excavation of Marina del Rey. These habitats only support common

intertidal plant species in a severely degraded state, and provide little habitat for wildlife. Some of the alternatives include the creation of seasonal wetlands in areas that do not support salt marsh plant species; in these areas freshwater seasonal wetlands may be created that could support vernal pool habitat.

Riparian scrub and woodland occurs in small groves or in riverine corridors that drain into estuaries. As with other riparian habitats, riparian scrub supports a diverse assemblage of wildlife species, especially passerine bird species. Mammal assemblages are similar to those found in freshwater marsh habitats as the two often intergrade. In an undisturbed estuarine system, wouldow scrub habitat would generally occur upstream of tidal influence as wouldows are very sensitive to salt. Like freshwater marsh, this habitat is dependent upon a constant source of freshwater.

Uplands

Most of the peripheral uplands of estuaries have been disturbed in southern California. Historically, upland communities of the systems were likely comprised of coastal dunes, scrub, or grasslands, and woodlands in some cases.

Dune habitat represents a form of transition zone between the land and the sea and includes Coastal Dune Scrub and Dune Herb vegetation. Coastal dune habitats have been largely lost due to development in southern California. Prior to development, plants stabilized the loose sand, and the dunes were thereby anchored. Following human disturbance, many of the native plants were eliminated and exotics, such as sour-fig (*Carporotus edulis*) and sea rocket (*Cakile maritima*) invaded or were planted.

Coastal sage scrub can be described as low, soft to woody shrubs and subshrubs that occur in a variety of situations and are characterized by a variety of dominant plant species. Coastal Sage Scrub is now generally rare along the coast. This vegetation community is typically dominated by coastal sagebrush (*Artemisia californica*) and California buckwheat (*Eriogonum fasciculatum*), together with laurel sumac (*Malosma laurina*), white sage (*Salvia apiana*) and others. Other forms of upland coastal scrub include, for example, Delta Scrub and Baccharis Scrub, which can be transitional to wetland scrub types. A variety of terrestrial animals, including amphibians, reptiles, mammals and birds are supported by coastal scrub habitat.

Native grasslands were a common upland vegetation associated with estuarine ecosystems in southern California. Existing conditions within coastal ecosystems often include extensive areas of non-native annual grassland and forblands generally dominated by introduced species. The function and importance of perennial and annual grasslands, however, are often similar for the support of small mammals and the raptors that prey upon them.

The proposed creation of treatment wetlands provide a means of cleaning contaminated water before it enters the wetlands. Treatment wetlands require periodic maintenance, including

harvesting of wetland plants and removal of sediments as they accumulate contaminants. Thus, treatment wetlands are not considered valuable for their structure, but for their function.

3.1.1 Habitat Acreages

Each of the alternatives would make changes to the existing distribution of habitats. In some places there would be enhancement of the existing habitat, either by management or by increasing tidal inundation (for the case of muted tidal areas). In some places, there would also be replacement of existing habitat by a different habitat type, which would generally involve the regrading of the existing ground elevation and introduction of tidal flows.

For each alternative the area for each habitat type was calculated. Where the alternative did not change the existing habitat then that habitat was assumed to remain. Where a muted tidal regime has been proposed, the distribution of low, mid and high marsh has been defined by the specified tidal inundation regime.

Table 3-2 shows the acreage of each habitat type by subarea and alternative. Table 3-3 show the area of habitat type by alternative. Totals are given for estuarine, freshwater/riparian and upland habitats. These show the shift in emphasis from upland and muted tidal habitat, in the existing situation, to increasing proportion of fully tidal estuarine habitat. Alternatives 3, 4 and 5 each create over 450 acres of estuarine habitat. Included in Table 3-3 is the acreage of shallow subtidal habitat adjacent to mudflat habitat for each alternative. As noted earlier, extensive dredging and development along the southern California coastline has reduced the amount of functional subtidal habitat adjacent to mudflats and wetlands. Alternatives 4 and 5 are the only alternatives that create subtidal habitat adjacent to mudflats, each with over 40 acres.

3.1.2 Quality of Habitat

Each of the proposed restoration alternatives implies varied degrees of improvement over the current existing conditions. Alternative 1, for example, proposes minimal grading and creation of wetland habitats; however, it offers enhancement of existing uplands and seasonal wetlands, resulting in an increase in the quality of the existing habitats (CSS and palustrine wetlands on fill). For the purposes of this document, quality of habitat is described based on a variety of factors: the regional “rarity” of each habitat; the characteristics of habitat patches; the connectivity between habitats both within the project site and with adjacent complimentary habitats; the relationship to adjacent developed areas; and the degree of transition from wetland to upland habitats.

3.1.2.1 Regional Rarity

One important factor in prioritizing habitats for restoration is to identify those habitats that are rare in the region. This includes habitat types that have been lost due to development as well as habitats that require a specific combination of natural processes so that they can only be created

in a few, specific places. Regional rarity, which may be considered both in terms of local (Santa Monica Bay or Los Angeles County) or regional (Southern California coast) extent of habitats, can be used to aide in this selection.

Estuarine Wetlands

Due to the dredging of wetlands and the expansion of harbors, subtidal habitat is not regionally rare; but it is often severely degraded. Shallow subtidal habitat connected to functioning wetland habitat is rare.

Estuarine wetlands, including vegetated tidal marsh, intertidal channels, mudflats and salt pans, are a regionally rare habitat that can only be restored in very specific locations. The Ballona Wetlands has long been identified as a significant regional opportunity for estuarine wetland restoration. The Southern California Wetlands Recovery Project, identifies tidal wetland restoration as a key priority in their Regional Strategy. The Regional Strategy states tidal wetlands can only be established within a small elevation range and a compatible geologic setting, and the region's rugged topography and extensive development restricts opportunities for restoration of tidal wetlands in Southern California. The project site represents the only opportunity to restore a large tidal wetland in Santa Monica Bay, and fills a large gap in the chain of wetlands along the Southern California coast.

Transitional zones provide a rare habitat due to the unique conditions created as tidal wetlands convert to uplands with increasing elevation. These habitats are regionally rare and have been significantly impacted as tidal wetlands have been lost.

Brackish marsh habitat is found at the transition of freshwater and intertidal marsh. These habitats are regionally rare and have been significantly impacted as tidal wetlands have been lost.

Non-tidal Wetlands

The seasonal wetlands in Ballona are on saline dredge spoils and are not a naturally occurring habitat type. However, seasonal wetlands may be created that could support vernal pool habitat of much more significant value. Vernal pool habitat has been nearly extirpated from Los Angeles County. These unique habitats support plant and wildlife species that rarely occur elsewhere.

Freshwater marsh and riparian scrub/woodland have also been severely degraded throughout southern California. These habitats require a consistent surface or subsurface freshwater input. While there are additional sites in the region to restore riparian and freshwater habitat, few occur in the vicinity of the Ballona Wetlands.

Upland Habitats

Coastal dunes habitats once stretched from Torrance to Santa Monica. Some of the small remaining patches are currently being restored along the south bay. Dune habitats are also rare in the sense that they require sandy substrate and specific physical processes (wind) to be maintained. Given impacts of the development surrounding the project area, there are limited opportunities to restore functioning dune systems and there may be better opportunities for coastal dune restoration adjacent to the coast.

Coastal sage scrub habitat is considered sensitive by the CDFG, but it is much more common in southern California than coastal wetland habitats. The bluffs immediately adjacent to the site and the nearby Baldwin Hills provide significant areas for potential restoration of coastal sage scrub.

Grassland habitats provide essential foraging habitat, and much of this habitat has been lost or severely impacted along the southern California coast. Restoration of upper marsh and transitional zones may provide equivalent foraging opportunities.

3.1.2.2 Habitat Patch Characteristics

The number, size and shape of habitat patches can determine the long-term stability of the created ecosystem. Restoration plans that incorporate numerous, small patches of different habitats are less likely to be self-sustaining in the long term due to edge effects. Edge effects may include colonization by invasive exotic plant species and/or competition with dominant plant species from other nearby created native habitats. Edge effects may also be reduced in habitat patches of similar area with smaller perimeters (edges). Small patches are also more susceptible to disease as fewer individual plants or clones may equate to reduced genetic diversity. Additionally, specialized pollinators may not be supported by small habitat patches. In general, larger more genetically diverse patches are more likely to survive in the long term without active management.

Edge to area ratio and edge to area index for each alternative is presented in Table 3-4. Patches have been defined by combining together all connected estuarine habitats. Edge to area ratio is simply the ratio of perimeter length to habitat patch size. Alternatives with larger patch sizes would have a lower edge to area ratio. Edge to Area Index is the ratio of the shape's edge-to-area ratio compared to the edge-to-area ratio for a circle of the same total area. The lower the index the closer patch shape is to a circle; the shape that maximizes area and minimizes edge length.

3.1.2.3 Connectivity Between Habitat Patches

Habitat connectivity includes the connection between similar habitats, as well as the connection between complementary habitats. The degree of habitat connectivity within each restoration alternative is an important factor to determine the quality of habitat which may result. Connectivity of similar habitats allows for local migration of plant and animal species providing

alternative sites for these species when conditions of one site or patch become unsuitable, i.e., during drought. While bird and insect species may be able to migrate across roads and waterways, terrestrial animals, such as reptiles, amphibians and mammals, are prevented or discouraged from by these barriers. Tidal exchange is an important component of connectivity in a wetland system. Tidal exchange provides diurnal replenishment of gases and nutrients; conveys pelagic eggs and larvae of marine organisms, and distributes floating propagules of salt marsh and other plant species. Connectivity of wetland and to transitional or upland habitat is also important to the quality of a restored wetland, allowing migration terrestrial species to migrate to dry areas during high tides. Thus, habitat connectivity can be measured on at least three scales within a restoration project: 1) connectivity of similar habitats within the project area, 2) hydraulic connectivity between wetland/estuarine habitats and the ocean, and 3) connectivity between wetland habitats and the uplands or transition zones.

Roads or levees can affect the connectivity within the project area. They bisect habitat areas, restrict movement of species, increase the area of disturbed habitat and force channels through culverts. Alternatives 1 through 4 contain 3 miles of roads and 3.8 miles of levees, while Alternative 5 has 2.2 miles of roads and no levees within the project area.

3.1.2.4 Relationship to Adjacent Developed Areas

Transition zones affect the species diversity and function of both the intertidal wetland and the adjacent upland. This habitat supports a unique assemblage of both plants and animals that may not exist in either the adjacent upland or wetland. Thus, the inclusion of transitional habitats in restoration projects is highly desirable. Table 1 gives the areas of transitional habitat for each alternative. The approximate slopes for transitional habitats in the alternatives is about 1:50 to 1:100.

In addition to a wetland-upland transition zone, buffer areas are important for various wetland functions, such as area for transgression, sediment filtration or retention, pollution retention, habitat and food web support, and flood protection. These would improve the quality of the wetland habitat.

Typically, southern California wetlands are bounded by homes, roads and levees that create abrupt, narrow transitions from wetland to upland. This adjacency does not allow animal species the refugia needed during some tides and introduces human disturbances to the wetlands. For example, during extreme high tides, species like light-footed clapper rail are subjected to predation by cats as they are forced from their preferred low marsh habitat into adjacent uplands. In some cases, adjacent developed areas provide habitat for desirable species. For example, non-native cedar trees located to the north of the Area A provide nesting habitat for a small colony of great blue herons. These herons may forage in the wetland and upland habitats of Ballona, but it is the adjacent habitat that serves as the rookery.

3.1.3 Connectivity

Connectivity may be measured in terms of geographical position of the restored wetland relative to other similar or complimentary habitats, locally and regionally.

3.1.3.1 Connectivity Within the Greater Ballona Ecosystem

Within the greater Ballona system there exist areas of complimentary habitat. These include Del Rey Lagoon, Grand Canal, El Segundo Dunes, Oxford Lagoon, adjacent bluff areas, nearshore and beach habitat, Ballona Creek and Marina del Rey jetties and breakwater, and the Pacific Ocean. Some of these sites are hydraulically connected and support a limited wetland component; those that are not provide upland habitat primarily for avian and insect species.

Connectivity within the greater Ballona ecosystem can be accomplished, via improved hydraulic connection, for fish and other aquatic species and for wetland and upland plants. This allows exchange of nutrients gases; transportation of eggs, larvae, juveniles and adult aquatic organisms; provides habitat for avian species and a pathway for water-dispersed seed. Connection by air is possible for flying insects and birds, as well as wind-dispersed seeds. The ability to access similar habitats within the greater system provides refugia for animal species during times of environmental instability; provides greater genetic variation and a greater potential foraging area.

3.1.3.2 Regional Connectivity to Other Southern California Wetlands

A further measure of connectivity is the position of the restored wetland to other wetlands in southern California, such as Mugu Lagoon and Upper Newport Bay. Such connectivity applies primarily to avian and fish species. It may also apply to aquatic plankton and nekton and plant propagules, as these are transported tidally. Certain habitats, such as mudflat, may be created in order to facilitate the connectivity between these wetland systems by providing a string of mudflats along the southern Californian coast.

3.1.4 Tables

Table 3-1. Tidal Habitat Types with Elevation Limits and Inundation Regime
(Based upon Ferren et al, 2007)

Habitat Type	Lower	Upper	Lower	Upper
	NAVD ft	NAVD ft	% time tide exceeds	% time tide exceeds
Subtidal	-5.0	-3.0	100%	100%
Intertidal Channel /Mudflat	-3.0	1.0	100%	90%
Salt pan	4.5	5.5	28%	14%
Low Marsh	1.0	2.5	90%	74%
Mid Marsh	2.5	3.5	74%	50%
High Marsh	3.5	4.5	50%	28%
Transition Zone	4.5	5.5	28%	14%

Table 3-2. Acreage of each habitat type by area and alternative

Habitat Type	Existing					Alternative 1					Alternative 2					Alternative 3					Alternative 4					Alternative 5	
	Area A	Area B	Area C	Ballona Creek	Total	Area A	Area B	Area C	Ballona Creek	Total	Area A	Area B	Area C	Ballona Creek	Total	Area A	Area B	Area C	Ballona Creek	Total	Area A	Area B	Area C	Ballona Creek	Total	All Areas	Total
TOTAL Existing	**137.6**	**347.5**	**71.4**	**74.0**	**630.5**	**137.6**	**347.5**	**71.4**	**74.0**	**630.5**	**137.6**	**347.5**	**71.4**	**74.0**	**630.5**	**137.6**	**347.5**	**71.4**	**74.0**	**630.5**	**137.6**	**347.5**	**71.4**	**74.0**	**630.5**	**137.6**	**630.5**
TOTAL for Alternative						**137.7**	**334.7**	**71.8**	**74.0**	**618.1**	**139.8**	**335.4**	**71.7**	**74.0**	**620.9**	**141.4**	**357.3**	**71.5**	**74.0**	**644.2**	**141.4**	**356.7**	**71.5**	**74.0**	**643.5**	**632.4**	**632.4**
Subtidal				74.0	**74.0**				74.0	**74.0**				74.0	**74.0**				74.0	**74.0**	41.4			74.0	**115.4**	48.6	**48.6**
Intertidal Channel /Mudflat		1.7			**1.7**	0.3	10.2			**10.4**	2.9	8.7	0.1		**11.7**	5.6	14.5	0.3		**20.4**	25.7	14.5	0.3		**40.6**	26.2	**26.2**
Salt pan		22.4			**22.4**					**0.0**					**0.0**					**0.0**					**0.0**		**0.0**
Muted Low Marsh		8.5			**8.5**		64.7			**64.7**		37.0			**37.0**					**0.0**					**0.0**		**0.0**
Muted Mid Marsh		17.6			**17.6**		34.3			**34.3**		19.6			**19.6**					**0.0**					**0.0**		**0.0**
Muted High Marsh		40.6			**40.6**		17.8			**17.8**		10.2			**10.2**					**0.0**					**0.0**		**0.0**
Fully Tidal Low Marsh					**0.0**	1.3				**1.3**	14.7	14.2	0.4		**29.3**	27.8	72.5	1.6		**102.0**	13.5	72.5	1.6		**87.6**	131.0	**131.0**
Fully Tidal Mid Marsh					**0.0**	0.8				**0.8**	9.5	9.2	0.2		**19.0**	18.1	47.1	1.1		**66.3**	10.3	47.1	1.1		**58.4**	85.2	**85.2**
Fully Tidal High Marsh					**0.0**	0.8				**0.8**	9.5	9.2	0.2		**19.0**	18.1	47.1	1.1		**66.3**	10.3	47.1	1.1		**58.4**	85.2	**85.2**
Transition Zone					**0.0**	5.7	26.1			**31.9**	28.9	44.4	7.7		**81.1**	38.4	79.2	5.9		**123.5**	10.0	79.2	5.9		**95.2**	96.1	**96.1**
Brackish Marsh		3.0	0.1		**3.1**		2.6	0.1		**2.7**		2.6			**2.6**		2.6			**2.6**		2.6			**2.6**	2.6	**2.6**
TOTAL Estuarine	**0.0**	**93.8**	**0.1**	**74.0**	**167.9**	**8.9**	**155.6**	**0.1**	**74.0**	**238.7**	**65.6**	**155.2**	**8.6**	**74.0**	**303.5**	**108.0**	**263.0**	**10.0**	**74.0**	**455.0**	**111.2**	**263.0**	**10.0**	**74.0**	**458.2**	**474.8**	**474.8**
Fresh Water Marsh		1.1			**1.1**		1.0			**1.0**		1.0			**1.0**		1.0			**1.0**		1.0			**1.0**	1.0	**1.0**
Seasonal Wetland	10.9	74.2	0.6		**85.7**	10.9	2.5	0.6		**14.0**		2.5	4.0		**6.5**		2.5	5.8		**8.3**		2.5	5.8		**8.3**	2.5	**2.5**
Riparian Scrub	3.2	15.1	3.3		**21.6**		5.1	1.7		**6.7**		5.1	0.5		**5.6**		5.1	0.5		**5.6**		5.1	0.5		**5.6**	5.6	**5.6**
Riparian Woodland		2.9			**2.9**		2.9			**2.9**		2.9			**2.9**		2.9			**2.9**		2.9			**2.9**	2.9	**2.9**
TOTAL Freshwater/Riparian	**14.1**	**93.3**	**3.9**	**0.0**	**111.3**	**10.9**	**11.5**	**2.2**	**0.0**	**24.6**	**0.0**	**11.5**	**4.6**	**0.0**	**16.0**	**0.0**	**11.4**	**6.3**	**0.0**	**17.7**	**0.0**	**11.4**	**6.3**	**0.0**	**17.7**	**11.9**	**11.9**
Grassland/Herbaceous	64.0	62.7	49.7		**176.4**		13.3	30.0		**43.4**		13.3	7.3		**20.7**		13.2	7.3		**20.5**		13.2	7.3		**20.5**	13.5	**13.5**
Coastal Scrub	58.9	26.0	8.9		**93.9**	117.2	91.7	30.6		**239.5**	73.5	92.9	44.4		**210.9**	32.9	7.3	41.1		**81.3**	29.7	7.3	41.1		**78.1**	69.8	**69.8**
Coastal Dunes		9.9	2.1		**12.0**		8.3	2.1		**10.4**		8.3			**8.3**		8.3			**8.3**		8.3			**8.3**	8.3	**8.3**
Forest/Woodland	0.6	0.2			**0.7**		0.1			**0.1**		0.1			**0.1**		0.1			**0.1**		0.1			**0.1**	0.1	**0.1**
TOTAL Upland	**123.5**	**98.8**	**60.7**	**0.0**	**283.0**	**117.2**	**113.5**	**62.7**	**0.0**	**293.4**	**73.5**	**114.7**	**51.8**	**0.0**	**240.0**	**32.9**	**28.9**	**48.4**	**0.0**	**110.2**	**29.7**	**28.9**	**48.4**	**0.0**	**107.0**	**91.7**	**91.7**
Unvegetated/Paved		10.9			**10.9**	0.7	0.7			**1.4**	0.7	0.7			**1.4**	0.6	0.7			**1.2**	0.6				**0.6**	0.7	**0.7**
Ballfields			6.7		**6.7**			6.7		**6.7**			6.7		**6.7**			6.7		**6.7**			6.7		**6.7**		**0.0**
Gas Company		10.9			**10.9**		13.6			**13.6**		13.6			**13.6**		13.6			**13.6**		13.6			**13.6**	13.6	**13.6**
The Freshwater Marsh		39.8			**39.8**		39.8			**39.8**		39.8			**39.8**		39.8			**39.8**		39.8			**39.8**	39.8	**39.8**
TOTAL Other areas	**0.0**	**61.6**	**6.7**	**0.0**	**68.3**	**0.7**	**54.1**	**6.7**	**0.0**	**61.5**	**0.7**	**54.1**	**6.7**	**0.0**	**61.5**	**0.6**	**54.0**	**6.7**	**0.0**	**61.3**	**0.6**	**53.4**	**6.7**	**0.0**	**60.6**	**54.0**	**54.0**

Table 3-3. Summary of Habitat Acreages

Habitat Type	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Subtidal	74.0	74.0	74.0	115.4 (41.4†)	48.6 (48.6†)
Intertidal Channel And Mudflats	10.4	11.7	20.4	40.6	26.2
Low Marsh	66.0 (64.7††)	66.3 (37.0††)	102.0	87.6	131.0
Mid Marsh	35.1 (34.3††)	38.6 (19.6††)	66.3	58.4	85.2
High Marsh	18.6 (17.8††)	29.2 (10.2††)	66.3	58.4	85.2
Transitional Habitat	31.9	81.1	123.5	95.2	96.1
Brackish Marsh	2.7	2.6	2.6	2.6	2.6
Total Estuarine	**238.7**	**303.5**	**455.0**	**458.2**	**474.8**
Freshwater/Riparian	10.6	9.5	9.5	9.5	9.5
Seasonal Wetland	14.0*	6.5	8.3	8.3	2.5
Upland	293.4	240.0	110.2	107.0	91.7
Unvegetated	8.1	8.1	7.9	7.3	0.7

† Area of shallow subtidal habitat adjacent to mudflats
†† Area of muted tidal
* Habitat created on saline soils

Table 3-4. Edge/Area indices for Estuarine Wetland Habitats

Alternative	Edge to Area Ratio (ft/ac)	Edge to Area Index*
ALT1	218.3918	4.4645
ALT2	243.0364	4.7857
ALT3	193.1576	4.6057
ALT4	178.0851	4.4550
ALT5	111.3358	2.8696

* Edge to Area Index is the ratio of the shape's edge-to-area ratio compared to the edge-to-area ratio for a circle of the same total area.

3.2 BIODIVERSITY

Habitat restoration provides opportunities for the preservation of the region's plant and animal species as well as the opportunity for the recovery of lost or declining biodiversity. The biological communities of coastal southern California have experienced a decline in species richness, or diversity, as a result of loss of over 90% of their wetland habitat following urban and agricultural development. Declining biodiversity includes plant and animal species that are listed as threatened or endangered, many of which are associated with wetland habitats. Restoration of Ballona wetlands offers the opportunity to create refuges for these species and habitats for other species to recover locally and potentially act as a "seed" source for other nearby wetland systems. Because a major goal of this restoration project is to restore estuarine habitats and processes, diversity of species supported by estuarine habitats would be of particular interest. Therefore, for the purpose of this document, biodiversity is discussed in terms of the sustainable richness of representative interdependent native estuarine habitats along with their associated and expected species biodiversity. The diversity of species dependent upon other habitat types (eg. freshwater wetland or coastal dune habitats) included in the alternatives is also noted.

The five restoration alternatives for Ballona range from preservation and enhancement of large areas of upland habitat with limited wetland habitat to restoration and creation of large areas of wetlands with less upland habitat. Upland-dominated restoration should increase the biodiversity of the existing upland habitats. This would primarily benefit woody vascular plants and associated animals at the expense of opportunities to increase diversity of wetland plant and animal groups. Wetland-dominated restoration would benefit non-vascular aquatic plants, vascular plants, aquatic invertebrates, aquatic vertebrates, terrestrial invertebrates and terrestrial vertebrates.

Biodiversity is discussed at the level of large taxonomic groups. Some specific examples are given; however, not all species that may be supported by each of the restoration alternatives are discussed. For the purposes of this document, taxonomic groups are defined as vascular and nonvascular plants; terrestrial invertebrates (insects); terrestrial vertebrates (birds, herpetofuana, mammals); aquatic invertebrates (infauna and epifauna); and aquatic vertebrates (fish).

<u>Estuarine Wetlands</u>

Maximizing shallow subtidal habitat would benefit the biodiversity of the system especially for birds and fishes. Non-vascular plants (e.g., phytoplankton) would presumably be most functional in the upper water column where light penetration is greatest and thus would not necessarily benefit from deeper water. Similarly, vascular plants, insects, benthic invertebrates, herpetofuana and small mammals would not directly benefit from deeper salt water.

Fishes, primarily those associated with the nearshore ocean habitat, would be supported by deeper waters with a connection to the open coast. Such species as Queenfish (*Seriphus politus*), white croaker (*Genyonemus lineatus*), northen anchovy (*Engraulis mordax*) that inhabit the mid- to

upper water column would increase the biodiversity of the system as would demersal species such as California halibut and shovel-nose guitarfish (*Rhinobatos productus*).

Gulls and terns, including California least tern and such species as double-crested cormorant (*Phalacrocorax auritus*) and brown pelican (*Pelicanus occidentalis*) would be supported by increased fish diversity and abundance. Osprey (*Pandion haliaetus*) may also forage for fish in the subtidal areas.

As more tidal wetland habitat is included in an alternative, additional taxonomic groups are supported. Creation of channel, low and mid-high marsh would support non-vascular aquatic plants, vascular plants, aquatic invertebrates, aquatic vertebrates, terrestrial invertebrates and terrestrial vertebrates.

Non-vascular plants include phytoplankton, micro-algae, and macro-algae, that are found in the channels and marsh habitats. Salt marsh micro-algae are dominated by diatoms. Macro-algae include green algae and blue-green algae. Tidal influence, light penetration and nutrients are factors that can limit salt marsh algal populations.

Vascular plants that inhabit a typical Southern California tidal salt marsh include the perennials Pacific cordgrass (*Spartina foliosa*), common pickleweed (*Sarcocornia pacifica*) and fleshy jaumea (*Jaumea carnosa*), as well as annual pickleweed (*Salicornia bigelovii*). They occur in narrow elevation zones determined by the frequency of tidal inundation, salinity, duration of saturated soil, and temperature. These plants, along with non-vascular algae, contribute to the complex food web that supports the high productivity of coastal wetlands. The detritus of vascular and non-vascular plants provides food for aquatic invertebrates, including both infauna (organisms that live within the sediment) and epifauna (those that live on the surface of the sediment).

Common infauna associated with mud or sand bottoms of channel and low marsh habitats include polychaete worms and filter-feeding bivalves, such as California jackknife clam (*Tagelus californica*), littleneck clam (*Prototheca staminea*) and bent-nose clam (*Macoma nasuta*). Common epifuana of channels include detritivores, such as California horn snail (*Cerethidia californica*), bubble snail (*Bulla gouldiana*), and *Nassarius* sp., and omnivores such as lined shore crab (*Pachygrapsus crassipes*) and yellow shore crab (*Hemigrapsus oregonensis*).

Restoring intertidal mudflat area would increase the biodiversity of benthic infauna, including polychaetes, which in turn would support a higher diversity of wading birds. Perhaps the most conspicuous animals of the intertidal mudflats are the shorebirds that feed and rest there during low tide. Many of their invertebrate prey items are widely distributed, from the subtidal channels to the lower limit of the salt marsh. Wading shorebirds, such as western sandpiper (*Calidris mauri*), semipalmated sandpiper (*C. pusilla*) and dowitchers (*Limnodromus* spp.) would be expected to forage on the mudflats during their migration.

Cordgrass associated with low marsh habitat provides structure, and possibly food, for insect species, such as the larvae of *Incertella* and *Cricotopus* species, the beetle *Coleomegilla fuscilabris* and the plant hopper (*Prokelesia* sp.). The longjaw mudsucker (*Gillichthys mirabilis*) forages in the low and mid-high marsh, especially along creek banks during high tides. Mid-high marsh habitat provides food and structure for California horn snails, amphipods, and snails of the genus *Assiminea*. Water boatmen (*Trichocorixia* spp.) feed on algae in pools and in turn provide food for California killifish (*Fundulus parvipinnis*) that feed in the marsh during high tides

The wetland-dominated restoration alternatives would create/restore large blocks of habitat that would be connected via channels and tidal flows. These large blocks of habitat would be more sustainable in the long-term as they would be less susceptible to edge effects of invasive species. They would also be less susceptible to human disturbance, as many areas would be inaccessible.

Creation of channels and mudflats provides habitat for breeding and foraging for estuarine fishes. Some, such as gobies (Gobiidae), complete their life cycle in southern California estuaries, attaching their eggs to the burrows of commensal invertebrates. Other common wetland fish species, such as topsmelt (*Atherinops affinis*), attach their eggs to filamentous algal mats that also shelter their larvae and post-larvae. Species such as California halibut spawn offshore but spend the first few years of life in protected coastal waters. Still others, such as striped mullet (*Mugil cephalus*) live their lives in protected inshore habitat but spawn offshore. In general, the channels and low marsh habitats of southern California coastal wetlands act as nursery grounds for coastal fisheries.

Larger aquatic benthic invertebrates, such as snails and crabs, as well as fish, are preyed upon by a number of bird groups, including herons and egrets, wading birds and terns and gulls. Southern California coastal wetlands support dozens of species and many thousands of individual birds that migrate along the Pacific flyway. Herons, egrets, gulls, terns, shorebirds, ducks, geese, coots, gallinules and rails occur in southern California wetlands throughout most of the year. Most of these birds appear to prefer intertidal flats to salt marsh habitats for foraging and other activities. However, marsh habitats contribute to the support of birds by: providing food (either directly or indirectly), cover from predators, and structure for nesting and roosting. Birds of the low marsh include rails, such as Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), and the endangered light-footed clapper rail (*Rallus longirostris levipes*).

Common bird species of the mid-high marsh include wading species such as willet (*Catoptrophorus semipalmatus*), marbled godwit (*Limosa fedoa*), long-billed curlew (*Numenius americanus*) and great blue heron (*Ardea herodias*). These species prey upon fishes and aquatic invertebrates and, in the case of herons, upland terrestrial animals such as small mammals and herpetofauna.

Terns and gulls observed in southern California coastal wetlands occur primarily in intertidal flats and on the adjacent beaches; however, some taxa do utilize salt marsh habitats. Western gull (*Larus occidentalis*) and ring-billed gull (*Larus delawarensis*) forage and roost in intertidal salt

marsh habitats while the endangered California least tern (*Sterna antillarum browni*) forages in intertidal channels. Forster's tern (*Sterna forsteri*) and elegant tern (*S. elegans*) can use a variety of wetland habitats, including salt marsh. Most of the bird groups, with exception of a few small species, forage and roost in southern California wetlands but breed elsewhere.

The mid-high marsh provides structure for some nesting birds, including the state endangered Belding's Savannah sparrow (*Passerculus sandwichensis beldingi*). This small songbird builds its nest low to the ground under marsh vegetation, such as pickleweed. Belding's Savannah sparrows forage on insects, often at the interface of marsh and channel.

Small mammals associated with southern California tidal wetlands include the western salt marsh harvest mouse (*Reithrodontomys megalotis limicola*) and meadow mouse (*Microtus californicus stephensi*). Harvest mice are granivorous, while meadow mice are primarily herbivorous. While little is known about their diets, neither feeds on pickleweed, the most common vascular plant species at Ballona.

Both upland-dominated and intermediate tidal restoration alternatives preserve areas that are currently muted-tidal wetlands. Muted-tidal wetlands provide functions similar to fully-tidal wetlands, but reduced in terms of biodiversity. For example, muted tidal channels may have similar species composition and densities of phytoplankton and benthic micro-algae but may support fewer salt marsh vascular plant species than do fully tidal channels. Similarly, fewer fish species might occur in muted tidal systems. With less tidal influence, muted tidal areas would be susceptible to periodic fresh water inflows. Conversely, during neap tides, muted tidal systems may be subjected to prolonged drying and increased salinity, unless they impounded water continuously, in which case, they would not support vascular plants. Thus, muted tidal systems are likely to be less sustainable than fully tidal systems.

Creation of wetland habitats allows for creation of transitional habitats, which would increase the regional diversity of vascular plants and terrestrial vertebrates. Examples of transition zone vascular plants include boxthorn *(Lycium californicum)*, bush seepweed *(Suaeda nigra)*, coast golden bush (*Isocoma menziesii*), and Parish's glasswort (*Arthrocnemum subterminale*). These overlap with the highest elevation salt marsh species including, for example, saltgrass, alkali weed *(Cressa truxillensis)*, and shoregrass *(Monanthochloe littoralis)*. Boxthorn is a common perch for birds and various small mammals and herpetofauna burrow beneath it or use it for shade.

The transition zone of southern California wetlands, such as Carpenteria salt marsh, have a euryhaline zone that fluctuates between wet season low salinities and dry season hypersaline conditions. The habitat is characterized by winter annual plant species such as salt marsh daisy (*Lasthenia glabrata* ssp. *coulteri*), salt marsh sand-spurry (*Spergularia marina*), toad rush (*Juncus bufonius*), and hutchinsia (*Hutchinsia procumbens*), which tolerate the fluctuating salinities by growing in the wet season.

The animals of the higher elevations of the transition zone are primarily terrestrial species. These include various snakes, lizards, small mammals and birds. Herpetofauna may include California kingsnake *(Lampropeltis getulus californiae)*, San Diego gopher snake *(Pituophus melanoleucus annectens)* and side-blotched lizard *(Uta stansburiana)*. Common mammals of the shrub-dominated transition zone include western harvest mouse, deer mouse *(Peromyscus maniculatus)*, pocket gopher (*Thomomys* sp.*)*, and California ground squirrel *(Spermophilus beechyi)*. The small mammals are preyed upon by a variety of birds including northern harrier *(Circus cyaneus)* and white-tailed kite *(Elaneus caeruleus)*. Ground-nesting bees that pollinate salt marsh bird's-beak (*Cordylanthus maritimus* spp. *maritimus*) live above the high tide in this habitat.

Non-tidal Wetlands

It is anticipated that brackish marsh would develop in areas where fresh water marsh and salt marsh intergrade. This habitat supports many of the taxa associated with both of those habitats, although species that cannot tolerate either extreme are likely to be absent. Brackish water marsh habitat has a range of conditions from briefly fresh to briefly hypersaline and would provide a small increase in the biodiversity of the wetlands. For example, *Juncus acutus* is regionally rare and can thrive where soil is at least briefly brackish; tall tules can provide critical cover for rails during high tide.

Seasonal wetlands would support regional biodiversity of non-vascular and vascular plant species, herpetofauna, birds and small mammals. However, much of the existing seasonal wetlands are on saline fill soils that would not support biodiversity. Vascular plants that might be supported include common pickleweed (*Sarcocornia pacifica = Salicornia virginica*), alkali weed (*Cressa truxellensis*), and alkali heath (*Frankenia salina*). Smaller areas of freshwater seasonal wetlands would provide breeding grounds for toad and frog species, such as Pacific chorus frog (*Pseudacris regilla*) and California tree frog (*Hyla cadaverina*). Ponded water provides nesting and foraging habitat for American avocet (*Recurvirostra americana*), black-necked stilt (*Himantopus mexicanus*) and killdeer. Small mammals common to upland habitats could also use seasonal wetlands.

Creation of vernal pool habitat has been proposed as part of upland-dominated restoration schemes. Vernal pools are regionally rare habitats, and adding water-holding depressions would increase the biodiversity of the Ballona ecosystem. Vernal pools are formed over impervious substrates, such as a soil with a subsurface clay layer that impounds seasonal rainfall. Such topography and soils are lacking from Ballona upland areas. Creation of vernal pools would benefit primarily non-vascular and vascular plants, aquatic invertebrates, and herpetofauna, although small mammals and birds may also benefit. Non-vascular species that inhabit vernal pools include diverse phytoplankton, green and blue-green micro-algae, and occasional macro-algae. These are food sources for a number of invertebrates, including fairy shrimp (*Branchinecta* spp.), several species of which are listed as endangered. Many of the vascular plants associated with vernal pools are unique in their adaptations to water levels that fluctuate widely over short periods of time. These range from fairly common species, such as isoetes (*Isoetes* spp.) to the

endangered San Diego mesa mint (*Pogogyne abramsii*). Herpetofauna, such as discussed above, would benefit from vernal pools, although survival through metamorphosis depends on the amount of rainfall and the duration of impoundment.

Created vernal pools, especially those requiring importation of clay to line the pools so they would hold water for the appropriate duration, would not only be difficult build but subject to invasion by unwanted species once wetted. Imported soils often contain plant propagules, such as non-native grasses, that could invade the proposed restoration. Furthermore, small vernal pools would be subject to edge effects. Pools that dry early in the growing season of vernal pool vascular plants would be subject to invasion by non-desirable species, such as non-native grasses.

Fresh water marsh and riparian habitats would, in some way, provide support to all of the taxonomic groups. Detritus from vascular plants, such as cattail (*Typha* spp.) and bulrushes (*Scirpus* spp.), and a variety of non-vascular algae would provide food for aquatic invertebrates, including gastropods, copepods, amphipods and decapods, and insects, such as beetles (Coleoptera), flies (Diptera) and true bugs (Hemiptera). These taxa provide food for passerine birds, such as blackbirds (*Agelaius* spp.), wrens (*Cistothorus* spp.), rails (*Rallus* ssp.) and waterfowl; fishes, primarily non-native species; herpetofauna, including Pacific chorus frog and California tree frog, and snakes, such as two-striped garter snake (*Thamnophis couchi hammondi*); and small mammals. Larger mammals, such as raccoon (*Procyon lotor*), may forage directly on invertebrates and fish.

Treatment wetlands could support similar species as fresh water marsh habitat. However, these areas would require active management and removal of sediments, contaminants, and invasive plants, all of which would limit their value for biodiversity support.

Upland Habitats

Existing disturbed uplands would be preserved and their biota enhanced through the removal of exotic plant species and planting of native coastal sage scrub and native grassland species. Coastal sage scrub habitat (CSS) would be enhanced through planting of species such as coastal sagebrush (*Artemisia californica*), California buckwheat (*Eriogonum fasciculatum*), deerweed (*Lotus scoparius*), sage species (*Salvia* spp.) and lemonadeberry (*Rhus integrifolia*). Planting of these vascular plant species would, in turn, provide nesting and foraging habitat for a number of migratory and non-migratory terrestrial passerine bird species, including the federally-listed threatened coastal California gnatcatcher (*Pilioptila californica californica*), towhees (*Pipilo* spp), wrens (*Troglodyte*s spp.), and finches (*Cardeulis* spp.). Many of these passerine birds rely on insects and seeds for food. CSS enhanced by more diverse flowering plants would support insects that provide forage for the above birds. Enhanced CSS would also support insect pollinators, including bees and flies. The diversity of other insects, such as butterflies and moths, would be enhanced by providing plant species that serve as larval foods and adult nectaring plants.

Native grassland habitat would be created from disturbed upland habitat through the removal of exotics and planting with a variety of native grasses and annual forbs. Examples include purple needlegrass (*Nassela pulchra*), nodding needlegrass (*N. cernua*), bluegrass (native *Poa* spp.) goldenstar (*Bloomeria* spp.), brodiaea (*Brodiaea* spp.), clarkia (*Clarki*a spp.) and valley tassels (*Castilleja attenuata*). Populations of these vascular plant species would enhance nesting and foraging habitat for passerine birds such as western meadowlark (*Sternella neglecta*) and grasshopper sparrow (*Ammodramus savannarum*), and also wading birds such as killdeer (*Charadrius vociferous*) and owls, including burrowing owl (*Athene cunicularia*). Grasslands are important foraging grounds for raptors including red-tailed hawk (*Buteo jamaicensis*) and white-tailed kite (*Elanus leucurus*). Like coastal sage scrub, this upland habitat would increase the diversity of flowering plants which, in turn, would support a variety of insects.

A number amphibians and reptiles occur in upland habitats, including Gilbert's skink (*Eumeces gilberti rubricaudatus*), western toad (*Bufo boreas*), spadefoot toad (*Scaphiphus hammnodi*), western fence lizard (*Sceloporus occidentalis*), side-blotch lizard (*Uta stansburiana*), rosy boa (*Charina trivirgata roseofusca*), gopher snake (*Pituophis catinefer*), horned lizard (*Phrynosoma coronatum*) and various species of rattle snake (*Crotalus* sp.). Enhancement of the existing habitat would increase foraging and breeding habitat for these and other herpetofauna.

Upland habitats also support numerous small mammals. Examples include shrews (*Sorex* sp.), deer mice (*Peromyscus* spp.), voles (*Microtus* sp.), rabbits (*Sylvilagus* spp.), and skunks (*Mephitis mephitis*). These small mammals are preyed upon by larger upland mammals, such as coyote (*Canis latrans*) and grey fox (*Urocyon* sp.), and birds of prey, such as red-tailed hawk and northern harrier (*Circus cyaneus*).

The existing disturbed upland habitats at Ballona are dominated by non-native vascular plant species, such as crown daisy (*Chrysanthemum coronarium*), mustard (*Brassic*a spp.), wild radish, fennel, castor bean, pampas grass and brazillan pepper tree. Seeds of many of these and other invasive plants are wind dispersed and off-site sources are numerous. Non-native animal species, such as Virginia opossum (*Didelphis virginianus*) and house mouse (*Mus mus*) are also common. Non-native animals that are adapted to humans are also likely to disperse into created upland habitats, competing for food with native species. Additionally, upland predators, including red fox and feral cats, can significantly affect birds nesting in the wetland as well as small mammals. Because restored upland habitats are highly susceptible to invasion by non-native plants and animals, their sustainability is constrained by the urban landscape.

All alternatives include the preservation and enhancement of coastal dune habitat at Ballona. Similar to CSS and native grassland, coastal dunes would support flowering vascular plants, such as lupines (*Lupinus* sp.), which would support and benefit from insect pollinators and provide larval and adult food sources. Coastal dune habitats provide habitat for reptiles, including horned lizard (*Phrynosoma* spp.) and California silvery legless lizard (*Anniella pulchra pulchra*). Passerine birds and small mammals could forage on seeds produced by vascular plants.

3.3 HYDROLOGY

The hydrology of each of the alternatives would have a significant impact on the functioning of the habitats. The depth and period of tidal inundations is a major influence on the type of habitats that would each alternative would support. The flow of water would erode, deposit and transport sediment. The period of time water stays on the wetlands and the amount it mixes with water from other water bodies would affect water quality. The hydrology of each alternative also affects the flood protection for existing infrastructure surrounding the wetlands. Hydrology is one of the main processes that link both the different project areas with each other and with Ballona Creek and Marina del Rey. The hydrology of the site would be sensitive to climate change and sea level rise in particular; the sustainability of the alternatives is discussed in Section 3.5.

Each restoration alternative proposed for the project has varying degrees of tidal inundation in terms of area and tidal range. Alternative 1 has minimal grading and most of the tidally inundated areas have a muted tidal range in portions of Area B. Alternative 2 and 3, by contrast, have fully tidal wetlands covering significant portions of Areas A and B. Alternative 4 has a large subtidal component connected to Marina del Rey. Alternative 5 has the greatest hydraulic connectivity with the main channel and between the restoration areas, due to the removal of levees. The degree of tidal inundation has a fundamental impact on the vertical and horizontal distribution of habitat types that would be supported.

The degree of tidal inundation inside the wetlands would also change the way the wetlands interact with Ballona Creek and Marina Del Rey. Larger, fully tidal wetlands would have larger tidal prisms which would have a greater impact on the surrounding water bodies, in particular on the amount of mixing. The location of the tidal connections is also important; a location inside Basin H, with its smaller tidal prism, would have a greater local effect on mixing than one connected to the main channel of Marina del Rey, which has a very large tidal prism.

3.3.1 Muted Tidal System versus Full Tidal System

A fully tidal wetland at Ballona would experience a tidal range equivalent to the oceanic tide in Santa Monica Bay. Mean Lower Low Water (MLLW, the long term average of the lowest tide each day) is -0.21 ft NAVD, Mean Higher High Water (MHHW, the long term average of the highest tide each day) is 5.29 ft NAVD and the diurnal tidal range (MHHW-MLLW) is 5.49 feet. The land area between the upper and lower limits of tidal range is the total area of intertidal habitat.

A muted tidal wetland experiences a more limited tidal range than a fully tidal wetland. Existing muted tidal wetlands at Ballona have Self-Regulating Tide gates (SRT), which close when the water surface elevation reaches a set height. Muted tidal systems would tend to compress the vertical range of wetland habitat types and would cause intertidal habitats to be created at lower elevations. Connections through culverts, open breaches and removal of levees are intended to allow the full oceanic tide to enter the site.

Inundation regime is the percentage of time that a given water level is exceeded during a Neap-Spring tidal cycle. It a useful parameter for characterizing the tidal inundation at a particular location with a specific elevation. The inundation regime for the unrestricted tidal system in the Santa Monica Bay is shown in Table 3-3; for example 2 ft NAVD is exceeded for 80% of the time and 4 ft NAVD for 38% of the time.

The inundation regime in some of the alternatives can be modified by setting the closure of the SRT in Area B at different elevations, which limits the maximum tidal elevation but maintains the rate of rise and fall of the tide. The inundation regimes were estimated for three SRT closure elevations using hydraulic modeling. The existing gate is set to close at 3.6 ft NAVD. Two additional closure elevations were modeled at 4.9 ft NAVD and 6.6 ft NAVD.

Table 3-3 shows how the inundation regime varies with different closure elevations. The inundation regime for lower elevations stays roughly the same between gate settings (e.g. 2 ft NAVD is exceeded about 77% of the time in all cases, which is comparable to the 80% for Santa Monica Bay). The effect of the muting is more pronounced at higher elevations (e.g. 4 ft NAVD is exceeded 38% of the time in Santa Monica Bay, but only 6% with a gate that closes at 4.9 ft NAVD). The inundation regime for intermediate closure elevations can be estimated by interpolation.

The vertical zonation of intertidal habitats can be estimated from the inundation regime. Different species would favor being inundated for different frequencies. For instance, high marshes are inundated approximately 28 to 50% of the time, while for low marsh the range of frequencies are 74 to 90%. Table 3-4 shows the inundation regime for intertidal habitats and the corresponding elevations for the oceanic tide in Santa Monica Bay (based on Ferren *et al*, 2007 in Appendix B). Each of the marsh habitat types covers a vertical range of about one foot.

Habitat zonations for the muted tidal regimes have been derived by determining the muted tidal elevation that has the same inundation regime as the open ocean. Table 3-4 shows the expected habitat distribution for different closure elevations for the SRT. Muting can also be achieved by undersized culverts that constrict the flow. These change the rate at which the tide rises in the site such that maximum elevation would not be the same on each tide. However, undersized culverts cause problems of erosion, backwater effects, and drainage.

For muted tidal systems the elevation range for the intertidal habitats is compressed which in turn limits the areal extent of these habitats compared to fully tidal alternatives. The zonation for intermediate closure elevations can be estimated by interpolation. This compression is most significant for the highest zones of the marsh (e.g. high marsh, transition zone). For instance, with the existing SRT closure elevation of 3.6 ft NAVD, mid marsh has the same vertical range as in a fully tidal system (1 foot) but occurs 0.3 feet lower. However, for the same SRT setting, the high marsh has a much reduced vertical range of 0.3 ft (between elevations 3.2 -3.5 ft NAVD).

In summary:

- varying the SRT closure elevation would mute the inundation regime in a predictable manner in Area B;
- vertical zonation of habitat would be compressed, particular at higher elevations, by muting of the tidal inundation;
- habitat area would be limited by the reduced vertical range of habitats.

3.3.2 Tidal Prism

The tidal prism is the volume of water entering the wetland on each tide. The tidal prism is a function of the topography and the tidal range of the site. For example, Alternatives 2 to 5 include substantial grading which would increase the volume of tidal water entering the site on each tide. If the tidal range is muted, the tidal prism would be reduced. The tidal prism was evaluated for each restoration area and for each of the main water connecting water bodies (Basin H, Marina Del Rey and Ballona Creek).

The tidal prism is important both within and outside the wetland:

- the tidal prism would influence the channel geometry and channel network properties.
- the tidal prism would influence the source of tidal water (as it affects the excursion length) and the residence time.

Table 3-5 shows the tidal prism of Ballona Creek in relation to the southwest wetland of Area B. In this case the main variable is the type of connection, either a SRT (Alt 1) or open breach (Alt 3). The muted tidal wetland has a tidal prism of about 30 ac-ft. Replacing muted tidal wetlands in Area B with fully tidal wetlands (Alt 3), connected to the creek by a breach, adds about 150 ac-ft to the existing tidal prism. One effect of increasing the tidal prism of Ballona Creek would be to increase the potential for scour at the mouth, in the vicinity of the jetty heads. Increased scour at the mouth has both positive and negative implications. It may reduce the need for dredging of Ballona Creek, improving the flood conveyance of the channel; however, it may also remobilize contaminated sediment that has settled at the mouth and there is the potential for undermining the breakwater as the channel readjusts to the larger tidal prism.

Table 3-6 shows the variation of tidal prism in relation to the southwest wetland of Area B. For a muted tidal wetland in this area the tidal prism is about 15 ac-ft. A tidal wetland created in this area in Alternatives 2 to 4 has a tidal prism of about 30 ac-ft.

Table 3-7 shows the variation of tidal prism for Area A. For those alternatives that connect to Marina del Rey, the tidal prism across the mouth of Basin H was used as a measure as this allows the effect of restoring the wetland tidal prism on Basin H water quality to be assessed. The larger the combined tidal prism, the greater the turnover of water in Basin H. The existing tidal prism of Basin H is about 12 acre-feet. A 38 acre wetland in Area A (Alt 2) increases the tidal prism by

about 25 ac-ft, a 73 acre wetland (Alt 3) adds about 46 ac-ft, and the large subtidal pond and wetland in Alternative 4 adds about 330 ac-ft. The same alternatives connected to Marina del Rey at Via Venetia do not have a significant effect on the overall tidal prism as the tidal prism of Marina del Rey is so large.

Alternative 5 has the largest tidal prism of all of the alternatives at 600 ac-ft. This is nearly three times the existing tidal prism and it is expected that tidal flow velocities through the mouth of Ballona Creek would increase.

In summary:

- in the southwest wetland of Area B, an open breach and full tide would have a tidal prism about 100 ac-ft greater than a muted tidal option;
- southeast wetland would have a tidal prism of about 30 ac-ft;
- a tidal connection from Area A at Dock 52 has a large impact on the circulation of Basin H, but no alternative has a tidal prism sufficiently large to impact the much larger Marina del Rey channel.
- Alternative 5 has the largest tidal prism at 600 ac-ft.

3.3.3 Connections

The nature of the connection between open water and the wetland would greatly influence tidal conditions within the wetland. Four types of connections are present in at least one of the five alternatives:

- open (non-gated) culverts,
- gated culverts (e.g. self-regulating tide gate (SRT) and flood gates)
- open breach, and
- complete levee removal

The large pipes which penetrate levees to convey water between Ballona Creek and the inundated areas are referred to as culverts. Conveyance through a culvert is limited by its dimensions, particularly its cross-sectional area. Flow through culverts can be controlled by different types of gates that prevent flow through the culvert. SRT include a mechanism to close itself when water levels reach a specified elevation. Manual flood gates can be closed manually as dictated by conditions. Gated culverts can be used to prevent contaminants entering the site from Ballona Creek or Marina del Rey or to reduce peak flood elevations. The SRT has an advantage of being adaptable so that the desired water surface elevation within the site may be controlled.

The second type of connection through a levee is a breach. Breaches would be sized to the same width and depth as the connecting marsh channel and would have no top boundary. Breaches would therefore convey water with negligible restriction during normal tides and much more effectively during flood conditions. Breaches may be combined with lowering of the levee to

about marsh plain elevation, thereby allowing higher tides to enter the site. This would mimic the flood routing of natural overmarsh tides and restore the hydraulic connection between the creek and the marsh plain. Controlling regular tidal flows or flood events is not possible with either a breach or levee removal.

The capacity of connections would vary. The SRT and culvert would have fixed capacity dependent upon their physical dimensions. A breach, depending on the nature of the material in which it is excavated, may be able to erode wider or deeper. Sizing levee breaches and connecting channels to the predicted tidal prism is generally necessary to limit how much the channel and breach erode. Tidal exchange and sediment supply to a wetland would be limited if the levee breaches or channels are undersized compared to the tidal prism. As the breaches or slough channels erode in response to the large tidal prism, tidal exchange and sediment supply would increase. Levee removal provides the most complete connection for water exchange and sediment supply between wetlands and the tidal source.

The location of the connections would have an impact on the evolution of the wetland, in particular the channel network. The alternatives have been developed to maximize opportunities for creating a single unified channel network within each marsh unit rather than multiple smaller networks, each with their own connection to open water. Using two connections for a hydrologic unit may increase the circulation in subtidal areas if there is sufficient head difference between the two entrances; this would be most effective in Alternative 4, which has a large open water area. For intertidal channels, flow may occur preferentially through only one of the entrances. Ideally, each marsh unit should be large enough to sustain its own network, containing a range of channel sizes and habitat. The southwest wetlands in Area B have the only remnant channel system that could be rejuvenated.

The use of structures as part of the connection, while increasing control, does have a number of issues:

- Gates and trash grilles, common on such structures, can impede the movement of sediment, seeds, fish and fish larvae. These restrictions would not be present with breaches.
- Culverts and gates generally have a smaller cross-section than natural channels and flow velocities within the structures would generally be higher. Scour would therefore be expected in the vicinity of the structure, especially in the channels leading into the wetlands.
- The potential for blockage is greater for gates and culverts, compared to an open breach, due to the smaller size of the opening and the presence of moving parts.
- Failure of a gate in the open position, due to trapping of debris or the failure of the control mechanism, may allow increase the potential for flooding. Failure of a gate in the closed position could delay drainage of tidal habitats.

3.3.4 Channel Network

Vegetated wetlands are typically drained by a complex network of dendritic and sinuous tidal channels. A dendritic sinuous tidal channel network is expected to provide better habitat and support a wider range of wetland functions than linear channels. For examples, channel bends provide sheltered foraging habitat for birds. Each tidal channel within the channel network drains and fills an area of marsh or "tidal watershed." Marsh drainage areas in natural marshes are distinguished by very subtle changes in marsh plain elevation and inundation patterns. The channel size adjusts to the flow to and from the marsh drainage area (i.e., the tidal prism of the marsh drainage area). Tidal channels may scour or fill in with sediment (shoal) in response to changes in the tidal prism and/or sediment dynamics.

In a natural system, as mudflats accrete to intertidal elevations, mudflat tidal channels form and become fixed as vegetation establishes and the marsh plain develops. Within this channel network, the tidal channel geometry at any given point is mainly dictated by the tidal prism of the watershed upstream. If the channel geometry is too small for the tidal prism, current speeds would increase and erode a larger channel. If the channel geometry is too large for the tidal prism, current speeds would decrease, allowing sedimentation to decrease the channel geometry.

Much of the natural channel system in Ballona Wetlands has been lost and a new channel networks would be constructed in tidal marsh restoration areas using the same tidal prism channel geometry relations found in natural channels. Larger tidal channels may be graded by excavating channels with dimensions that closely mimic channels in natural tidal marshes. The smallest channels may only be partially excavated, allowing these channels to develop over time through channel scour. Channel dimensions would be sized relative to the tidal prism of the marsh drainage area. Table 3-8 shows the channel network characteristics expected for each alternative, including tidal prism, channel length and order of channels. The method of calculation is described in Appendix C.

Channel networks constructed within the Ballona restoration are expected to be relatively stable, with limited potential for channel scour or shoaling. Tidal habitat would be restored by excavating fill and grading the site to elevations suitable for high, mid, and low marsh plain; mudflat; and subtidal habitat. The restored marsh plain would be graded with gentle slopes from the channel edge to upland areas to allow for the transgression of tidal habitats with sea level rise (see Section 3.5.1 below). Sedimentation rates within restored marsh areas are expected to be slow due to low sediment supply from the urbanized Ballona Creek watershed. The tidal prism of the restored marsh is therefore not expected to change rapidly after construction. The constructed tidal prism and channel dimensions are expected to maintain a relatively stable equilibrium condition. Also, as the restored marsh would be graded to higher marsh elevations, the tidal prism would be less than for lower elevation tidal areas. The potential for channels to form through channel scour is therefore expected to be low.

The presence of roads and levees within the site somewhat constrain the channel pattern as flow through this infrastructure must be routed through culverts. These culverts would set both the location and capacity of the channel at that place, reducing the ability of the channels to evolve over time. The culverts should be oversized in anticipation of larger tidal prisms in the future to increase the sustainability of the wetlands.

Permanent ponds in the marsh plain may be constructed to increase the amount of subtidal habitat. These would be connected to the channel network. These ponds would be shallow, well-defined, persistent depressions, 1 to 2 ft deep, that contain about 0.5 ft of standing water at all stages of the tide. They would receive tidal inflow on most tides.

3.3.5 Residence Time

Residence time is an estimate of how long water would remain in a flooded area before it is replaced by water from outside the wetland. A shorter residence time indicates a faster rate of turnover of the water. For this study, the residence time is estimated as the fraction of volume exchanged each tidal period, calculated by dividing the total volume in the flooded area by the tidal prism.

The residence time would depend on the proportion of tidal prism to total (subtidal plus intertidal) volume. Intertidal areas with an open connection to the ocean would have a residence time equal to the average tidal period because they dry out each tide. In areas with a large subtidal volume relative to intertidal volume (such as in Area A in Alternative 4), the residence time can be as long as several tidal periods. Short residence times indicate rapid and continuous exchange with the ocean water, with positive effects, for example, on exchange of gases, nutrients, fish larvae, sedimentation and water quality. Longer residence times indicate delayed exchange with the ocean.

The method for estimating residence time is an average for the entire flooded area and range of tides. Actual residence time would vary across the site. For example, residence times would be longer for regions of the flooded areas which are far from the exchange outlet or during periods of reduced tidal prism, such as neap tides. Similarly, actual residence times would be shorter for regions of the flooded areas which are close to the exchange outlet or during periods of increased tidal prism, such as spring tides.

3.3.6 Excursion Length

Excursion length is an estimate of the distance traveled by water during a tidal period. It is analogous to dropping a buoy in the water and measuring how far the buoy travels during a single tide. Excursion length provides an indication of the spatial extent of water movement within the tidal timeframe. As a first approximation, the water within an excursion length of a particular location is the source of inflowing water, the destination for departing water, and the volume of

water that would most rapidly mix with that location's water. Water within an excursion length can be categorized as hydraulically well-connected to that location.

A major influence on excursion length is the addition of intertidal area upstream of a location which increases the flow of water past that location. In accordance with increasing flow, current speeds and hence, excursion length, also increase. Alternatives with the largest intertidal area would yield the largest excursion lengths.

Water in Ballona Creek, at the western side of the project area, exchanges with Santa Monica Bay on each tide. In contrast, water at the eastern side of the project area remains in Ballona Creek for more than a single tide. The different outlets from Area B are just a bit further than an excursion length of each other, indicating that water that exits one flooded area would typically take at least two typical tidal cycles to enter into another flooded area. The outlets from Area A to Marina del Rey and the outlets from Area B to Ballona Creek are separated by approximately three times the excursion distance and pass through a portion of Santa Monica Bay. This indicates that Area A and Area B are not well connected by Alternatives 1-4. Only Alternative 5 would closely connect Area A and Area B.

3.3.7 Flooding

Increasing tidal inundation within the Ballona wetlands may also affect the potential for flooding. Potential changes to the flood hazard as a result of the alternatives were evaluated.

Flood hazard was considered to arise from two sources – stormwater discharge from the Ballona Creek watershed and elevated ocean water levels in Santa Monica Bay. The watershed of Marina del Rey is small and its stormwater contribution is not considered a significant flood hazard. Flood events are typically characterized by their likelihood of occurrence, where the likelihood is expressed as a return interval. For this study, the selected stormwater discharge event has a return interval of 50 years or a 2% chance of occurring in any one year. The hydrograph of this 50-year stormwater discharge, which relates the rate at which water enters Ballona Creek as a function of time, was developed by the U. S. Army Corps of Engineers (2008). This hydrograph was developed by combining: (1) modeling of the transformation of rainfall into runoff and (2) frequency analysis of past discharge events.

The second source of flood hazard, elevated ocean water levels, arises from meteorological events acting at the regional or global scale. Regional meteorological events which elevate water levels include low atmospheric pressure associated with storm systems and wind setup. El Niño is the global meteorological event which leads to elevated ocean water levels along the entire western coastline. Since a detailed frequency analysis of elevated ocean water levels has not yet been conducted, this study relied upon an event selection approach to identify typical increases in ocean water level. Water levels at the Port of Los Angeles during 12 large storm events increased an average of 1.1 ft above expected water levels (USACE Hydrology Report).

These sources of water, stormwater discharge and elevated ocean water levels, interact with the ground surface elevation to determine the depth and spatial extent of flooding. Because of the existing levees which bound Ballona Creek, flooding is also a function of hydraulic connection. By adding tidal connections, the restoration alternatives alter the potential for flooding while decreasing the peak water levels within Ballona Creek. Within the flooded areas, flood exposure increases because of additional conveyance through the new tidal connections. However, the exposure within these flooded areas can be managed to acceptable levels by configuring the tidal connections and/or the flood hazard to infrastructure can be mitigated by structural means. The input of flood waters into the flooded areas acts to reduce the flood hazard within Ballona Creek itself. Because the flooded areas provide additional storage for flood waters, flood peak water levels along Ballona Creek, downstream of the tidal connection, are reduced.

Infrastructure that is exposed to flood hazard as a result of its location within or adjacent to the project area can be protected in several ways. The infrastructure itself can be raised above peak flood levels. For instance, roadways which cross the project site could be raised on structures or earthwork to elevate them above anticipated flood levels. Flood risk for infrastructure adjacent to the project area can be mitigated by constructing new levees or improving existing levees to constrain the flooded area extent.

Alternatives 1 and 2, which have muted tidal systems, have flood peaks at or below the closure elevation. If the rate at which the water level rises is rapid then the gate may close when elevations within the site are lower. For those alternatives that allow a full tide, flood peaks in the wetland channels are generally about a foot lower than in Ballona Creek. For instance, with the 50-year storm, Ballona Creek has a flood elevation of about 8.9 ft NAVD; for the same storm conditions the southeast wetland in Area B records 7.1 ft NAVD, and the southwest marsh was 7.6 ft NAVD.

Flood peaks also lower along Ballona Creek. At the seaward end of the channel, the existing peak flood elevation is predicted to be 8.9 ft NAVD. Predictions under Alternatives 1 and 2 have similar elevations as existing conditions. Alternatives 3 and 4 exhibit a 0.5 ft reduction in peak levels because of storage in the restored wetlands. Alternative 5 has slightly less of a reduction of 0.3 ft, due in part to the channel configuration and roughness of the vegetated floodplain.

3.3.8 Tables

Table 3-3. Inundation Regime of the SRT Gates in Area B, Showing Percentage of Time Tidal Water at or Above a Given Elevation

Elevation	% of time tides at or above given elevation				
ft NAVD	Santa Monica Bay (open ocean)	SRT closes at 3.6 ft NAVD	SRT closes at 4.9 ft NAVD	SRT closes at 6.6 ft NAVD	
7.5	0%				Inundation muted
7.0	1%				
6.5	4%				
6.0	8%				
5.5	14%			0%	
5.0	19%			4%	
4.5	28%		0%	16%	
4.0	38%	0%	6%	29%	
3.5	51%	23%	42%	44%	
3.0	65%	56%	58%	57%	
2.5	74%	69%	72%	70%	
2.0	80%	76%	78%	77%	Inundation similar
1.5	85%	82%	83%	82%	
1.0	90%	87%	88%	87%	
0.5	95%	100%	91%	91%	
0.0	98%	100%	97%	97%	
-0.25	100%	100%	100%	100%	

Note: all these examples use the existing 39 ft^2 culvert; with the gate set to close at 6.6ft NAVD the tide range is damped due to the lack of capacity of the culvert.

Table 3-4. Habitat Zonation in Terms of Inundation Regime and Elevation for Full and Muted Tidal Regimes

Habitat type	**Inundation regime**	**Elevation range, ft NAVD**			
	%r	Santa Monica Bay (open ocean)	SRT closes at 3.6 ft NAVD	SRT closes at 4.9 ft NAVD	SRT closes at 6.6 ft NAVD
Salt pan	14-28%	4.5-5.5	3.5-3.6	3.8-3.9	4.0-4.6
Transition Zone	14-28%	4.5-5.5	3.5-3.6	3.8-3.9	4.0-4.6
High Marsh	28-50%	3.5-4.5	3.2-3.5	3.3-3.8	3.3-4.0
Mid Marsh	50-74%	2.5-3.5	2.2-3.2	2.4-3.3	2.2-3.3
Low Marsh	74-90%	1.0-2.5	0.7-2.2	0.7-2.4	0.7-2.2
Intertidal Channel /Mudflat	90-100%	-3.0-1.0	-0.1-0.7	-0.1-0.7	-0.1-0.7
Subtidal	100%	-5.0- -3.0			

Table 3-5. Variation of Tidal Prism for Area B Southwest Wetland

	Ballona Creek tidal prism,
	ac-ft
Ballona Creek only	235
Alt 1 and 2 Area B SRT	267
Alt 3 and 4 Area B breached	386

Table 3-6. Variation of Tidal Prism for Area B Southeast Wetland

	Ballona Creek tidal prism,
	ac-ft
Ballona Creek only	235
Alt 1 Area B add muted tidal HW and tp	250
Alt 2, 3, 4 Area B fully tidal	390

Table 3-7. Variation of Tidal Prism for Area A

	Basin H tidal prism,
	ac-ft
Existing	9
Alt 2 Area A	36
Alt 3 Area A	69
Alt 4 Area A subtidal	345

Table 3-8. Channel Network Characteristics

Alt	Area	Channel length, ft			Order, no. of channels				
		Subtidal	Intertidal	Total	1	2	3	4	5
2	Area B East	1,530	13,730	15,260	43	12	4	1	
	Area A and C	1,820	14,730	16,550	43	12	4	1	
	Total	**3,350**	**28,460**	**31,810**	**86**	**24**	**8**	**2**	**0**
3	Area B East	1,530	20,270	21,800	67	20	6	1	
	Area B West	8,010	42,070	50,080	150	43	12	4	1
	Area A and C	4,770	27,030	31,800	150	43	12	4	1
	Total	**14,310**	**89,370**	**103,680**	**367**	**106**	**30**	**9**	**2**
4	Area B East	1,530	20,270	21,800	67	20	6	1	
	Area B West	8,010	42,070	50,080	150	43	12	4	1
	Area A (5 sub watersheds)	0	10,850	10,850	60	20	5		
	Total	**9,540**	**73,190**	**82,730**	**277**	**83**	**23**	**5**	**1**
5	**Total**	**17,810**	**164,650**	**182,460**	**678**	**198**	**58**	**14**	**2**

3.4 SEDIMENT AND WATER QUALITY

Water and sediment quality are key to the proper functioning of wetland systems. Contaminants associated with poor sediment and water quality can have an effect on the health of wetland plant and animal communities and to the long-term sustainability of any restoration efforts. Accumulated contaminants may also pose a human health risk. A healthy wetland depends on the continuing flow of non-impacted tidal waters and sediment into and out of the restored areas.

Contaminants that have been detected in the water column in Ballona Creek above the water quality criteria include copper, lead, zinc, bacteria indicators, polyaromatic hydrocarbons (PAHs), and several pesticides. These contaminants are generally associated with urban runoff that may contain heavy metals, PAHs and pesticides. These constituents generally are adsorbed to, and carried by, fine-grained soils (clays) and organic materials. These materials then settle out when the water flow velocity decreases such as in a wetland. Continuous flushing through adequate circulation and channel flows would reduce the accumulation of impacted sediments; in a muted tidal system there may be periods of high water slack where increased sedimentation may occur.

Evaluation of sediments in both the Ballona tidal prism and in Marina del Rey has indicated benthic impacts and in some cases toxicity responses to aquatic organism. As indicated by the toxicity testing and benthic studies, these constituents may have negative impacts to the benthic and aquatic organisms within the wetland. Certain metals such as selenium and mercury can bio-accumulate in the wetland environment and are carried up the food-chain. Organic compounds such as PAHs and pesticides such as DDT can also bio-accumulate in organisms in the wetlands resulting in a long-term impact.

Through the Total Maximum Daily Load program, pollutant load reduction is required to reduce these impacts to the benthic and aquatic communities. TMDL implementation is, however, in its initial phases which include developing an implementation plan and identifying source of pollutants. Due to the challenges of reducing pollutant loads from highly urbanized watersheds, improvements in water quality and significant reduction in potential impacts may take twenty years or more. Therefore, alternative for the wetland restoration need to consider the potential impacts from storm flows within this projected timeframe.

Water quality in Ballona Creek may improve as a result of efforts to meet TMDL targets. The need for restricted wet weather flows would diminish compared to the importance of water quality within the wetlands achieved through adequate circulation and residence time that would require less restriction of flow in and out of the wetland

Alternatives are compared by evaluating the sediment and water quality issues associated with different sources of tidal and fresh water flows, which include Ballona Creek, tidal waters and urban storm water runoff. These issues form the criteria for which the alternatives can be assessed to assure a healthy and sustainable wetland.

3.4.1 Ballona Creek Flows

Historical and current water quality data indicate that dry weather flows from Ballona Creek exceed water quality objectives for bacteria indicators, metals, and other constituents. Dry weather flows may result in pollutant loading to the restored areas. Any alternative that increases the connection of the creek to the wetlands, through larger culverts and breaches, may increase this loading.

Storm water flows frequently exceed water quality objectives for bacteria, metals, PAHs, and pesticides in Ballona Creek. Alternatives that allow for the use of flood gates can prevent the inflow of contaminated storm water into the wetlands and reduce pollutant loading. Restricted connections, for example culverts, may reduce inflow from the Creek but would also restrict drainage leading to ponding of polluted waters on the wetlands. Unrestricted storm flows from Ballona Creek, through larger breaches and levee removal, would allow the greatest exchange of water between the Creek and wetlands. Compared to muted tidal systems this would maximize the area exposed to pollutants but this may be mitigated by the improved circulation and flushing of the system.

3.4.2 Tidal Water from Ballona Estuary and Marina del Rey

In general the oceanic water quality is better than in Ballona Creek or Marina Del Rey. In Ballona Creek the tidal influence extends up to Centinela Creek and water quality reduces further away from the ocean as a result of less mixing (a function of tide and fresh water flow). Water in Marina del Rey also exceeds the water quality objectives for bacteria indicators, metals and other constituents. However, the magnitude and frequency of these exceedances are lower in comparison to Ballona Creek. The main channel of Marina del Rey has better water quality than the back basins due to greater circulation, proximity to the ocean, and less direct input from urban runoff.

Accessing the cleaner oceanic water is dependent upon the location of the tidal connection and the excursion length of the waters in the wetlands. Alternatives that have inlets or breaches closer to the ocean would provide water of higher quality to the restored areas. Alternatives that have greater excursion lengths, through larger tidal prisms, would draw from more distant, higher quality waters. Water quality within the wetlands, compared with the muted tidal systems, would also be improved by adequate circulation and lower residence time.

3.4.3 Suspended Sediment Loading

Suspended sediment and organic matter in urban runoff attract and provide the mechanism to transport constituents such as heavy metals (copper, lead, zinc), bacteria, pesticides, PAHs and other organic compounds to receiving waters. These sediments then settle out as velocity decreases when storm flows meet tidal waters or enter into the wetlands.

Historical and current data indicate long term accumulation of these constituents in sediments in Ballona estuary and at the tide gates into Area B; sediment testing has indicated toxic effects on aquatic organisms. Suspended sediments from Ballona Creek and from local resuspension during storms, may continue to enter the wetlands and impact sediment quality.

Marina del Rey also has impacted sediments in the main channel and in several of the back basins. The sources of the impacted sediments may include the Ballona estuary, resuspension of coastal sediments during storms, storm water discharges directly into Marina del Rey and human activities within the Marina.

Alternatives that restrict flows into the wetlands during and, for a period, after storm events may reduce the supply of sediment to the wetlands but increase the potential for settling of finer material due to longer slack periods. In the long term, restricted flow and import of sediment would limit sediment cycling. This may further reduce the already limited sediment supply from the urbanized watershed.

Other storm water inflows are at the ends of Falmouth and Pershing Drives and along Lincoln Boulevard and Marina Freeway. Continued loading of these constituents into the existing wetland areas has resulted in localized impacts to sediment. All the alternatives include storm water treatment wetlands to reduce the pollutant loading. Treatment wetlands can be effective in removing heavy metals, sediment and organic compounds that adsorb to fine-grain soil particles and organic matter. The effectiveness of these systems depends on the retention time that flows entering the wetlands and the maintenance of the plants and sediments. These wetlands may only be able to reduce loads from a portion of storm water flows due to the constraints of size, through flow, and number of inflow locations.

3.4.4 Sediment Impacts

Within the project area there are contaminated soils in the creek and wetland channels. Grading of the site for an alternative may make these contaminants bioavailable. All the alternatives would alter the local flow patterns within the wetlands, either by altering the path or velocity of the flow. As a result there would be localized accretion and erosion of the existing sediment as the channels adapt to the new flow regime. This may result in the mobilization of contaminated soils which may be deposited within the site or transported out to the Creek or Marina del Rey.

Culverts and other constrictions should be sized to reduce the flow velocity below that for significant erosion. Alternatives may also include structures that reduce the velocity at locations of high flow.

3.5 SUSTAINABILITY AND MAINTENANCE

All natural systems have a certain amount of variation or trends that occur over different time scales. In a tidal wetland, these variations may include floods or droughts over the short term or

changes in climate over the long term. These variations can cause stress to the system, which may be anticipated and accommodated within the design of a restoration project. Climate change, for example, would affect not only sea level but also temperature and precipitation.

In addition to long term changes, there would also be individual events that would stress the system. Variations in timing and frequency of storms are difficult to predict, as is the accidental release of contaminants. The uncertainty in the timing and magnitude of these stressors makes the operation and maintenance (O&M) of the system to unexpected changes important.

3.5.1 Long-term Sustainability - Sensitivity to Climate Change

Long-term sustainability of the restored wetlands is evaluated as the sensitivity to climate change and other long-term trends, including sea level rise and also changing rainfall patterns and sediment supply within the watershed.

Tidal wetlands exist within a very narrow vertical range, set primarily by the tidal frame. A small change in the tidal frame due to sea level rise would result in movement of the vertical distribution of tidal habitats. The response of tidal wetland to sea level rise depends primarily on:

1. sediment supply to the wetland and the associated rate of wetland accretion, and
2. the availability of space for the transgression of wetland habitats to higher elevations.

If sediment is readily available, vertical accretion may keep pace with sea level rise and the spatial distribution of tidal habitats may not change significantly. If sediment supply is low, as in Ballona Creek, accretion rates may be slower than sea level rise and habitats would transgress landward. In Alternatives 2, 3, 4 and 5, tidal wetlands would be graded to elevations that support the desired vegetation, as it is assumed accretion rates would be slow.

As sea level rises, habitats that are higher in the tidal frame would be converted to habitats that are lower in the tidal frame (e.g., high marsh is converted to low marsh, low marsh is converted to mudflat, and mudflat is converted to open water). If the transitional zone has a shallow slope, higher tide levels due to sea level rise would inundate transitional and upland habitats and convert these areas to high marsh. The space provided by shallow upland slopes allows tidal habitat to transgress up the slope with sea level rise, thereby maintaining similar acreages of habitat. If the transitional slope is steep, higher elevation habitat acreages would decrease as open water and lower elevation habitats transgress landward.

The tidal wetland habitats in Alternatives 2, 3, 4 and 5 include broad transitional slopes (1:50 to 1:70) that allow habitat transgression and can accommodate 2 to 3 feet of sea level rise. These shallow slopes would also provide valuable interim transitional habitat and act as a buffer from the surrounding urban activity. Where space is constrained and shallow slopes are not feasible, particularly where wetlands are located close to levees or roads, the transgression process would still occur but the higher elevation marsh habitat would be compressed against the slope of the

levee into a narrow horizontal band. There may be loss of some wetland in the future due to the steep transitional slopes in these locations.

Alternatives 1 and 2, which include culverts or gates, allow some control of the water surface elevation. In these alternatives, a muted tidal regime would be implemented that limits the maximum water surface elevation. The result would likely be a vertical and horizontal compression of the higher elevation habitats (high marsh and transition zones). The culverts and gates would be designed to accommodate expected sea level rise.

Current assessments of climate change in California do not indicate a clear trend or significant change in precipitation patterns. Higher temperatures are expected to cause a significant shift from snow to rain in the mountains, but coastal California is relatively unaffected by snow. Significant changes in precipitation and streamflow in coastal watersheds are therefore not currently predicted. There is the potential for decreased precipitation and more severe droughts. Small changes in water balance for sensitive habitats, such as seasonal wetlands and brackish marsh, may result in temporary or permanent changes in the salinity regime of these areas. Those areas that are already fully tidal wetlands may not be directly affected but they may still be influenced by changes in occasional freshwater inputs. In this respect, wetland areas connected to Ballona Creek and its watershed would be more sensitive than those connected to Marina del Rey.

3.5.2 Operations and Maintenance (O&M)

The alternatives require varying levels of ongoing operations and maintenance (O&M). Fully tidal wetlands in Alternatives 3, 4, and 5 would be designed to be self-maintaining and are expected to require little O&M. Muted tidal wetlands in Alternatives 2 and 3 would require regular and ongoing O&M of tide gates.

In addition to routine O&M for typical conditions, there would always be unforeseen or difficult to predict events – a large flood, the accidental release of a pollutant, the failure of a mechanical structure. Ideally the alternatives should be flexible enough to accommodate such unknowns and allow the opportunity for intervention. The muted tidal wetlands in Alternatives 1 and 2 provide the ability to occasionally close off the wetlands from its main tidal source, which could prevent high flows or contaminants from entering the site. A flood or tide gate may be added to a culvert with relative ease; however, it is much more difficult to close off the breaches and lowered levees in Alternatives 3, 4, and 5 from Ballona Creek. On the landward side, preventing flows from entering the site is more difficult due to the number of potential inflows and the difficulty of rerouting the flows to the ocean. For fully tidal wetlands in Alternatives 3, 4, and 5, the breaches may allow better flushing of contaminants entering from either the creek or adjacent land.

If controls are used as part of the management of the alternative, planning should include system response if the control fails. For instance, if a tide gate fails to operate then the impact it would have on the wetlands would differ depending on whether it failed open or shut, at high or low

water. Ideally the tide gate should not be the only protection against excessive water levels, there should be redundant measures such as additional ebb culvert barrels and landward levees.

Another consideration is the reversibility of an alternative. All alternatives would have an adaptive management plan in which it may be desirable to manipulate conditions. Changing the operation of an existing gate has less risk than changing the tidal inundation by removing a section of the levee. If conditions change and the system does not respond as required then the ability to revert to the former state may be desirable. Another example may be the enhancement of existing uplands, where changes envisioned in Alternative 1 and 2 are mainly related to management rather than structural changes and could more easily be reversed.

3.5.3 Vectors

Mosquitoes occur in wetland ecosystems where certain species can be vectors for viral diseases such as forms of encephalitis and more recently West Nile Virus. Understanding the life cycles and habitat requirements of the species that can be disease vectors is important in their control. Mosquitoes breed in standing water. Mosquitoes rarely occur in significant numbers in areas of tidal wetlands that are regularly inundated and drained over the tide cycle. Problems can occur in areas of tidal wetlands that are not well drained, such as ponds and pans that are infrequently or seasonally inundated, densely vegetated areas that pond water between tides, or locations where tidal drainage has been interrupted. Maintenance (e.g., spraying) may be required to address vector issues for poorly drained areas of tidal marsh.

For muted tidal wetlands, the designs should provide the ability to drain areas of standing water when required. This could be accomplished by operating gated culverts to drain the wetland on an occasional basis. Open areas of standing water should be large enough to allow wind waves to disturb the surface and dense vegetation around the edges should be avoided.

Additionally, wide buffers between wetlands and residential areas can reduce the likelihood of vector issues. The design of the alternatives should provide access points for mosquito surveillance and control.

3.5.4 Invasives

Biological invasions by exotics represent one of the most serious threats to ecosystem integrity and functioning. Invaders can detrimentally alter habitats, eat native species, and act as disease agents. Millions of dollars are spent annually in combating exotic plant pests just within southern California. Managing exotic species is complicated, as invaders are living organisms that can adapt to their new environments and have diverse, cascading effects. Invasive species may become established in restored upland and wetland habitats, requiring costly removal and maintenance efforts.

Salt marshes in southern California have been relatively free from invasions of wetland plants. Some localized exceptions include a mangrove (*Avicennia marina*) intentionally introduced into Mission Bay, San Diego, a sea lavender (*Limonium ramosissimum provinciale*) in Carpinteria salt marsh in Santa Barbara and *Tamarix* which has invaded the high marsh at Tijuana Estuary in San Diego County.

Upland area in southern California have some particularly troublesome plant invaders including giant reed (*Arundo donax*), which forms dense stands in riparian, brackish and fresh water wetlands, and salt cedar (*Tamarix* spp.), which have invaded riparian habitats, uplands, transition zones and high salt marsh. The major invaders at Ballona include , wattle (*Acacia* spp.), myoporum (*Myoporum laetum*), Russian thistle (*Salsola tragus*) mustard (*Brassica* spp.), garland daisy (*Chrysanthemum coronarium*), wild radish (*Raphanus sativus*), castor bean (*Ricinis communis*), pampas grass (*Cortaderia jubata*), fennel (Foeniculum *vulgare*), brazillian pepper tree (*Schinus terebinthifolia*), slender fan pam (*Washingtonia robusta*), non-native spurge (*Euphorbia* spp.), multiple varieties of ice plant (*Aizoaceae*) and non-native grasses have invaded disturbed upland areas and continues to spread.

Important vertebrate invaders that may affect restoration efforts include cowbirds, which are nest parasites that affect the endangered Least Bell's Vireo, and predatory red fox and house cats. These primarily upland invaders can also enter the wetland areas, impacting the native species. Estuarine and marine invaders include the clam-smothering mussel (*Muscalista senhousia*) and the carnivorous yellowfin goby (*Acanthogobius flavimanus*), the "killer" alga *Caulerpa taxifolia*, the salt-marsh destroying crustacean *Sphaeroma quoyanum*, and the mud-flat invading cordgrass *Spartina alterniflora*.

Alternatives with greater area of upland habitats would have greater impacts from invasive species and provide more opportunities for them to impact the adjacent wetland habitats. Alternatives 3, 4 and 5 provide the greatest area of contiguous wetland habitat (see Table 3-3), while Alternative 5 provides a significantly smaller edge to area ratio (Table 3-4).

3.6 PUBLIC ACCESS, RECREATION AND SAFETY

The goal of the public access plan is to provide "enhanced access to and within the Ballona Ecosystem consistent with ecosystem preservation and restoration values in a safe, consistent, coherent and functional manner," as per project objectives in the Ballona Wetland Restoration Plan Goals and Objectives (Appendix A). Public access features would be developed in concert with habitat restoration efforts to ensure maximum resource protection while providing a valuable recreational experience for the community. Providing public access and interpretive features about habitat restoration in turn provides increased public education, awareness, and support of local biological and physical resources present within the Ballona Wetlands. Providing strategically-placed public access features and limiting the intensity and duration of recreational use at the Ballona Wetlands would reduce impacts to the wetlands and enhance opportunities to involve the public in restoration and monitoring efforts.

The proposed public access and recreation features include a system of trails and overlooks, gateway entrances, interpretive stations, pedestrian bridges, bicycle parking, parking areas, boardwalks, vehicular pullouts, and visitor center. These would provide a diversity of public access and recreation opportunities for a wide range of users. The goal for the future design of these features would be to integrate all aspects of the project into a coherent system of restoration and public access that provides a clear sense of place within the context of the Ballona Wetlands and surrounding landscape.

The California Fish and Game Commission has designated the majority of the project area as a State Ecological Reserve. The purpose of the designation is to provide protection for rare, threatened or endangered native species. Public entry and recreational use of ecological reserves is subject to general rules and regulations to ensure that recreation is compatible with the primary purpose of resource protection.

In order to protect natural resources on the site and limit impact to wetland areas, a controlled and appropriate level of access to the Ecological Reserve would be provided as part of restoration. The public access strategy would focus on managing and concentrating recreation use within the site. The restoration and public access design would accommodate an appropriate level of fishing, boating, walking, and other activities consistent with the Ecological Reserve designation and ecosystem restoration values:

- **Walking**. Currently, access to the Ecological Reserve for walking or hiking is authorized on a case-by-case basis, and the site is not yet open to the general public. However, there is a public trail and self-guided interpretive tour located along the perimeter of the Freshwater Marsh. Walking or hiking would likely be the predominant recreational use of the site.

- **Biking**. Several local and regional bicycle routes are located near the Ballona Wetlands. No formal off-road or trail bicycle paths exist within the wetlands. The Ecological Reserve designation permits biking only on the designated bicycle path located on the north bank of Ballona Creek. Bicycle use is not permitted within the Ecological Reserve or Freshwater Marsh area.

- **Fishing**. Fishing currently occurs on both sides of Ballona Creek and from the downstream pedestrian bridge. The Ecological Reserve designation permits fishing with barbless hooks from the shoreline of Ballona Creek or from boats within the Ballona Creek channel. Fishing within the wetland area is restricted and by permit only.

- **Boating**. The Ballona Creek channel is currently used for both motorized and non-motorized boating. The University of California Los Angeles and Loyola Marymount University rowing teams use the Ballona Creek channel for crew practice. The Ecological Reserve designation permits boating within the Ballona Creek channel. Boating within the wetland area, however, is restricted and by permit only.

- **Other Recreational Uses**. Playa Vista Little League currently plays baseball on three fields located within the Ecological Reserve (Area C).

Public access and recreation features would provide a variety of settings, including access to the estuarine environment and retreat from urbanized areas, and would provide recreation opportunities for a variety of visitors. Access would be designed to be as barrier-free as possible to provide access for visitors of varying abilities and to comply with the Americans with Disabilities Act. In some locations, trails may be designed to accommodate vehicular use in order to provide access for security or maintenance. Raised boardwalks would be strategically located to maximize interpretive and educational opportunities related to the site and ongoing restoration activities. Exact trail locations and characteristics would be further developed when the preferred alternative is identified.

Table 3-9 details the number, length and location of public access features.

The Ballona Wetlands are also an important crossroad within the regional trail network. Both the coastal South Bay Bicycle Trail and the Ballona Creek Bicycle Trail run along the boundary of the site. Running north/south, the South Bay Bicycle Trail is a 22-mile paved trail that runs from Will Rogers State Beach in the north to Torrance County Beach in the south. Running east/west, the Ballona Creek Bicycle Trail runs along the south boundary of Area A and concludes in Culver City. The project is an opportunity to increase regional connectivity by developing an integrated trail network within the project site that connects to the surrounding regional trail network. The Alternatives would both preserve and enhance regional connectivity through connections of loop trails within the project area to the regional network. These connections would provide regional and local trail users with a range of opportunities and destinations.

Providing public access and interpretive features regarding habitat restoration in turn provide increased public education, awareness, and support of local biological and physical resources present within the Ballona Wetlands. Interpretive stations would be developed at strategic locations such as at gateway entrances, overlooks, or along the trail network within the project area. Educational signage and interpretive panels would facilitate a greater understanding and appreciation of the landscape. A potential visitor center and other opportunities for outdoor education and interpretation would provide a rich diversity of public access and recreation opportunities for a wide range of users. The goal for the future design of these features would be to integrate all aspects of the project into a coherent system of restoration and public access that provides a clear sense of place within the context of the Ballona Wetlands and surrounding landscape.

The prehistoric resources within and near the Ballona project area, including LAN-54, contain human remains and other materials that are of extremely high heritage value and sensitivity to the contemporary Gabrielino/Tongva Native American groups. Efforts to enhance cultural awareness of these resources and Native American lifeways in general should therefore be closely

coordinated with the California Native American Heritage Commission and those groups identified as having specific concerns for the Ballona area.

As outlined in the Ballona Wetland Early Action Plan, interpretive panels would highlight habitat characteristics and diversity, watershed history, and Native American site usage through clear, consistent and attractive displays (Conservancy 2007). Overlooks or viewing platforms would be located at vista points where important features of the landscape can be viewed and/or opportunities for wildlife viewing and birding exist. Associated interpretive information would be provided at these facilities based on the opportunities provided at the facility sites.

Public access within Ballona Wetland would be developed in a manner that is "safe, consistent, coherent and functional" for the safety of the public, long-term management, and maintenance of the site. The separation of incompatible uses, such as bikers and walkers or bikers and cars is important for public safety and security in the area. The Ballona Wetlands are located in a densely population area surrounded by busy roads and popular regional bike paths. The Ecological Reserve designation provides clear guidance on allowable recreational uses within the site.

The most common unauthorized uses within the project area are BMX biking, dog walking, homeless encampments, dumping, and off-trail walking. Unauthorized use of the site can have an adverse impact on the landscape. Therefore, controlling these uses is critical to successful habitat restoration. Wetland restoration would inherently preclude access to portions of the site by creating deepwater and wetland habitat.

Lincoln Boulevard, Jefferson Boulevard, and Culver Boulevard, as well as street ends to the west and north, provide site access for automobiles. Current on-site parking includes an unimproved lot behind Gordon's Market in Area B, paved on-street parking along Jefferson Boulevard at the Freshwater Marsh, and a paved parking lot at the Little League baseball fields in Area C. Safe traffic access would be provided by designating parking areas, creating roadside pullouts to provide formalized automobile access and viewing locations, and discouraging unauthorized roadside parking.

3.6.1 Tables

Table 3-9. Public Access Features Comparison

Public Access & Recreational Features	Alternative 1 (length/ number)	Alternative 2 (length/ number)	Alternative 3 (length/ number)	Alternative 4 (length/ number)	Alternative 5 (length/ number)
Trails					
Area A: Trails	8,800 feet	8,000 feet	9,450 feet	3,550 feet	4,450 feet
Area B: Trails	29,600 feet	29,600 feet	27,000 feet	27,000 feet	16,200 feet
Area C: Trails	7,200 feet	6,700 feet	7,150 feet	6,550 feet	2,250 feet
Boardwalks	1,900 feet	1,450 feet	1,350 feet	3,650 feet	3,850 feet
Access Points & Overlooks					
Gateway Entrances	11	11	11	10	7
Overlooks	4	6	9	9	10
Parking and Pullouts					
Formal Parking Areas	4	4	4	4	4
Vehicular Pullouts	0	0	2	2	2
Pedestrian Crossings					
Pedestrian Creek Bridge Crossing	1	1	1	1	1
Pedestrian Road Crossing	2	2	1	1	5

3.7 PHASING AND COSTS

This section describes the probable construction costs for the five selected alternatives as described in Chapter 2. In determining an opinion of probable construction costs appropriate to conceptual level design, several assumptions were required. These assumptions included:

- construction methods
- unit costs
- project sequencing and phasing
- permitting
- property acquisition

Table 3-10 is included to illustrate the level of accuracy and amount of contingency which is typically included in cost estimation for construction projects at various levels of design. This table is from the Cost Estimate Classification System, developed by the Association for the Advancement of Cost Estimating (AACE, 1997). As shown in the table, a particularly wide range in accuracy is assumed inherent for project design at the conceptual level. In addition, contingency is a large percentage of the estimated project costs, decreasing as the level of design is increased.

The "estimates of probable costs" are summarized in Table 3-11. Appendix D contains detailed cost estimates for each alternative by area and supporting information. It is important to note that these are large scale construction projects and that the alternatives involve significant intervention, and hence would require further detailed analysis and engineering design that would likely lead to additional refinements. Consequently, at this conceptual design phase, a cost contingency of 35% is included. We anticipate that actual construction costs could be reduced significantly through more detailed engineering. This is particularly true of the unit costs identified for fill placement; if a major fill element is included in the project, there is an opportunity to develop a construction methodology with a lower cost. Also, land costs are not included. At this stage, it is anticipated that all construction can be accomplished on publicly-owned land, and land and easement purchase costs are therefore not included. Also, costs associated with environmental restrictions of construction including timing and phasing are not explicitly treated.

These estimates are subject to refinement and revisions as the design is developed in future stages of the project. The cost tables summarize the cost of construction, and do not include estimated project costs for additional studies, permitting, detailed design, construction observation, monitoring and ongoing maintenance. Estimated costs are presented in 2008 dollars, and would need to be adjusted to account for price escalation for implementation in future years. This opinion of probable construction costs is based on: PWA's prior experience, prices from similar projects, and consultation with contractors and others involved in comparable projects.

Note these estimates of probable construction costs and the actual costs at the time of construction may vary. The cost of construction would be impacted by the availability of construction equipment and crews and fluctuation of supply prices at the time the work is bid. PWA makes no warranty, expressed or implied, as to the accuracy of such opinions as compared to bids or actual costs.

3.7.1 Notes on Cost Estimate Assumptions

Quantities were estimated conservatively (high). For the grading of the subtidal, mudflats and marsh plain, it is assumed the grading was to the desired elevation and volumes were calculated using the "average end area method." For channels, it is assumed that only the largest channels (order 3, 4 and 5) would be excavated, and that these channels would be excavated to their modeled, equilibrium dimensions. Quantities of material used in levees were increased to account for settlement.

Appendix D (Table D-2) includes the unit costs and assumptions used in the cost estimate. The cost of excavation is the most expensive item in Alternatives 2 to 5. The cost used for excavation is $15/CY, which may be high. The use of scrapers or other efficient construction methods may have a lower unit cost. However, in this case, over-excavation and/or ripping of the soil may be required to give a suitable substrate for wetland restoration. This additional work would increase costs. Therefore, lower unit costs are not recommended for use in the cost estimate without further analysis of engineering and constructability considerations.

Onsite trucking and placement of excavated material is included as a separate item in the cost estimate. The cost estimate assumes that as much material as possible is reused within the same area to construct levees. Even so, each alternative generates more material than can be reused on site. There is no requirement to move material from one area to another, with the exception of Alternative 1. In Alternative 1, material excavated in Area A would be trucked to Area B and used as fill for levy construction along the daylighted culvert. It is assumed that the excess quantity from each area will be placed on site in stockpiles, at least until the material is disposed of off site. Table 3-12 lists the volume of excess material to be stockpiled (Appendix D, Table D-4 includes a rough calculation of possible stockpile areas).

Options for disposal may include:

Option 1 / 2. Remove sediment, barge sediment to the Port of Los Angeles (POLA), and unload dredged material at POLA (Option 1) or dispose material at a confined disposal facility (CDF) at POLA (Option 2).

Option 3. Remove sediment, barge sediment to POLA, and truck to landfill for beneficial use as landfill cover.

Option 4. Remove sediment, barge sediment to POLA, and dispose contaminated material at a hazardous waste landfill. The level and extent of on-site contamination is presently unknown.

Option 5. Remove sediment, barge sediment offshore, and dispose sediment offshore (Offshore Disposal).

Option 6. Remove sediment and dispose sediment on a nearby beach (Beach Disposal).

POLA identified and evaluated disposal Options 1 to 4. A preliminary draft cost estimate table prepared for POLA by Weston (Weston, undated) for these options was provided. There are uncertainties associated with the preliminary draft table and conceptual-level cost estimates. Disposal costs were not estimated for this report. The POLA/Weston cost estimate information was used to estimate the costs for Options 1 to 3. Mobilization (8%) and a 35% contingency were added to the disposal cost estimates for consistency with the estimates in this report and to account for uncertainties. Cost estimates for Option 4 are not included because information on contamination is not currently available.

For offshore disposal (Option 5) and beach disposal (Option 6), a range of costs is included in the estimate. On the lower end of the range, the costs for offshore disposal (Option 5) and beach disposal (Option 6) may be as low as the costs for disposal at POLA (Option 1 / 2). The upper end of the range for offshore disposal (Option 5) may be as high as the unit cost for dredging and offshore disposal at Upper Newport Bay provided by the SCC (G. Gauthier, SCC, pers. comm.) This unit cost is $28 per cubic meter for dredging and disposal about three to five miles offshore (S. Brodeur, County of Orange, pers. comm.). For beach disposal (Option 6), the upper end of the unit cost may be about $10/CY higher than the costs for Option 1 / 2. The cost estimates for disposal options should be updated at the next opportunity. Table 3-13 summarizes the disposal option cost estimates for each alternative.

3.7.2 Phasing

Areas A and C and Area B are not hydraulically connected in Alternatives 1 to 4 and so their construction may be phased in either order. In addition, it would be possible to construct Area A prior to Area C in each of these alternatives. Since each area generates more than enough material to construct levees, there is no need to stockpile material for use in later phases.

Alternative 5 is shown as being constructed in three phases (see Figure 2-9). A breakdown of the cost estimate between phases is included in Table 3-11. Excavation of Area A and removal of the Ballona Creek levees downstream of Lincoln Boulevard would occur first. This would require the construction of a temporary levee across the northern part of Area B and adjacent to Culver Drive. This temporary levee would increase the costs of phasing Alternative 5 compared to the cost estimated for Alternative 5 without phasing. The second phase would consist of restoring the remaining portion of Area B once the first phase habitat had been successfully established. Finally, Area C would be restored in the third phase. The advantage of phasing would be to

spread costs over a longer period of time and take advantage of the timing of other projects, such as the widening of Lincoln Boulevard. The project could be stopped at the end of any of the phases and still leave a functioning system.

3.7.3 Tables

Table 3-10. Levels of Cost Estimate Accuracy and Contingency for Different Levels of Design

Design Completion Level	Cost Estimate Accuracy	Contingency
Conceptual (order of magnitude costs)	-30% to +50%	35–50%
Preliminary (30%)	-15% to +30%	20-25%
40 to 70% complete	-15% to +30%	15-20%
70 to 100% complete	-5% to +15%	10-15%

Table 3-11. Summary of Engineer's Estimates[1] for Alternatives 1 to 5 (cost in Millions of Dollars)

Alternative	Area A	Area B	Area C	Total
1	$4.0	$2.6	--	**$6.6**
2	$42.6	$16.0	$3.3	**$61.8**
3	$69.3	$55.5	$5.2	**$130.0**
4	$108.4	$55.5	$5.2	**$169.0**
5	$99.8	$59.0	$50.4	**$209.3**
	Phase 1	**Phase 2**	**Phase 3**	
5 [2]	$110.4	$48.8	$50.5	$209.7

Notes:

1 - Estimated construction costs include a 35% contingency

2 - The cost estimate for phasing Alternative 5 is higher due to the construction of a temporary levee

Table 3-12. Estimated Volumes of Excess Material to Be Stockpiled.

	Stockpile Volume (ac-ft)			
	Area A	**Area B**	**Area C**	**Total**
Alternative 1	50	-	-	**50**
Alternative 2	590	120	60	**770**
Alternative 3	1,040	600	90	**1,730**
Alternative 4	1,700	600	90	**2,390**
Alternative 5	1,650	760	840	**3,250**
	Phase 1	**Phase 2**	**Phase 3**	
Alternative 5	1,790	570	830	**3,190**

Table 3-13. Summary of Estimated Costs[1] for Disposal Options. Costs in Millions of Dollars

							Alt 5 with Phasing [2]			
		Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Phase 1	Phase 2	Phase 3	Total [2]
On-Site Work		**$6.6**	**$61.8**	**$130.0**	**$169.0**	**$209.3**	$110.4	$48.8	$50.5	**$209.7**
Disposal Volume (CY)		**86,400**	**1,241,440**	**2,789,580**	**3,853,140**	**5,231,600**	2,889,960	923,500	1,344,600	**5,158,060**
Off-Site Disposal Options										
Option 1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**	**$1.3**	**$19.1**	**$43.0**	**$59.4**	**$81.0**	$44.5	$14.2	$20.7	**$81.0**
Option 3	**Beneficial Use - Landfill Cover**	**$4.2**	**$59.7**	**$134.1**	**$185.2**	**$252.6**	$138.9	$44.4	$64.6	**$252.6**
Option 4	**Disposal at Hazardous Waste Landfill [3]**									
Option 5	**Offshore Disposal (low end of range)**	**$1.3**	**$19.1**	**$43.0**	**$59.4**	**$81.0**	$44.5	$14.2	$20.7	**$81.0**
	Offshore Disposal (high end of range)	**$3.6**	**$51.0**	**$114.6**	**$158.3**	**$216.**	$118.7	$37.9	$55.2	**$216.0**
Option 6	**Beach Disposal (low end of range)**	**$1.3**	**$19.1**	**$43.0**	**$59.4**	**$81.0**	$44.5	$14.2	$20.7	**$81.0**
	Beach Disposal (high end of range)	**$2.7**	**$38.3**	**$86.0**	**$118.7**	**$162.**	$89.1	$28.5	$41.4	**$162.0**

Notes

1 - Estimated construction costs include a 35% contingency

2 - The cost estimate for phasing Alternative 5 is higher due to the construction of a temporary levee

3 - Estimate not included for Beneficial Use - Landfill Cover, contamintant report pending

4. SUMMARY

1. The project goal is to create functional estuarine habitat, including shallow subtidal, mudflats, fully tidal wetlands, salt pan and transitional habitats. Extensive enhancement of muted tidal wetlands or upland habitat, such as coastal sage scrub, grassland and saline seasonal marsh, does not achieve the project goal. However, upland habitat may provide some support for functioning estuarine habitat. Alternatives 3, 4 and 5 create the largest areas of fully tidal estuarine habitat while Alternatives 1 and 2 have larger areas of upland and muted tidal habitat. As discussed in Section 3.1, tidal estuarine habitats would benefit vascular and non-vascular plants, small mammals, a diverse community of aquatic invertebrates and many bird species known to utilize other southern California wetlands. Alternatives 4 and 5 create large areas of shallow subtidal habitat adjacent to mudflat. This would provide spawning and nursery habitat for pelagic and demersal fish species; these may disperse to the adjacent nearshore habitat and to other regional wetlands.

2. Transitional habitats, between tidal wetlands and upland, support a unique assemblage of vascular plant species and provide additional support for terrestrial species such as snakes, lizards, small mammals and birds. Transitional habitats also provide refuge for wildlife during periods of high water, serve as buffers against human activity, and allow for transgression of wetland habitats with rising sea levels. Alternatives 3, 4 and 5 provide the widest and largest area of transitional habitat. Muted tidal systems, as in Alternatives 1 and 2, have a reduced tidal range and therefore a compressed vertical range of habitats, limiting the area of transitional habitat that can be created.

3. Upland areas would support populations of vascular plants and provide foraging and nesting habitat for a number of bird species. Upland areas would also provide breeding and foraging habitat for insect pollinators, butterflies and moths, birds, herpetofauna and some mammals. All alternatives provide some upland habitat; however, there is a trade-off between the acreage of estuarine habitat and upland habitat. Alternatives 1 and 2 have the most upland habitat and the least change to the existing habitat mix. Freshwater seasonal wetlands, including vernal pool habitat, would benefit specific vascular and non-vascular plants, aquatic invertebrates and herpetofauna uniquely adapted to this environment, Alternatives 2, 3 and 4 create vernal pools.

4. Alternatives with larger, contiguous, areas of wetland habitat are more likely to sustain populations of associated species. Alternatives 3, 4 and 5 have larger areas of contiguous wetlands with fewer roads, wider transitions and more channels. These alternatives would have a higher quality of wetland habitat because they would be more remote from noise, lights, cars, and other human impacts. Alternatives with larger areas of contiguous wetland would also have fewer impacts from, and require less active management for, invasive plant and animal species.

5. Fully tidal systems allow for greater tidal circulation and reduced residence time. This would lead to a more rapid exchange of water with the ocean, and positive effects on exchange of gases, nutrients, fish larvae, sedimentation and improved water quality. Alternatives 1 and 2 have large areas of muted tidal wetland; Alternatives 3, 4 and 5 create fully tidal wetlands. The large intertidal areas of Alternative 2, 3 and 5 would have the shortest residence times, completely draining on most tidal cycles. Alternative 4 has a substantial subtidal volume, which would flush over several tidal cycles.

6. A complex tidal channel system allows water, sediment and nutrients to reach all parts of the wetland and provides diverse habitats. The complexity of the channel network depends on the area of the wetland and its tidal prism. Alternatives 3, 4 and 5 have large tidal prisms and would support an extensive and complex channel network with a large range of channels sizes.

7. The higher quality sources of tidal water are the ocean and Marina del Rey. The ability to bring this water into the wetlands would depend on the location of the tidal connection and the tidal excursion length. Alternatives 2, 3 and 4 improve tidal connections between Area A and higher quality water in Marina del Rey; this would also benefit habitat connectivity for fish species. All alternatives have some connection to Ballona Creek, which has poorer water quality. Longer excursion lengths increase the mixing of water on each tidal cycle, improving water quality. Alternatives 3, 4 and 5, with the largest tidal prism, have excursion lengths extending to the ocean.

8. The form of the tidal connection would affect the connectivity and function of habitat by influencing the movement of sediment, seeds, gases, nutrients, fish and fish larvae. Tide gates in Alternatives 1 and 2 would control water surface elevations within the wetlands but would limit connectivity with Ballona Creek and Marina del Rey, reducing diversity, and limiting primary productivity. Gates can also control pollutant loading, especially during storm events, although muted tidal systems would have a longer residence time allowing greater settling of pollutants. Gates would require regular maintenance and management as failure could impact habitat and cause flooding. Fixed structures, such as gates and culverts, need to accommodate both scour and sea level rise in their design.

Breaches in Alternatives 3 and 4 allow for full tidal range, movement of larger fish and greater seed dispersal. Open breaches would allow greater tidal circulation, reduced residence times and would be able to adapt to rising sea levels. Levee removal in Alternative 5 has the advantages of breaches and increases the interaction between the wetlands and the Creek - creating gradients of inundation and salinity across the site, letting the morphology evolve and allowing for periodic disturbance by flooding and scouring.

9. All of the alternatives would maintain the existing level of flood protection. Alternatives 1 and 2 have muted tidal systems, which would maintain the existing flood levels. These

alternatives rely on tide gates. Alternatives 3, 4 and 5 can accommodate higher flood levels by the construction of new levees and provide additional flood storage, reducing peak flood elevations.

10. All the alternatives would include principles of adaptive management in their Operation & Maintenance strategy. Alternative 1 has little change from the present situation and the risk associated with implementation is low. The restoration of wetlands in Alternative 2, 3 and 4 could be undertaken in distinct hydrologic areas which would allow for adaptive management and experimentation. Alternative 5 restores a large, contiguous area of habitat connecting a number of existing hydrologic units with Ballona Creek. This alternative makes the greatest change to the site, would be the hardest to reverse and consequently has the most risk. This risk may be mitigated to an extent by phasing the implementation.

The following tables have been developed from the above summary. They indicate favorable characteristics in terms of habitat, hydrology and public access. Check marks indicate which alternatives have these characteristics and the number of check marks indicates the relative degree. The number in brackets refers to the relevant summary paragraph above.

4.1 TABLES

Table 4-1. Summary of Habitat Characteristics

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Large areas of fully tidal estuarine habitat (1)		√	√√	√√√	√√√
Large areas of mudflat (1)			√	√√	√√
Large areas of shallow subtidal habitat, adjacent to mudflats (1)				√√	√√
Extensive channel network (6)	√	√	√√	√√	√√√
Wide transitional habitat (2)		√	√√	√√	√√
Large areas of enhanced upland habitats (3)	√√	√√	√	√	
Allows for dynamic interaction between Ballona Creek and the Wetlands					√
Larger and more hydraulic connections between wetland habitats, Ballona Creek and the ocean (5, 7, 8)		√	√√	√√	√√√
Hydraulic connection to Marina del Rey (7)		√	√	√√	
Fewer culverts and tide gates; more breaches and levee removal (7, 8)			√	√	√√
Larger contiguous areas of estuarine habitat with fewer roads and more channels (4)			√	√	√√

Table 4-2. Summary of Hydrology, Sediment and Water Quality Characteristics

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Full tidal range (1)		√	√√	√√√	√√√
Large channel network (6)		√	√√	√√	√√√
Daylights culverts, creates breaches (8)	√	√	√√	√√	√√
Large tidal prism (5, 7)		√	√√	√√√	√√√√
Short residence time (5)		√√	√√	√	√√√
Long excursion length (7)		√	√√	√√√	√√√
Control of flows by gates (8)	√	√			
Maintains existing flood levels (9)	√	√			
Increase in flood storage (9)			√√	√√√	√√√
Stormwater wetlands	√	√	√	√	√
Hydraulic connection to Marina del Rey (7)		√	√	√√	

4.2 RANKING OF ALTERNATIVES

Ranking is based upon the ability of each alternative to meet the project goals: the creation of functioning estuarine habitats, tidal circulation, connectivity of habitat areas, ability to address sediment and water quality, sustainability and maintenance. The alternatives are ranked from 1 to 5, with 1 being the highest rank.

In order to protect natural resources on the site and limit impact to wetland areas, a controlled and appropriate level of access to the Ecological Reserve would be provided as part of restoration. The alternatives are not ranked according to public access; each alternative can be modified to accommodate varying degrees of access as described in the feasibility analysis.

Alternative 1 – Rank 5

Alternative 1 is ranked the lowest because this alternative:

- does not achieve the project goals of creating a functional estuarine habitat;
- maintains existing upland habitat and does not provide fully tidal habitat;
- does not address existing problems of invasive species, limited buffers, poor tidal circulation, poor connectivity between habitat areas, and supports only a limited number of targeted wetland species;
- has upland areas that would require continuous management for a muted tidal system, invasive species and human impacts; and
- accommodates sea level rise through tidal muting.

Alternative 2 – Rank 4

Alternative 2 is ranked 4th because this alternative:

- creates fully tidal areas with better connections to Marina Del Rey although existing muted tidal areas remain;
- maintains significant upland areas;
- does not take advantage of whole site;
- does not address existing problems of invasive species, limited buffers, tidal circulation restricted by levees, poor connectivity between habitat areas;
- has upland areas that would require continuous management for a muted tidal system, invasive species and human impacts; and
- accommodates sea level rise through tidal muting.

Alternative 3 – Rank 3

Alternative 3 is ranked 3rd because this alternative:

- creates fully tidal areas across the whole site;
- creates complex channel networks;
- improves tidal circulation with breaches and larger connection to Marina del Rey water;
- creates large contiguous areas of habitat and large buffer areas;
- has poor connectivity between habitat areas across the site; and
- accommodates sea level rise through transgression.

Alternative 4 – Rank 2

Alternative 4 is ranked 2rd because this alternative:

- creates fully tidal areas across the whole site;
- creates complex channel networks;
- improves tidal circulation with breaches and larger connection to Marina del Rey water;
- creates large contiguous areas of habitat and large buffer areas;
- has poor connectivity between habitat areas across the site;
- includes subtidal habitat adjacent to wetlands using Marina Del Rey water ;
- has longer residence time in subtidal areas; and
- accommodates sea level rise through transgression.

Alternative 5 – Rank 1

Alternative 5 is ranked the highest because this alternative:

- is the most likely to create a functional estuarine habitat as per the project goals;
- creates the largest complex channel network;
- improves tidal circulation through a direct connection to Ballona Creek;
- has the largest tidal prism, lowest residence time, and greatest tidal excursion;
- creates the largest contiguous area of wetland;
- has the greatest connectivity across the site;
- allows interaction between the wetlands and the Creek;
- restores gradients in salinity and inundation;
- allows periodic disturbance by flooding and scouring; and

  accommodates sea level rise through transgression

▪

5. LIST OF PREPARERS

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APPENDIX A.
GOALS AND OBJECTIVES, OPPORTUNITIES AND CONSTRAINTS

APPENDIX B.
HABITAT DESCRIPTIONS FOR RESTORATION ALTERNATIVES

APPENDIX C.
HYDRODYNAMIC MODELING

APPENDIX D.
DETAILED COST ESTIMATES AND SUPPORTING INFORMATION

MEMO

Date: October 15, 2008
From: Ballona Wetlands Science Advisory Committee
To: Ballona Project Management Team

Background and Overview

The purpose of this memo is to summarize the Ballona Wetlands Science Advisory Committee (SAC) technical review of the Ballona Wetlands Restoration Feasibility Report and to make recommendations to the Project Management Team for the development of more refined alternatives prior to the CEQA/NEPA environmental review.

One of the primary purposes of the SAC is to provide advice on science-based objectives for restoration and on the evaluation of restoration alternatives. Over a series of meetings, the SAC provided substantial input on the project's ecosystem restoration goals and subgoals. The overall goal of the project is to restore, enhance, and create estuarine habitat and processes in the Ballona Ecosystem to support a natural range of habitat and functions, especially as related to estuarine dependent plants and animals.

After input from the public, environmental organizations, and agencies, five conceptual project alternatives were developed by the project's consultant team which reflects possible restoration actions. The alternatives represent a continuum that ranges from preservation and enhancement of existing upland and wetland habitats to restoration and creation of a tidally influenced wetland system, including partial realignment and restoration of the lower portions of Ballona Creek/Flood Control Channel. It is also recognized that variations of these alternatives are possible.

To assist the project team in evaluating how the five alternatives meet the project goals and sub-goals, the SAC developed more specific "measures of change". The purpose of these measures was to identify a common means of comparison, quantified when possible, for the alternatives. The Restoration Feasibility Report applied the measures of change to each of the five project alternatives to compare how each alternative would be expected to meet the project goals. The Restoration Feasibility Report was reviewed by the SAC members and extensive comments were incorporated into the final version to ensure the report was technically accurate. With the exception of the sections on public access and costing (which are beyond the scope of the SAC's review), t***he SAC endorses the analysis provided in the Restoration Feasibility Report for use in subsequent stages of alternatives development and review***.

Although the Restoration Feasibility Report includes preliminary cost estimates, alternatives were compared only in relation to the project goals and subgoals, without regard to cost. In addition, the alternatives were only evaluated for conceptual feasibility; additional work is needed to determine if there are barriers (such as easements, public health and safety, or environmental constraints) that affect

the logistical, legal, or practical feasibility of a given approach. In developing more refined project alternatives for the environmental review process, the SAC recognizes that the Project Management Team will need to balance factors such as cost and practical feasibility to develop alternatives that best achieve the project goals.

The conclusions and recommendations below address only the ecosystem restoration goals of the proposed project. They focus on critical restoration choices that will affect the function of the habitat ultimately restored at the site. The purpose of these recommendations is to help the Project Management Team to develop more refined project alternatives that achieve the project's ecosystem restoration goal. Refined alternatives could include incorporating elements from several alternatives to produce a "hybrid" alternative that best achieves the project goals.

Relationship Between Alternatives and Project Goals

The Restoration Feasibility Report summarizes a number of trade-offs between different restoration approaches. Although the project area is 600 acres, making it the largest wetland restoration project in Los Angeles County, it is much smaller than its historical extent and is now surrounded by development. Consequently, restoration of one type of habitat may limit the area available for another habitat type. There are also a number of choices with regard to the hydrology of the restoration project that will affect the habitat function and its long-term sustainability.

The Science Advisory Committee agreed upon the following subgoals in support of the overall ecosystem restoration goal for the project:

1. *Habitat*: Preserve, restore, enhance, and create a variety of functional wetland and estuarine habitats representative of the Ballona Ecosystem.

2. *Biodiversity*: Preserve and increase the native biodiversity of the Ballona Ecosystem. Identify and protect multiple levels of diversity (e.g. species, habitats, biogeographic provinces and trophic structure).

3. *Physical/Chemical Processes*: Maintain and establish physical and chemical processes consistent with the restoration goals.

4. *Sustainability*: Facilitate the conservation and restoration of natural resources in a manner that maintains and improves the ecological integrity, function, diversity and productivity for future generations.

The SAC developed a number of measures of change to evaluate how the restoration would address the subgoals and objectives for the project. The SAC determined that the goals and objectives could best be met based on the following criteria.

1. Maximize area of estuarine habitat.

The SAC believes that the best way to achieve the habitat goals is to through the restoration of a functional estuarine habitat that includes shallow subtidal, mudflats, fully tidal wetlands, salt pan and transitional habitats. Tidal estuarine habitats would benefit vascular and non-vascular plants, small mammals, and a diverse community of aquatic invertebrates, fish, and many bird species known to utilize other southern California wetlands. Enhancement of muted tidal wetlands or upland habitat, such as coastal sage scrub, grassland and saline seasonal marsh, does have benefits to fish and wildlife, but not to the extent that can be achieved with full tidal restoration. The SAC recognizes that upland habitat is important for functioning estuarine habitat and may be necessary to accommodate potential sea level rise in the future, and has given consideration to including such areas within the alternatives.

Alternatives 3, 4 and 5 create the largest areas of tidal estuarine habitat while Alternatives 1 and 2 have larger areas of upland and artificially muted tidal habitat (controlled by tide gates). Alternatives 4 and 5 create large areas of shallow subtidal habitat adjacent to mudflat. This would provide spawning and nursery habitat for pelagic and demersal fish species; these may disperse to the adjacent nearshore habitat and to other regional wetlands

2. Restore large, contiguous and diverse estuarine wetlands with subtidal habitat adjacent to mudflat and wide transitional habitat areas. Refined alternatives should include preservation and enhancement of some upland and freshwater wetland habitat but should emphasize contiguous estuarine wetland habitat. Opportunities to create regionally significant habitat including vernal pools and native grasslands should be pursued, but not at the expense of the restoration of estuarine habitat.

Alternatives with larger, contiguous, areas of diverse estuarine wetland habitat are more likely to sustain populations of associated species. Alternatives with fewer roads, wider transitions and more channels would have a higher quality of wetland habitat because they would be more remote from noise, lights, cars, and other human impacts. Alternatives with larger areas of contiguous wetland would also have fewer impacts from, and require less active management for, invasive plant and animal species.

Generally, the alternatives that restore more estuarine habitat have less area available for adjacent upland habitats or other regionally significant habitats. While upland habitats provide support to functioning estuarine habitat, there are opportunities for restoration of coastal sage scrub and bluff habitats in nearby offsite areas. Nevertheless, inclusion of some native upland habitat within the restoration project would be desirable.

Alternatives 3, 4 and 5 allow for the greatest range of elevation gradients and variation in topography. As such, these alternatives would allow for restoration of shallow subtidal habitat, intertidal channel, mudflats, low to high marsh, salt pans and transition zones. Alternative 4 would provide for the most

extensive subtidal habitat and associated adjacent mudflats. The gradients associated with these habitats would be particularly beneficial for numerous fish and bird species.

3. Restore fully tidal wetlands by removing or breaching levees to the extent possible.

The form of the tidal connection would affect the connectivity and function of habitat by influencing the movement of sediment, seeds, gases, nutrients, fish and fish larvae. Muted tidal systems, as in Alternatives 1 and 2, will have a reduced tidal range and therefore a compressed vertical range of habitats, limiting the area of transitional habitat that can be created. Fully tidal systems allow for greater tidal circulation and reduced residence time which will lead to a more rapid exchange of water with the ocean, and positive effects on exchange of gases, nutrients, fish larvae, sedimentation and improved water quality.

Tide gates do allow for control of water surface elevations within the wetlands but would limit connectivity with Ballona Creek and Marina del Rey, likely reducing wetland species diversity. Gates can also control pollutant loading, especially during storm events, although the muted tidal systems would have a longer residence time allowing greater settling of pollutants in the wetland.

Levee breaches proposed as part of Alternatives 3 and 4 allow for full tidal range, movement of larger fish and greater seed dispersal. Open breaches would allow greater tidal circulation, reduced residence times and would be able to adapt to rising sea levels. Levee removal in Alternative 5 has the advantages of breaches and increases the interaction between the wetlands and the Creek - creating gradients of inundation and salinity across the site, letting the morphology evolve and allowing for periodic disturbance by flooding and scouring. However, this alternative would require reliance on upstream flood control and pollutant removal, and could necessitate periodic removal of accumulated pollutants from some portions of the restored wetlands. Furthermore, it is unknown how the flow and sediment yield from the upper watershed would affect the sustainability of the marsh in terms of scour or sediment deposition.

4. Maximize hydrologic connections within the subareas and minimize potential water quality effects associated with influent

The higher quality sources of tidal water are the ocean and portions of Marina del Rey. The ability to bring this water into the wetlands would depend on the location of the tidal connection and the tidal excursion length. Alternatives 2, 3 and 4 improve tidal connections between Area A and higher quality water in portions of Marina del Rey; this would also benefit habitat connectivity for fish species. All alternatives have some connection to Ballona Creek, which, at present, has poorer water quality. Longer excursion lengths increase the mixing of water on each tidal cycle, improving water quality. Alternatives 3, 4 and 5, with the largest tidal prism, have excursion lengths extending to the ocean. The large intertidal areas of Alternative 2, 3 and 5 would have the shortest residence times, completely draining on most tidal cycles. As stated above, Alternative 5 would rely on upstream pollutant control measures to ensure water and sediment quality within the restored wetland.

5. Adaptive management measures should be incorporated into any restoration alternative

Alternative 1 has little change from the present situation and the risk associated with failed implementation is low. The restoration of wetlands in Alternative 2, 3 and 4 could be undertaken in distinct hydrologic areas which would allow for adaptive management and experimentation. Alternative 5 restores a large, contiguous area of habitat connecting a number of existing hydrologic units with Ballona Creek. This alternative makes the greatest change to the site, would be the hardest to reverse and consequently has the most risk. This risk may be mitigated to an extent by incorporating an adaptive management approach through phased implementation.

Open breaches would allow greater tidal circulation, reduced residence times and would be able to adapt to changing sea levels. Gates would require regular maintenance and management as failure could impact habitat and cause flooding. Fixed structures, such as gates and culverts, will need to accommodate both scour and sea level rise in their design.

SAC Recommendations

The SAC evaluated the ability of each alternative to achieve the ecosystem restoration goals of the project. This evaluation was based primarily on the expected physical and biological processes and habitat enhancement that would occur as a result of each restoration concept. SAC evaluation was not based on other project considerations of cost, logistics, or feasibility. These are critical issues for project design and implementation and will be evaluated by the Project Management Team during later phases of the project. Relative rankings of alternatives based on the analysis in the feasibility report, and summarized above are provided in Table 1.

The SAC recommends that Alternatives 4 and 5 be carried forward to the next phase of the analysis. Alternative 5 would result in the greatest amount of contiguous wetland habitat and would have the least artificial structures or impediments. However, there are several unresolved issues associated with Alternative 5 that could affect its ability to provide sustainable, functioning wetland habitat. These issues would need to be addressed should it become a preferred alternative:

- Effect of erosive shear stress associated with high velocity storm flows on sustainability of the marsh plain
- Ability to manage potential adverse effects of pollutant input to the wetlands until such time as upstream management measures reduce watershed contaminant loading
- Ability to include additional upland habitat for both intrinsic value and as a buffer to the restored wetlands. For example, the Project Management Team could consider restoring Area C as primarily upland or transitional habitat.
- Lack of control structures to aid in accommodating sea level rise Refined analysis of potential flood elevations and associated implications for integrity of the restored wetland. This analysis

should include consideration of the need for new/additional flood protection measures if the Ballona Flood Channel levees are removed

- Ability to implement Alternative 5 in phases so that impacts to existing species and habitats can be minimized as restoration proceeds

- Although it would have lower internal connectivity and would retain more artificial structures, Alternative 4 would provide many of the same wetland functions as Alternative 5. Internal circulation and flushing would be lower than in Alternative 5, but Alternative 4 would provide more contiguous subtidal habitat and associated mudflats and transition zones. While Alternative 4 would reduce beneficial effects of flood inundation (e.g. temporary salinity reduction, nutrient influx), it would be less susceptible to the adverse effects of flooding, such as contaminant input. If Alternative 4 is carried forward as a preferred alternative, the subtidal area in Area A should be designed to be shallow enough to allow substantial turn over during a relatively few tidal cycles and should be reoriented to allow two tidal connections and gentle transition slopes.

The SAC also recommends that the following additional analyses be completed for both Alternatives 4 and 5:

- Potential effects of scour, sediment input, and deposition
- Potential effects of pollutant inputs (including trash and debris) and any necessary management measures
- Potential effects of sea level rise on long-term sustainability and/or adaptability of restored wetlands
- Potential ability of the restored wetland to support target species (to be defined in coordination with the SAC) as an additional measure of change in the final feasibility study. Each alternative should be evaluated for both the species that it would or would not be likely to support.
- Projected salinity and temperature regimes of Alternatives 4 and 5 to determine if defining estuarine transitions in these elements will be present (as opposed to primarily marine conditions). This analysis should also include the effect of potential salinity reduction and productivity-inducing effects of freshwater influxes.

Finally, whichever alternative is selected, it should be implemented in phases to allow mid-course corrections and re-evaluation of progress toward achieving project goals.

Table 1: Summary of Rankings of Alternatives Relative to Goals and Measures of Change

Subgoal	Measures of Change	Alt. Rankings Lowest	Alt. Rankings Highest	Rationale
Habitat				
	area of tidal habitat	1	3, 4 & 5	Alternatives 3, 4, and 5 would each provide most of the site with unrestricted tidal access
	quality of estuarine habitat	1	4 & 5	Alternatives 4 and 5 would provide for the greatest amount of estuarine habitat with complex edge habitat, diversity of habitat types, and transitions between areas with varying tidal regimes
	habitat connectivity	1	5	Only Alternative 5 would provide for full internal site connectivity
	lack of impact to existing habitats	5	1 & 2	Alternative 5 would results in severe impacts to existing habitats
Biodiversity				
	number of wetland/aquatic plant and animal functional groups	1	4	Alternative 1 would likely result in the highest upland species diversity; however, Alternative 4 would likely have the highest wetland species diversity, partially due to the opportunity for mudflats that are contiguous to transitional habitats
	capacity to support sustainable populations of wetland dependent species	1	4 or 5	Alternatives 4 and 5 each have advantages in terms of sustainability. Alternative 5 has fewer artificial features, so maintenance may involve removal of sediment or trash or restoring scoured marsh vs. repair of structures. Additional analysis is necessary to determine the likely ability of each alternative to support target species.
Phys/Chem Processes				
	tidal circulation	1	5	Alternatives 3, 4, and 5 would all provide for full tidal access; however, circulation and mixing in Alternative 5 would be most like a "natural" system
	quality and reliability of source water	1	4 or 5	Circulation and flushing patterns in Alternatives 4 and 5 are both high; however, Alternative 4 provides greater ability to control pollutant inputs from the upstream watershed

stormwater and freshwater inputs	1	5	Only Alternative 5 would allow for stormwater and freshwater inputs that simulate "natural" conditions and are least restricted by infrastructure
biogeochemical cycling	1	4 & 5	Alternatives 4 and 5 would both provide a variety of habitats of various moisture regimes. The somewhat natural flow and circulation in Alternative 5 may favor some processes, while the longer residence time in Alternative 4 may favor others
sediment supply and quality	1 & 2	3 & 4	Alternatives 3 and 4 would provide for wetlands that are less susceptible to scour and deposition patterns from the upper watershed than Alternative 5
flood management	5	1	Alternative 1 would involve the lowest risk to infrastructure

Sustainability

sensitivity to sea level rise	3 & 4	1 & 2 (short term) 5 (long term)	Alternatives that maintain existing infrastructure would be most stable to a changing climate until the point were increased sea level overwhelms infrastructure. The unrestricted features of Alternative 5 could allow for more natural migration patterns than Alternatives 3 or 4 over the long term
resilience to episodic events	5	1	Alternative 5 would be susceptible to scour, pollutant spills, etc. that accompany floods, due to the unrestricted access to Ballona Creek
risk of terrestrial invasion	1	5	Restoration of wetland processes would create conditions more conducive to native vegetation outcompeting invasive species. Full tidal flushing would likely prevent persistence of any non-halophytic plants that might occasional invade. However, all alternatives would require ongoing control of invasive species.
risk of aquatic invasion	4 & 5	1	Alternatives that result in more subtidal area would be more susceptible to aquatic invasion (e.g., Japanese yellowfin goby, Asian date mussel).
intensity of maintenance needs	1	5	Alternative 5 would have the least infrastructure that would require maintenance, but could require substantial maintenance if impacted by a large watershed event (e.g. flood, scour). Alternative 5 design

		and management features should allow for natural processes to compensate for periodic disturbance to the maximum extent possible.

Ballona Wetlands Restoration
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