Guidance for Restoration of Natural and Nature-Based Features in the Wetland-Upland Transition Zone

Images courtesy of SCWRP

Coastal Conservancy

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1. Introduction

The wetland-upland transition zone lies between tidal wetlands and adjacent upland habitat. The transition zone provides numerous ecosystem functions and services, including unique ecotone that can support specialized and rare plant species, flood refuge for marsh wildlife, foraging access for upland wildlife, and space for tidal wetlands to migrate upward as sea-level rises. Transition zones from coastal wetlands into upland areas are characterized by important gradients of topography, salinity, and soil moisture. These gradients foster the adaptation of wildlife populations to changing environmental conditions, and provide unique habitat types like alkali wetlands and salt pannes.

Much of the historical transition zone habitat in California has been lost as the drier areas adjacent to the wetlands have been developed for human uses, diminishing the environmental benefits of a natural transition zone. Accelerating rates of sea-level rise increase the challenge of protecting and expanding transition zone habitats due to “coastal squeeze” between the tidal wetlands and developed areas. Yet protection and restoration of wetland-upland transition zones are critically important if tidal wetland species and habitats are going to persist as sea-level rises. The Southern California Wetlands Recovery Project (SCWRP) 2018 Regional Strategy Update (RSU, SCWRP 2018) identified upland migration and vertical accretion as the most important adaptation strategies available to preserve coastal wetlands. Upland migration and vertical accretion potential will determine the long-term persistence and resilience of coastal wetlands. The RSU recognized the importance and vulnerability of the transition zone and provided recommendations for the protection and restoration of transition zone habitats. This guidance document expands upon the recommendations in SCWRP (2018).

2. Developing this guidance document

This guidance document was developed through a NOAA EESLR grant called “Marshes on the Margins.” Three tasks were identified: (1) to provide criteria to map wetland-upland transition zones; (2) to map transition zones in the Southern California Bight; and, (3) to provide guidance on their management. These tasks are described in more detail below.

Define Contemporary Estuarine-Terrestrial Transition Zones - SFEI developed criteria to define an upper boundary to facilitate the mapping of wetland-upland transition zones in Southern California. The mapping methodology was refined and tested for application in various wetland systems. Methods were developed to cover a range of environmental settings, including instances of marsh migration and steep bluffs. The transition zone methodology is an appendix of the RSU that was released in October 2018 (SCWRP 2018) and is also included as Appendix A of this guidance document. The report can be downloaded from scwrp.databasin.org/pages/regional-strategy-report.

Identify and Map Transition Zones for Conservation and Restoration - SFEI translated the revised mapping methodology into GIS analyses to allow for application to the coastal wetland systems of the Southern California Bight. Layers were created for developed areas, publicly-owned areas, privately-owned areas, marsh migration zone, present-day wetland-upland transition zone, and potential wetland-upland transition zone. All mapping layers were reviewed and made available online in August 2018 as part of the Marsh Adaptation Planning Tool (MAPT - scwrp.databasin.org/).

Develop Design Guidance for Transition Zone Restoration - SFEI developed this document, *Guidance for Restoration of Natural and Nature-Based Features in the Wetland-Upland Transition Zone*. This guidance uses analysis from the Regional Strategy 2018 and input from a series of MTAG (Management Transition Advisory Group) meetings. The MTAG consists of the Wetland Managers Group, composed of high-level staff from the 18 state and federal partner agencies of the Southern California Wetlands Recovery Project (SCWRP), and the Wetland Advisory Group, composed of active practitioners in the wetland restoration community in southern California. The first MTAG meeting and a site visit were held in March 2017 at Los Peñasquitos Lagoon. There, stakeholders discussed various definitions and descriptions of wetland-upland transition zones in order to develop specific criteria to be used for the transition zone mapping methodology and restoration objectives. The second MTAG meeting and a site visit were held in June 2018 at Los Cerritos; there, stakeholders provided input on the updated transition zone definitions and criteria following SFEI's incorporation of MTAG feedback from the first meeting. The MTAG provided feedback on the language, clarity, and practical utility of the objectives and mapping methodology.

The draft guidance was discussed at length at an all-day MTAG workshop in August 2018 to identify and prioritize future actions in transition zone restoration areas. Maps of transition zones were shared with the MTAG and a robust discussion was held regarding how the project could contribute to the overall goals of the SCWRP. The workshop focused on: (1) increasing understanding of wetland-upland transition zones and their role in the new Wetlands Recovery Project Regional Strategy 2018; (2) increasing understanding of different wetland-upland transition zone types and identifying what future opportunities and adaptations are viable for each type in the context of sea-level rise; and (3) discussing opportunities, challenges, and priorities associated with implementing various management measures to protect, restore, and enhance wetland-upland transition zones. The workbook developed for MTAG participants is attached as Appendix B.

This guidance document consists of: (1) a summary of the Regional Strategy 2018 objectives as they pertain to transition zones; (2) examples of transition zone management measures; (3) criteria to help select appropriate management measures; and (4) a series of site-specific examples reflecting the range of wetland types in Southern California—Los Peñasquitos (large river valley), Goleta Slough (large river valley), Los Cerritos (fragmented river valley), Kendall-Frost Mission Bay (open bay harbor), and Aliso Creek (small creek). The guidance is intended to increase project success by helping planners and managers choose or develop appropriate design concepts. Information from the Los Cerritos, Los Peñasquitos Lagoon, and Goleta Slough workshops, together with information from the 2018 MTAG workshop, allowed for the inclusion of site-specific recommendations. Recommendations for future studies are also made.

3. SCWRP Regional Strategy transition zone objectives

The RSU provides a Vision and Goals that articulate the collective approach of the SCWRP agencies and partners to wetland recovery. A set of Guiding Principles provide criteria for each restoration project. Quantitative Objectives provide numeric targets that help quantify progress towards meeting the SCWRP's Goals and realizing the Vision. Objective 5 of the RSU is to "Maintain and Expand Wetland-Upland Transition Zones." This objective consists of four parts, which are reproduced in full below from SCWRP (2018).

Objective 5A. Protect all existing natural areas of wetland-upland transition zones from the wetland boundary/edge out to 1,600 feet (500 meters).

> *Wetland-upland transition zones are areas that often attract development and much of this area has been lost due to competing land uses along the shoreline. Transition zone habitats are important for native wildlife populations, many of which are special status species in coastal Southern California. Protecting the existing transition zone adjacent to existing wetlands enhances physical processes that make the shoreline resilient and biological processes that support healthy native wildlife populations. Gradual wetland-upland transition zones allow marsh animals, particularly small mammals, to escape floodwaters and reduce wave heights during storms thus reducing erosion and coastal flooding. The proposed wetland-upland transition zone width of 1,600 feet (500 m) above the present highest astronomical tide (HAT) was developed through a literature review (Appendix A this document) (Figure 1).*

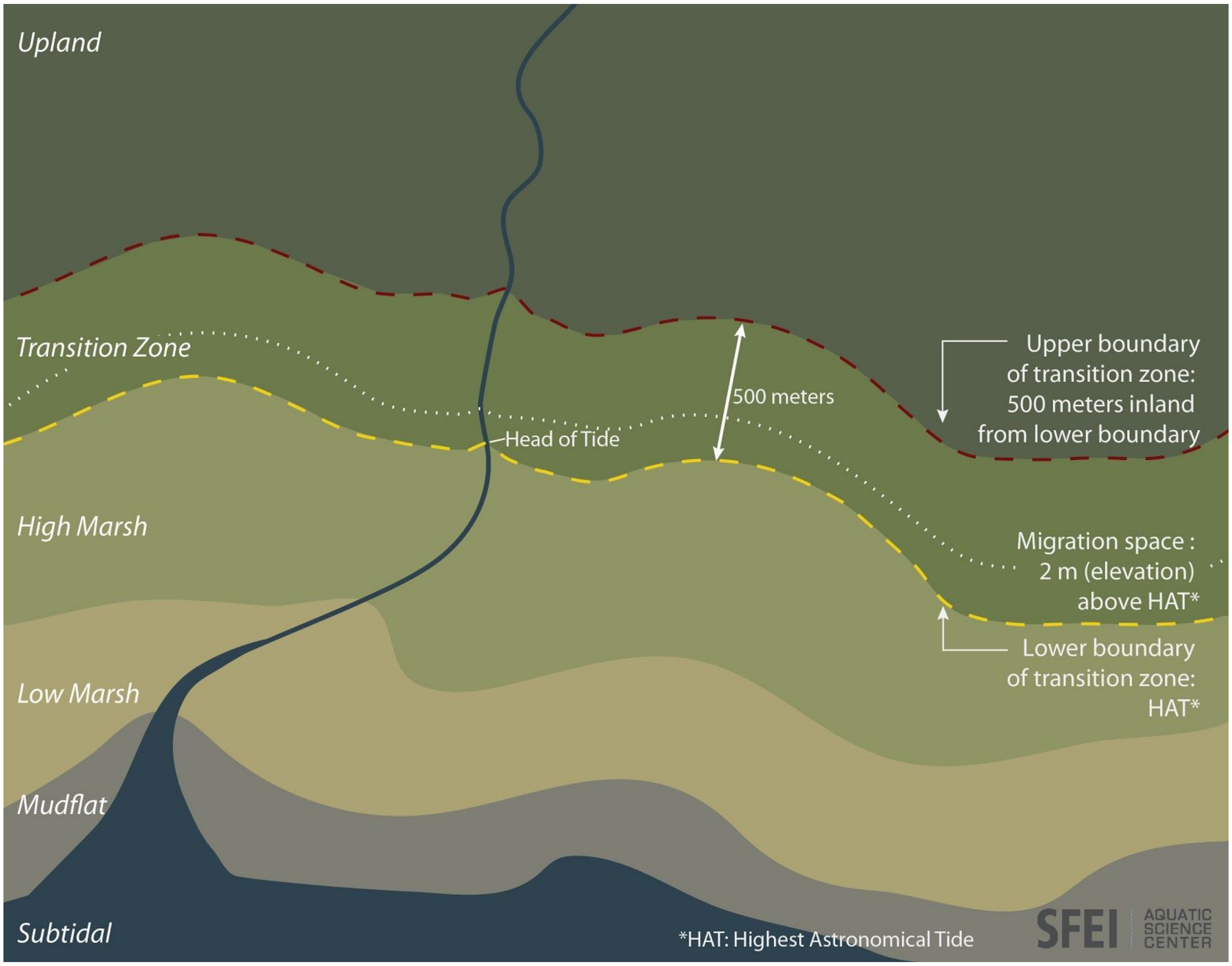

Figure 1. Visualization of transition zone mapping approach, as described in Appendix A of this document.

Objective 5B. Increase area of the natural wetland-upland transition zone to facilitate tidal wetland migration, so that at least 40% of the wetland perimeter is bounded by a transition zone that extends inland for at least the full estimated tidal extent under 24 inches (0.6 meters) of sea-level rise.

> *Over time, the land within the 24 inches (0.6 m) sea-level rise elevation band should be made available and accessible for tidal wetland migration. Given the strong likelihood that sea-level rise will eventually go beyond 24 inches (0.6 m), an additional inland area that would accommodate even higher sea-level rise should be anticipated and built into planning. The value of 40% represents the average proportion of the existing wetland perimeter, regardless of width, that is currently undeveloped and could potentially become a transition zone, for all the wetlands considered by the SCWRP. Therefore, 40% may not be achievable in some wetlands. Much of this area, although undeveloped, may not be in public ownership, or it may be managed open space, such as a park. It may also*

require restoration actions, such as removing levees, to achieve the full range of functions, especially tidal wetland migration.

Objective 5C. Increase areas of natural wetland-upland transition zone up to 1,600 feet (500 meters) from the tidal wetland edge (depending on topography, Appendix A), even in areas that are not contiguous with the tidal wetland.

Natural areas higher than the tidal wetland migration zone provide connectivity for wildlife in many ways: between wetlands along the coast, between coastal wetlands and river valleys, and between different areas of the transition zone itself. Broader transition zone areas with natural physical processes from tides, streams, and hillslopes create gradients of salinity, moisture, and plant communities that promote wildlife diversity at varying distances from the wetlands. Connectivity is important for the persistence of populations, especially in small habitat patches, by allowing refuge from high water, movement between habitat patches, and gene flow. Open space areas and habitat patches of any size throughout the landscape serve as stepping stones and seed sources for colonization.

Objective 5D. If the system has a river or creek, then an additional focus should be the creation of adjacent habitats that will allow the migration of wetlands upstream, at least to the head of the tide under 24 inches (0.6 meters) of sea-level rise.

Many of the former upland areas around coastal wetlands have been restricted by development. In many cases the best opportunity for creating and preserving space for tidal wetland migration is along river or creek valleys, taking advantage of the rising topography. Allowing for tidal wetland migration upstream will also improve movement corridors for species between the coastal wetlands and their associated watersheds.

To achieve Objective 5, a number of Management Strategies were suggested in the RSU (SCWRP 2018). These include: (1) remove barriers that prevent tidal wetlands from expanding or migrating; (2) protect, manage, and acquire adjacent land within the tidal wetland migration zone; (3) grade areas adjacent to wetlands to increase the opportunity for migration; and (4) relocate or modify adjacent infrastructure or development. For the transition zone, Objective 5 expands the area of interest beyond the land immediately adjacent to tidal wetlands by aiming to preserve and restore land landward of the tidal wetland migration zone. Within the tidal wetland migration zone, habitats can include riparian forest, non-tidal brackish marsh, valley freshwater marsh, and other estuarine and palustrine habitats. In many cases, the transition between fresh, brackish, and saline habitats would have been gradual rather than abrupt and would have varied from year to year. In some locations, these gradual transitions have been influenced by nuisance flows of freshwater from the watershed and drainages that border lagoons that are not natural and impact habitats that rely on higher salinity levels. Beyond the tidal wetland migration zone, within the wetland-upland transition zone, habitats can include many upland habitats such as coastal sage scrub, chaparral, grasslands, and woodlands. This larger, wetland-upland transition zone provides ecosystem services including wildlife support (high tide refugia, migration corridors, and roosting areas), flood detention areas in floodplains, sequestration, and public access.

Additional management strategies focus specifically on the wetland-upland transition zone; for instance, protecting, managing, and acquiring adjacent land within the wetland-upland transition zone. Areas that may be suitable as wetland-upland transition zones are not necessarily in public ownership and are likely to be subject to development pressures, making a land acquisition in transition zones a challenge. Protecting adjacent open space either by acquisition or by easement should be a priority. Though acquiring land for tidal wetland migration is important, it is equally important to acquire adjacent land beyond the migration zone. The adjacent land needed to achieve Objective 5 is even further inland than the area of land inundated by 24 inches (0.6 m) of sea-level rise. This adjacent land does not necessarily need to be contiguous. While the existence of some structures within the wetland-upland transition zone may be appropriate, those structures should not impede wildlife movement. These structures should also be potentially removable in the future when more land is needed for migration due to an increase in sea-level rise beyond 24 inches (0.6 m).

4. What is transition zone restoration?

Wetland-upland transition zone restoration is important because these habitats are an essential part of complete wetland systems, as described in the preceding section and Appendix A. Unfortunately, the transition zone is often contested because of its high development value, which is often at odds with protecting ecological value. These areas can also be impaired by impacts related to land use in the watershed that include rapid sedimentation and dry weather flows of freshwater. However, there are opportunities for development and protection to occur in tandem; for example, development could be planned in the transition zone above the tidal wetland migration space such that wildlife movement is not impeded. There are opportunities to regrade areas of high sediment deposition and reroute dry weather urban runoff. There may be opportunities to reuse sediment in wetlands from the dredging of adjacent ports and marinas. There may also be opportunities for partnerships between flood risk managers and wastewater treatment plants to develop nature-based features, such as ecotone levees, which mimic natural transition zone hydrology and promote both habitat and infrastructure resiliency goals (see section 5.6 below).

When designing transition zone restoration projects, it is important to consider both actions that benefit ecological function and actions that benefit neighboring human communities. Natural transition zones function as refugia for wildlife, so restoration actions that include stressor controls can help promote ecological function by reducing the detrimental impacts of predators and contaminants. Wildlife-friendly landscaping can help increase connectivity, allowing for daily movements, seasonal habitat shifts, and juvenile dispersal for a range of species including mammals, birds, and reptiles.

Many native transition zone species are adapted to niche habitats, including specific microclimate, salinity, and moisture gradients that occur only within the transition zone band. Therefore, it is important for restorations to emulate natural physical conditions beneficial to specific species, including hydrology, sediment transport and deposition, and topography. Gradual slopes can help ensure that the full range of physical conditions from tidal wetland to upland is represented. Niche habitats supported in the transition zone may include freshwater wetlands, alkali wetlands, and willow groves, among others. Restoration practitioners need not limit themselves to existing habitats but can also explore appropriate habitats that have historically been supported in similar conditions.

Transition zone restoration can promote the development of functional ecosystem services like water quality improvement and flood reduction, a particularly important service in the context of sea-level rise. Floodway improvements to attenuate flooding could be integrated with downstream enhancement of riparian corridor and transition zones, along with restoration of salt marsh. Restoration actions that may benefit the human community also include those actions that improve access and provide more space for recreation. Actions that promote wildlife and ecosystem function enhance the value of recreational spaces by allowing for activities like birdwatching in addition to boating, walking, and other types of outdoor recreation.

5. Examples of transition zone management measures

A number of transition zone management measures have been developed in the present study: initially through discussions with the WRP SAP, and later refined by land managers and restoration practitioners at MTAG meetings. The measures are described below.

5.1. Mitigating conflict in the transition zone

Management measures for the wetland-upland transition zone may need to balance habitat objectives with public access, development, and infrastructure. While promoting public access may be a component of a restoration project, it is important to establish clear rules and boundaries to ensure that visitors to restored transition zone areas do not cause undue harm to ecosystems. There will be a lot more conflict between nature and people in upland areas than in tidal wetlands, so finding a balance by separating recreational areas from habitat areas may be required. Invasive species will also be detrimental to transition zone restoration goals. Restored native ecosystems that thrive in the niche habitats of the transition zone may be compromised if an invasive species management plan is not in place. Finally, it may be necessary to modify, or, if possible, remove any infrastructure — such as roads, trails, railroad berms, and stormwater channels — that present an impediment to physical processes, restoration actions, habitat connectivity, or wetland migration in the transition zone.

5.2. “Light-touch” strategies

Some management strategies do not involve major changes to infrastructure or developed areas but are “light-touch” measures that can improve ecological function in the wetland-upland transition zone. Some of these “light-touch” strategies are green infrastructure interventions that allow for occasional flooding in developed areas. These strategies include bioswales and other vegetated areas that are designed to detain and filter stormwater. Floodproofing buildings in the transition zone, rather than protecting them with walls or levees, could allow periodic flooding of, and better connectivity with, adjacent wetland habitat.

Other light-touch strategies can also improve habitat connectivity across and along the shoreline. One such strategy is to create corridors for wildlife movement from tidal wetlands to uplands through, or along, the edges of developed areas. Implementing green corridors along and parallel to the shoreline can improve connectivity for wildlife as well as recreational access for communities. Protecting vacant or underdeveloped parcels from further development and planning for more appropriate land uses in these parcels can also help improve habitat connectivity. Examples of transition zone land uses with less impact than built-out residential/commercial/industrial areas include parks and playing fields. Around existing developed parcels, connectivity for wildlife can be promoted by planting hedgerows of native plants, modifying fences to allow passage, and widening bands of riparian vegetation along stream corridors. Integrating wildlife corridors with pedestrian/bike connections between watershed and lagoon may not be optimal, but is sometimes all that is available due to space or funding.

5.3. Transition zone restoration at the estuary scale

Estuary-scale restoration can involve implementing landscape-scale natural or nature-based restoration strategies that restore or mimic nature. Transition zone restoration may include creation of habitats which are not currently represented in the estuary, though they may have existed there historically. Examples of nature-based strategies include constructing ecotone levees, grading hillslopes, creating wetlands within concrete channels, and building islands in tidal wetlands. Starting with the preferred alternatives from an ecological perspective, identifying key drivers for wetland health, and modifying to address various constraints is a way to identify nature-based strategies that may be appropriate in a given area. In developing alternatives, it is important to involve key stakeholder groups, ecologists, and engineers early in the planning process to ensure that the ecological ideas are successfully interpreted in the engineering design. Including ecologists early in the process can help ensure that designed landscapes are more diverse in topography and vegetation, providing a wider range of habitats for species. Strong stakeholder support, including the public, increases the ability to generate multiple benefits (e.g. flood attenuation, vector control, habitat restoration and enhancement) and can widen the area of interest. The local community should also be engaged early in the process to ensure public access opportunities are adequately considered and the project is aligned with community goals.

There are several other factors that are important to consider early in the planning process. These include physical factors such as natural and modified watershed processes, existing land use, soil type, hydrology, and elevation, and edge effects involved with shifting habitat boundaries to new locations. The infrastructure, access, and space requirements for planned habitat under both existing and future environmental conditions require consideration. Consideration of the neighboring landowners is also important; identifying willing sellers and designing to increase neighborhood values can improve chances of project success. Owner and operators of key pieces of infrastructure such as railroad berms, tide gates and weirs need to be consulted.

The role of sediment fill depends on ecosystem context and physical setting. In some cases, re-grading fill (especially on steep slopes) can create a transition zone. Fill can also protect sensitive habitat near trails (e.g. Newport Bay) or be placed within tidal areas to create high tide refugia. Freshwater and groundwater processes are also important considerations for the development of transition zones and are integrally connected to elevation. Many of these processes have been modified by development and it is important to distinguish between natural and manmade water sources.

5.4. Nature-based features

In many large river valleys of Southern California, the floodplain has been dissected into smaller, spatially distinct units by flood risk management levees and stormwater channels associated with development, with significant distances separating wetlands from uplands. Traditional flood risk management levees are steep and narrow (with a length to height ratio generally between 3:1 and 4:1) and provide little transition zone. Nature-based features can be constructed to alter or replace existing structures and mimic some of the missing ecosystem functions. One such feature is the ecotone levee, which provides additional upland and transition zone for wetlands disconnected from their natural transition zone, while maintaining the existing levee alignment (SFEI and SPUR 2019). In some cases, hydrological functions can be reestablished on the ecotone levee. Ecotone levees are being actively developed in a number of pilot projects in San Francisco Bay.

The ecotone levee only makes sense in relatively large systems where naturally rising upland is absent, there is an existing marsh (or potential to restore marsh) in front of it, and there is sufficient area to construct the gradient needed for upslope migration. These levees are not as effective in systems with limited space such as creeks, nor in areas where naturally rising ground is near the wetlands and there is no need to divide the floodplain with levees. The slope of an ecotone levee is gentler than a traditional levee, more akin to the slope of a natural transition zone. Thus, the area of the transition zone will be wider, providing more space for ecosystem functions and services and more space for marsh migration. This slope stretches down from the crest of the flood risk management levee to tidal marsh elevation with a gradient between 10:1 and 20:1. The actual slope is dependent upon the available space (to minimize the amount of filling of marsh) and the volume of fill material available. The flatter the slope, the wider the transition zone habitat.

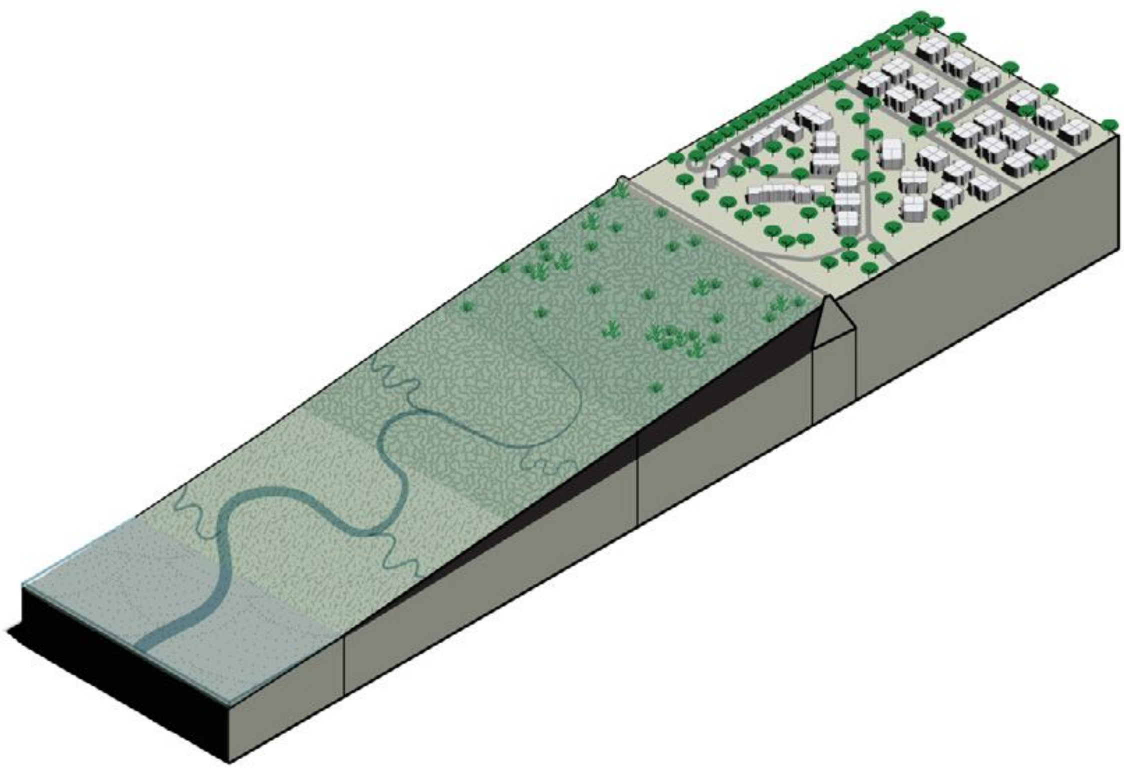

Figure 2. An ecotone levee is a gentle slope that connects the flood risk management levee to the marsh (SFEI and SPUR 2019).

The low-gradient slope is separate from the engineered flood risk management levee so it does not need to be constructed to the same specifications. Ecotone levees can support: a broader transition zone between marsh and upland areas than traditional flood risk management levees; vegetation communities associated with the wetland-upland transition zone; and high-tide refuge for marsh wildlife. The gentler ecotone slope can reduce wave run up and overtopping of the crest of the flood risk management levee.

Ecotone levees are largely untested. They will require considerable volumes of material to construct, with associated costs. In many places their construction in front of existing levees would require filling the backs of wetlands, which is highly regulated. The use of fill would need to be permitted. Environmental impact statements and consultations with state and federal wildlife managers will be required for locations that are home to threatened or endangered species. FEMA has not stated a view on the certification of an ecotone levee.

An enhancement of the ecotone levee is the “horizontal levee,” which introduces subsurface seepage to support fresh to brackish wetlands on the levee at the back end of the tidal marsh. This restores some functions of the natural salinity gradients that were historically found near small creeks. These brackish seepage slopes would be expected to support dense stands of tall sedges and bulrush, which would enhance the wave damping function of the levee and reduce erosion. A horizontal levee is being piloted at the Oro Loma Sanitary District in San Francisco Bay, where treated wastewater is being used to irrigate the slope with the additional benefit of further “polishing” of the effluent.

5.5. Land-use strategies

Land-use strategies, including financial incentives, policies, and regulations, can be used to achieve wetland-upland transition zone goals. Examples of these measures include buy-out programs, redevelopment restrictions, and development moratoriums. The following sections describe some possible improvements in land-use policy and inter-agency coordination to promote transition zone restoration.

Permitting

MTAG members identified the need to change permitting processes to better facilitate the implementation of restoration projects. The roles of maintenance versus restoration need to be clarified in permits, especially considering the dynamic nature of transition zone habitat and changing environmental conditions in the context of climate change. A need for increased flexibility in permitting was also identified, as new, experimental ideas for adaptation are difficult to pilot under the current system. Lengthy permitting processes that restoration projects are currently required to navigate pose major barriers to implementing innovative restorations.

It would be beneficial to have a streamlined or separate permitting process for conservation organizations, as different considerations apply for restoration projects than for development-focused projects. Educating policy-makers and resource agencies about innovations and challenges related to restoration and adaptation should be a priority. Discussions with the California Department of Fish and Wildlife and learning from the coordinated permitting process in place in San Francisco Bay (the Bay Restoration Regulatory Integration Team or BRRIT) will be valuable steps in streamlining the permitting process.

Funding needs

There are many limitations associated with funding. While there may be funding for implementation of projects there is often a lack of funding for planning and initial design. There is also a lack of funding for long-term maintenance, which is often needed in estuaries that have become managed systems due to urban encroachment and land use changes in the watershed.

One major funding issue is that most grants are short-term. Piecemeal funding means that restoration managers must constantly apply for grants, reducing the capacity for implementation. Often, funding is inadequate for pre- and post-restoration monitoring that can provide lessons learned for future projects. With piecemeal funding and inadequate monitoring of existing projects, it is difficult to thoughtfully pursue large-scale and long-term approaches.

Existing funding mechanisms could be restructured to allow for more effective planning and implementation. One idea suggested by the MTAG is to change grant proposal criteria to require innovative partnerships that advance cross-jurisdictional, watershed-scale projects. Currently, most funding for estuarine restoration is tied to the area of tidal wetland restored, with little recognition of wetland-upland transition zone or upland habitat restored. Adjusting these criteria to include adjacent upland or transition zones would increase the focus on these areas and allow more resilient long-term restoration strategies. Innovative partnerships can also expand the focus from transition zone habitat to tie in human-oriented ecosystem services like recreation and water quality, and promote other multi-benefit projects like creating flood control easements on transition zone areas.

Grants are not the only funding mechanisms that could be modified. Mitigation banking and in-lieu fee programs could also be more proactive in protecting wetland habitat if they were linked to current wetland migration areas that will become intertidal in the future. Transportation infrastructure intersects with almost every restoration project because historically, roads and railways often skirted wetlands along the drier wetland-upland transition zone. Regional transportation authorities should be included in restoration discussions and could be a source of funds for multi-benefit projects. For example, flood risk reduction efforts could be connected with the creation of protected transition zones.

Planning & coordination

As with many planning processes, it is difficult to align all the moving pieces to increase the effectiveness of transition zone management. Local and regional policy-makers need to coordinate the restoration and conservation process, to better align incentives and land use regulations to promote transition zone protection. Better coordination is also needed to link habitat goals between General Plan and Local Coastal Program updates. Coordination across agencies will allow for forward-thinking projects that incorporate sea-level rise planning and allow for innovative long-term solutions, such as allowing appropriate fill and thin-layer sediment augmentation in the coastal zone, and facilitating habitat transitions now to promote habitat persistence into the future.

One coordination issue to overcome is the conflict between restoration and transportation. There are right-of-way issues in the transition zone with existing transportation infrastructure, such as roads, rail, and parking lots. Balancing the maintenance of important transportation routes with transition zone management priorities requires coordination at the local and regional scale. Transportation, flood control, and other infrastructure planning needs to be better linked with habitat conservation to develop plans that achieve multiple goals. Mandates exist at the county and federal levels to provide flood protection, and FEMA funding is distributed after events to rebuild when this flood protection fails. A more planning-oriented system that links flood control with habitat conservation, and focuses on proactive rather than reactive measures, is more likely to result in resilient multi-benefit planning.

Incentives & buyouts

One way to initiate proactive transition zone management could be to create policies that incentivize transition zone protection. This may mean creating incentives for conserving land in transition zones, converting impermeable surfaces in the transition zone to permeable, etc. Green stormwater infrastructure and conservation incentives already exist in other contexts; creating transition-zone-specific ones would simply mean translating these policies to designated transition zone areas. Where incentive programs may not be adequate to achieve the desired level of protection, buyouts are another option for protecting the coastal zone.

5.6. Criteria to select management measures

The following selection criteria were developed during MTAG meetings to guide selection of appropriate transition zone management measures. “Project,” “strategy,” and “measure” are used interchangeably in this section, and the criteria may be used to evaluate any transition zone management effort. A good project serves multiple goals (flood attenuation, vector control, habitat restoration, public access/use, community plans, etc) in order to get buy in from multiple jurisdictions and (importantly) allows them to justify prioritization and allocation of funding that may be from public sources.

- **Solves a problem**
  The project proposal identifies a problem and explains how the strategy addresses the problem. The project mitigates a primary threat (e.g. armoring, invasives). Unfortunately, many problems in urbanized lagoons are complex and require consideration of multiple perspectives and trade-offs.

- **Appropriate**
  Selected measures are appropriate for the wetland system and sub-region of the Southern California Bight. The projects are feasible and the applicants well-qualified.

- **Scientifically sound**
  Strategies are based on scientific understanding of current conditions and projections of future conditions. Strategies also consider the historical context of the site and region and are integrated at the watershed scale from both an ecological and technical perspective. Many of these are managed systems that require ongoing maintenance (e.g. mechanized inlet openings) to protect and preserve existing habitats and ecosystem services. While historic context can inform restoration strategies, it is not always appropriate to go back in

time to “natural conditions” or even “historic conditions” since these systems evolve over time. The methodology has been developed through pilot studies and demonstration projects (proof of concept). Adaptive management based on experimental testing is designed into the project (i.e. monitoring experiments determine how the next stage of the project will be completed).

- **Broader impacts**
  The management measures are multi-beneficial. For instance, they provide recreational or community benefit in addition to ecological benefit. Multiple jurisdictions are involved in pursuing a common goal may be difficult to achieve since stakeholders have different values that influence directives and priorities. Impacts are analyzed from a benefit-cost perspective, and also in terms of their transferability to other locales.

- **Community support**
  Management measures have or will be able to gain community support and there is the political will to get the strategies implemented. Landowners are engaged and/or willing to sell.

- **Funding**
  Sufficient funding is available and the whole-life cost of the projects are considered and planned for.

- **Phasing & adaptability**
  The project may be completed in phases and part of a larger plan for the whole wetland system. What came before and what will come next has been considered, and alternatives evaluated according to their place within this timeline. The integration of various phases of a larger project has been evaluated based on feasibility and adaptability; for example, projects that will be unsuccessful if a critical component cannot be completed may not be feasible.

- **Long-term sustainability & success**
  Project owners have a commitment and ability to do long-term management and monitoring. The project outcome is resilient and sustainable, requiring little management intervention in the long term. Criteria to measure project success have been determined. The resilience of the wetland system to future environmental changes including climate change has been considered as an integral part of the project design.

6. Site-specific examples

The following site-specific examples are illustrative of the characteristic transition zones of several common Southern California wetland archetypes (as developed in the RSU, SCWRP 2018): large river valleys, fragmented river valleys, open bays or harbors, and small creeks. The mapping of transition zones developed for this project has been used to illustrate opportunities and constraints for transition zone restoration in these site-specific examples. Contemporary habitat mapping (current wetlands) shown in the site-specific example maps is from the Southern California Wetland Mapping Project (SCWMP) (2013), which uses the Cowardin classification system and National Wetlands Inventory (NWI) standards (see the RSU: SCWRP 2018, Appendix 4). This may not be the most recent wetland mapping available for some sites.

6.1. Los Peñasquitos Lagoon

The Los Peñasquitos Lagoon (Figure 3) is an example of the large river valley type (SCWRP 2018). In general, large river valley estuaries have open, flat, depositional floodplains that may be topographically confined by rising ground, steep bluffs, and mesas. Creek flow may be relatively low or seasonally-absent under natural conditions with intermittent floods. Relatively small tidal prisms can result in periodic inlet closure. Sedimentation from the watershed may be limited and deposited as an alluvial fan, although anthropogenic watershed changes can result in increased sediment delivery and freshwater (from urban runoff). Because they are flat and close to the coast, large river valleys are attractive for development, and most of these systems have been extensively modified. When development occurs in these floodplain areas, drainage is often rerouted by the construction of infrastructure such as flood channels, levees, roads, and railroad berms. Loss of floodplain in these scenarios can result in increased discharge rates during storm events, increased sediment transport that increases downstream deposition rates and volumes, and movement of coarser material (e.g., sand) onto the marsh plain.

Los Peñasquitos lagoon is constrained by the steep bluffs of Torrey Pines on the south side and by urban development to the north and east (Figures 3 and 4). The mouth of the lagoon is constrained by hardened embankments under a bridge on the Pacific Coast Highway. Marsh migration zone opportunities are limited due to steep slopes, though there are some small discontinuous areas on the southern, undeveloped side of the wetlands. Opportunities for transition zone protection exist in the undeveloped gentler slopes to the north, the alluvial fans to the east (just west of Interstate 5), and along the valleys to the east and south in the Sorrento and Carmel Valleys (Figures 5 and 6). Conversion of a parking lot to transition zone (such as dunes) near the tidal inlet, under the Pacific Coast Highway bridge. Further opportunities for creation of more natural transition zone habitat in the upper lagoon include restoration of freshwater- and sediment-impacted wetlands, which are heavily invaded by non-native plants in the upper lagoon. Recent restoration plans for the Los Peñasquitos wetlands are described in the Los Peñasquitos Lagoon Enhancement Plan (ESA 2018a).

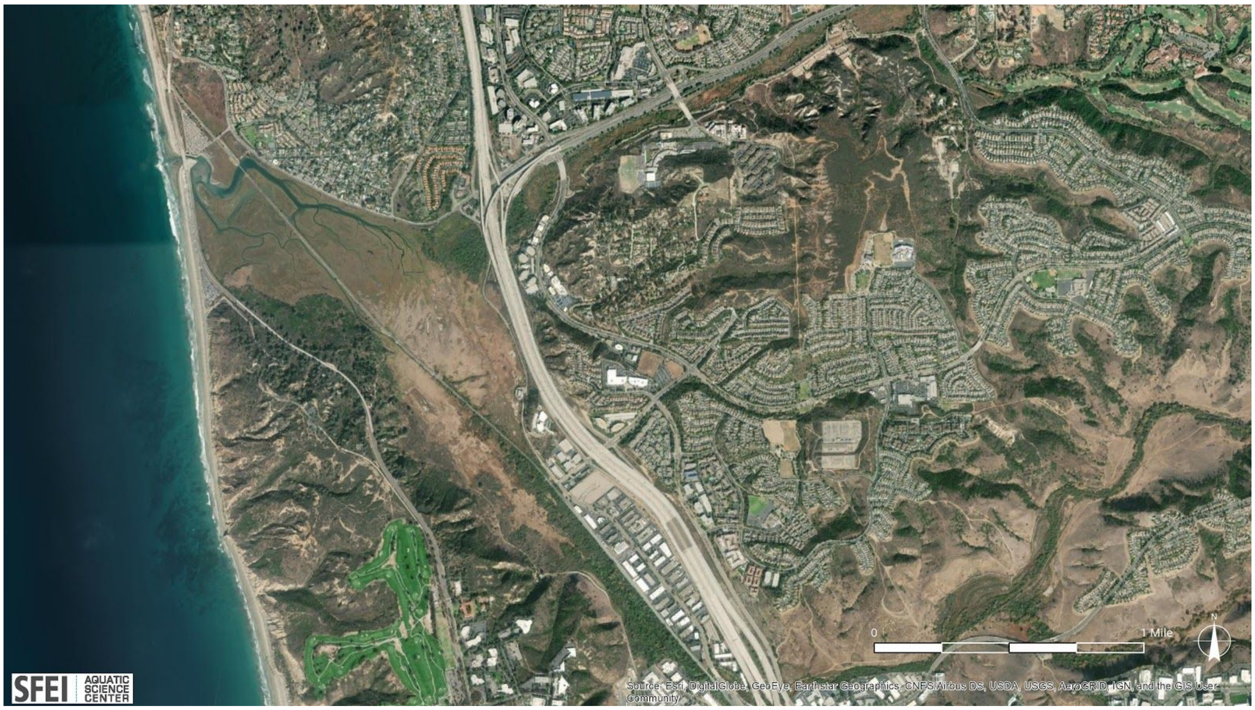

Figure 3. Aerial imagery of the Los Peñasquitos River Valley.

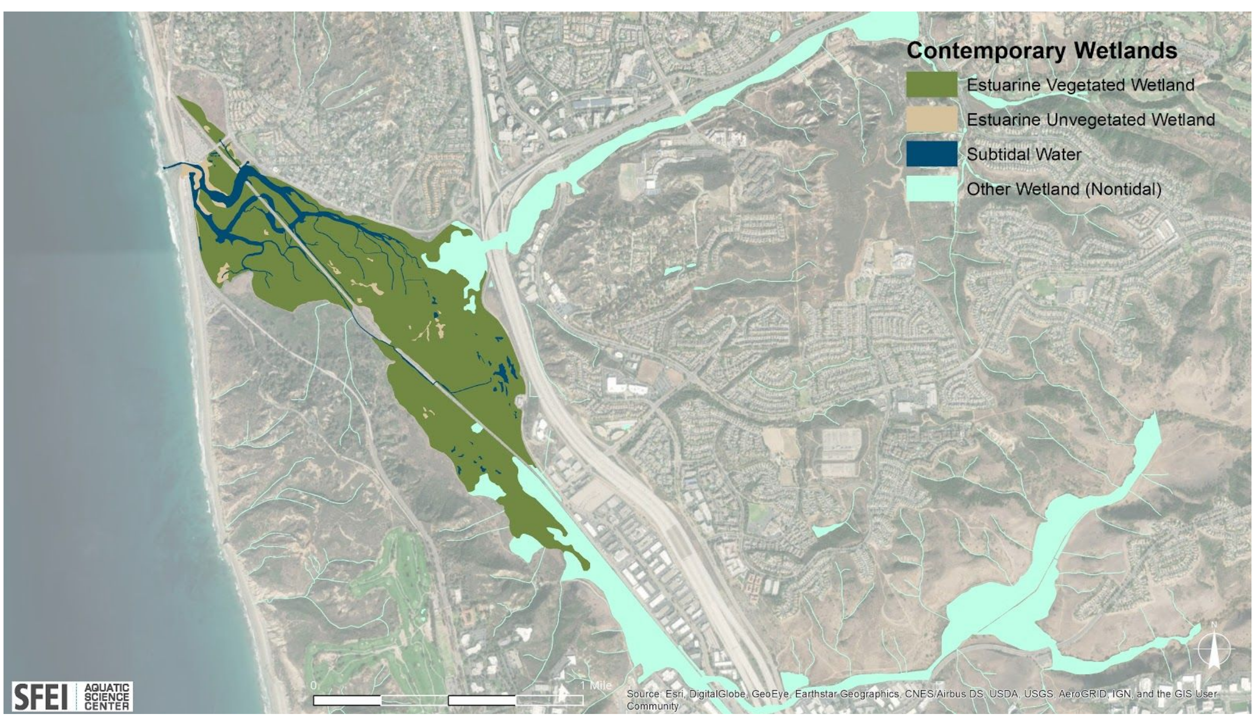

Figure 4. Current wetland habitat in the Los Peñasquitos River Valley.

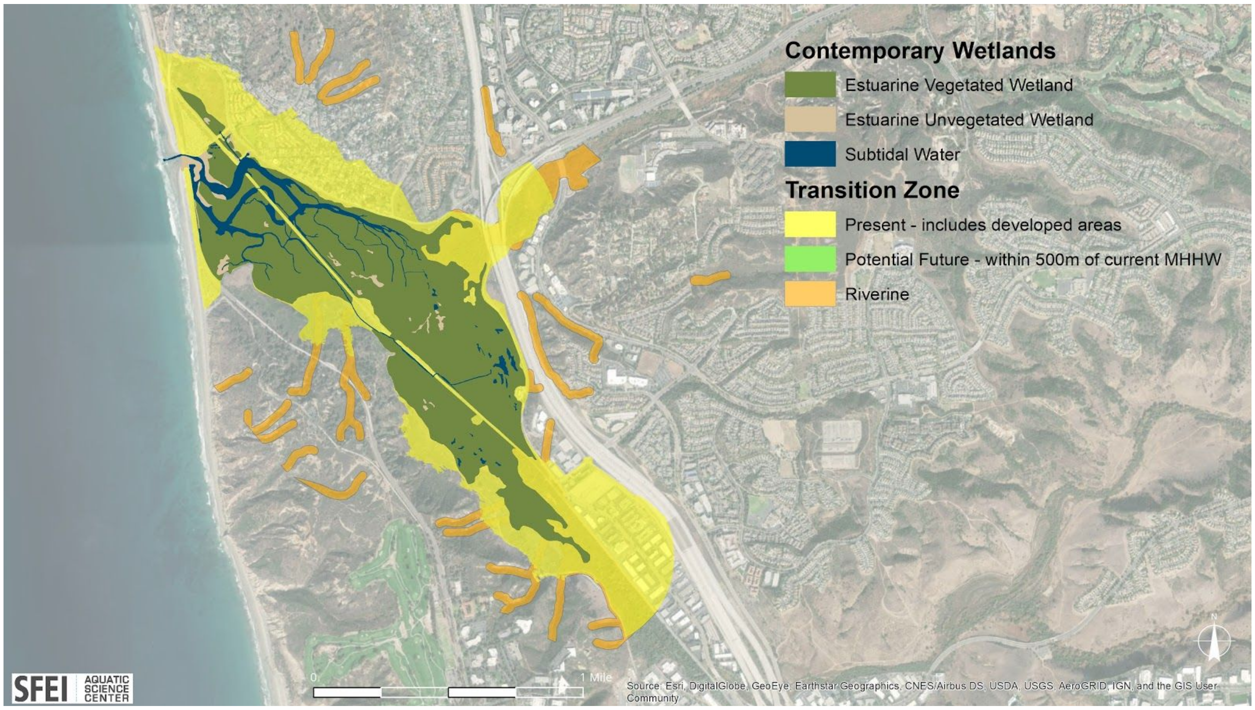

Figure 5. Mapped transition zone habitat for the Los Peñasquitos River Valley.

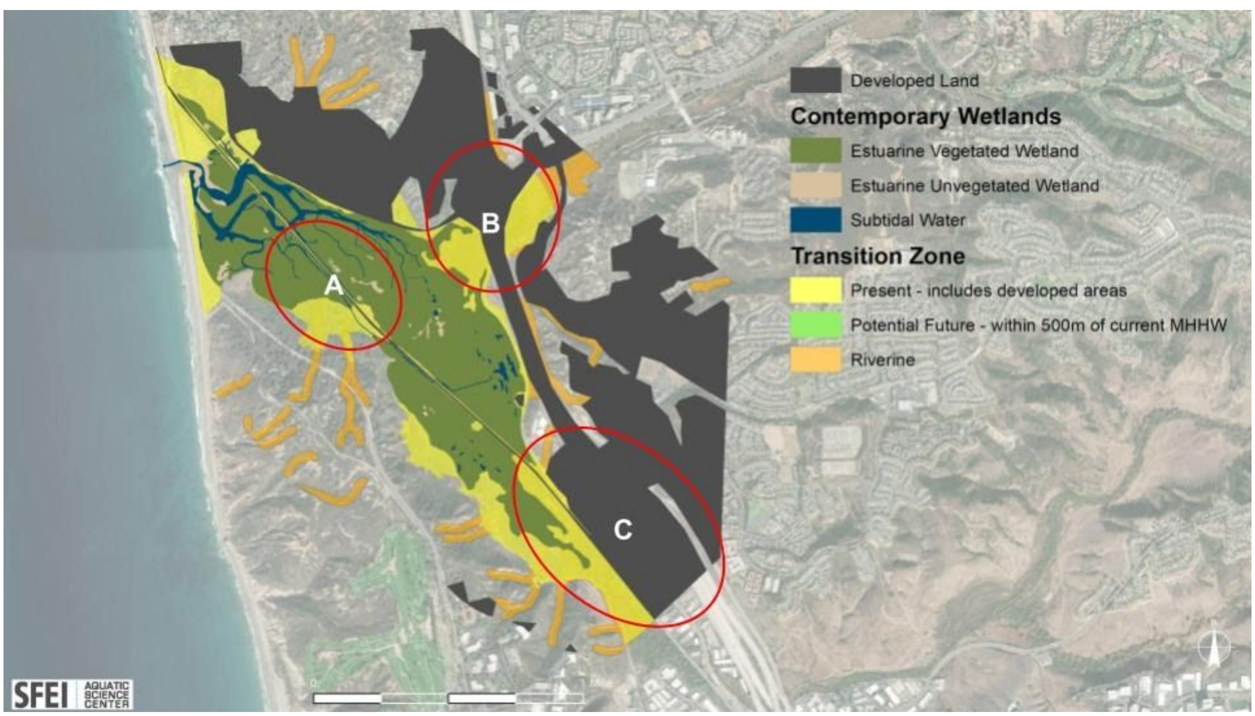

Figure 6. Mapped transition zone habitat for the Los Peñasquitos River Valley with developed areas excluded and opportunity areas labeled.

Los Peñasquitos is an example of a large, relatively complete wetland, with areas of undeveloped but topographically constrained edges along the southern margin of the estuary. The steep bluffs to the south and the development to the north limit the width of any transition zone immediately adjacent to the wetlands. The gentler topographic slopes and main transition zone opportunities are inland along the valleys where sedimentation and hydrology are as important as topography. Rapid sedimentation and alteration of freshwater flows due to development in the watersheds have precluded expansion of salt marsh and exacerbated freshwater ponding.

Participants at the MTAG workshop identified a number of potential management strategies for the Los Peñasquitos site. For example, there are opportunities to protect and enhance transition zones through acquisitions of adjacent lands. After extreme events (e.g., flooding), there might be willing sellers, so it would be advisable to put financial programs in place to discourage rebuilding in transition zones. Where acquisitions are unlikely (e.g., due to legal obligations for upstream jurisdictions to protect existing structures), incentivizing sustainable approaches and working with existing landowners to change land management practices could also enhance transition zone quality.

Freshwater connections occur throughout the transition zone. In the Los Peñasquitos estuary, the transition zone gradient is currently controlled both by salinity and elevation, largely due to anthropogenic impacts. It is important to maintain connectivity where appropriate, but also to consider the impacts of increased anthropogenic freshwater flows and associated contaminants ("urban drool"). Bioswales could be an approach for managing flows, as could creating freshwater wetlands that transition to tidal wetlands with sea-level rise. Interacting with the California Environmental Flows Framework will be useful in the planning process for considerations of freshwater inputs. There is also a need to improve our understanding of the relationship between groundwater intrusion and recharge as well as underlying geology. It would be advantageous to build on the recent focus on the management of groundwater basins driven by SGMA (Sustainable Groundwater Management Act).

Sediment inputs to the transition zone can be advantageous in helping tidal wetlands keep pace with sea-level rise, but they can also be detrimental when excessive sedimentation leads to smothering of tidal wetlands and blockage of channels. Sediment smothering in Los Peñasquitos Lagoon has been associated with changing land practices in the watershed, including increased soil erodibility from cattle grazing dating back two centuries. Paradoxically, tidal wetland smothering as part of the progradation of alluvial fans might actually be considered a creation of incipient transition zones, but this may not be considered advantageous depending on management goals (e.g. replacement of native salt marsh with weed-dominated transition zone). When thinking about long-term sediment management strategies, it is necessary to consider creative temporary use of stockpiled sediment. Consideration should be given to creating short- and mid-term storage areas associated with ongoing sediment management efforts, including detention basins. If longer-term storage is needed and habitat is created with sediment, this habitat might have to be eliminated someday to reuse the sediment. Trading sediment between systems is possible, but transportation and handling costs can be very high.

Managing invasive species is another important consideration for Los Peñasquitos (and all other transition zone areas). Transition zones tend to be much more invaded than the tidal wetland itself. Because of the many invasive species and their impacts, prioritization of management strategies based on urgency may be needed. Coordination of invasive species management across landowners, both in the estuary and watershed, is critical.

Figure 6 shows a number of opportunities in Los Peñasquitos:

Area A: Unlike the north side of the estuary, the south side is less disturbed with no residential development and no major road. The existing transitional zone adjacent to the Torrey Pines bluffs should be protected.

Area B: The alluvial fan at the mouth of Carmel Valley by the I-5 crossing is a transition zone opportunity, with rising ground adjacent to the wetlands and no significant hydraulic barriers. This area offers some desirable ecological functions, such as support for endangered Ridgway's Rails, but significant sedimentation and invasive vegetation impacts the quality and extent of the wetlands. There may be opportunities to grade topography to reduce the impact of excessive sedimentation, although considerations of trade offs will be important.

Area C: The Sorrento Valley appears to be one of the best opportunities to allow transgression of tidal marsh along the valley floor as sea-level rises, and is currently the focus of planning work associated with implementation of the Los Peñasquitos Lagoon Enhancement Plan. This includes:

- Protecting extant, high-quality habitat while restoring areas impacted by sediment loading, anthropogenic freshwater, and invasive species
- Restoring up to 23 acres of salt marsh through freshwater management and focused earthwork
- Reducing sediment loading in the lagoon through floodplain enhancements, including detention basins and bioengineered grade control structures
- Managing freshwater through improving conveyance, restoring grades, and flood attenuation

Between areas A and B and areas A and C are the best opportunities. These sites are currently identified for large-scale restoration, including up to 86 acres of salt marsh and 100 acres of transition zone by 2050.

6.2. Goleta Slough

Goleta Slough (Figure 7) provides another case study for transition zone habitat within a large river valley. The distribution and extents of habitat types at Goleta have changed substantially from historical conditions. Salt pannes have been eliminated from the system and tidal wetland area has decreased by 62%; today, tidal wetlands exist only in the lower reaches of the slough (Figure 8). There have also been reductions in intertidal flat (78%) and subtidal (58%) habitat area. The Goleta Slough estuary is intermittently open, breaching during large rains and closing during dry periods. It has been managed since the mid-1990s to open for flood control and water quality purposes. The likely evolution of Goleta Slough with sea-level rise is described in the Goleta Slough Area Sea Level Rise and Management Plan (ESA 2015).

Figure 7. Aerial imagery of the Goleta Slough area.

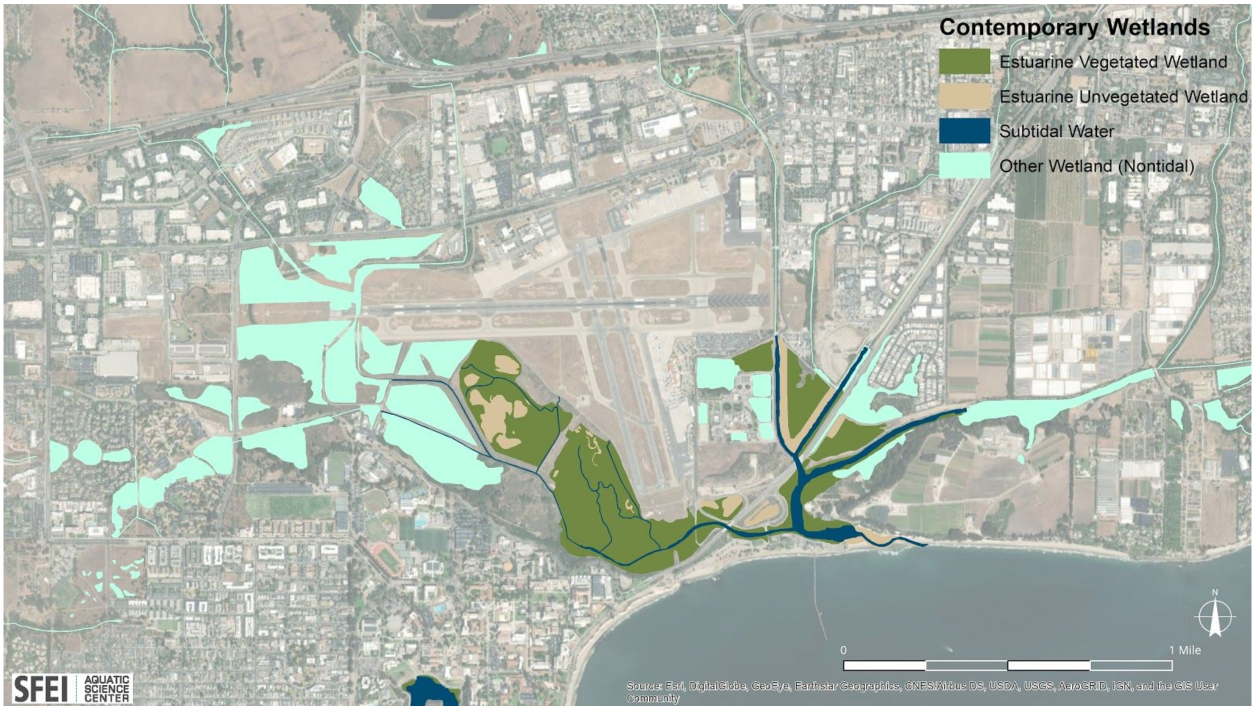

Figure 8. Current wetland habitat in the Goleta Slough area.

With projected sea-level rise scenarios, active management to keep the mouth of Goleta Slough open, and no special actions to address sea-level rise, a number of habitat shifts are expected (ESA 2015). Low salt marsh is likely to be converted to intertidal flats in the basins south of the airport runways. Upland habitats adjacent to the Slough could be colonized by tidal wetland transgression in the absence of development; however, the current land uses (e.g. airport outfield areas) for many of the uplands adjacent to the Slough are not compatible with wetland migration. Elevated tide levels are likely to shift the head of tide upstream and convert freshwater wetlands located near the downstream reaches of the Slough to tidal (saltwater) wetlands. Recent restoration projects in Goleta Slough include the Western Goleta Slough Wetland Restoration Project adjacent to South Los Carneros Road, which extended the tidal wetlands beyond those shown in Figures 7 to 10, opening up new transition zone opportunities.

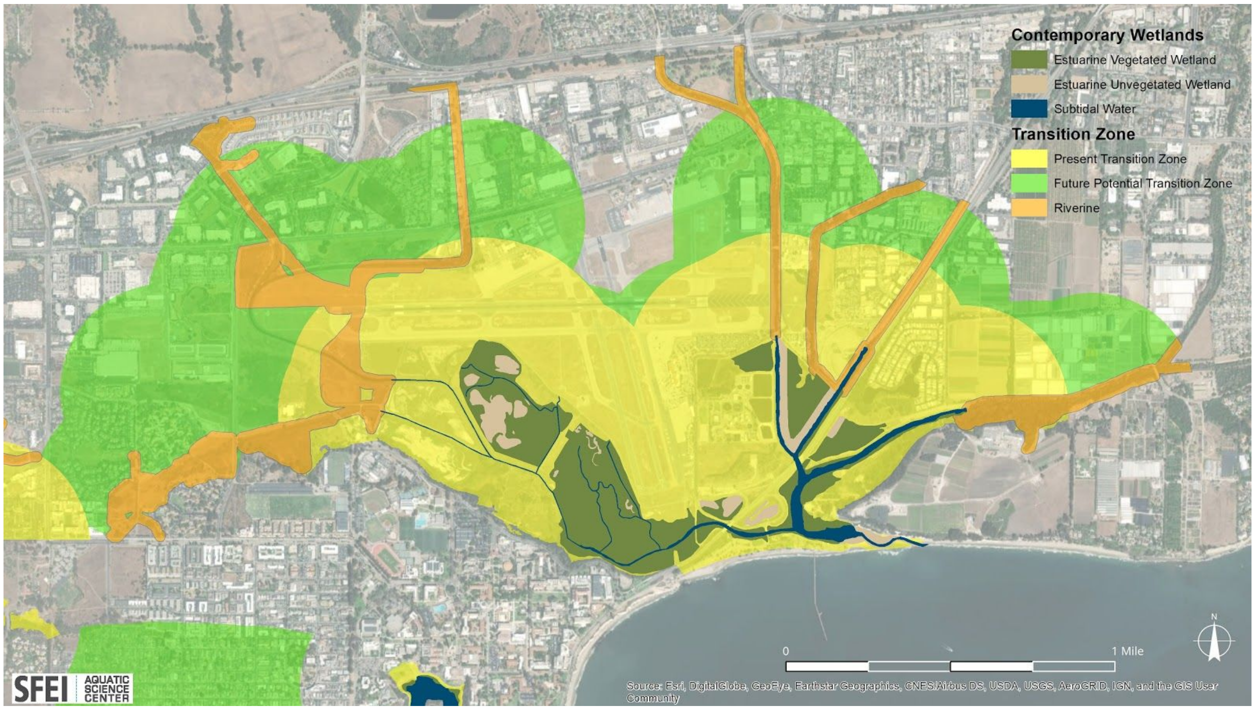

Figure 9. Mapped transition zone habitat in the Goleta Slough area.

Figure 10. Mapped transition zone habitat for the Goleta Slough area, with developed land excluded and opportunity areas labeled.

Goleta Slough is an example of a large river valley wetland dissected by levees and berms, with extensive development in and around the slough separating future transition zone areas into poorly connected fragments (Figure 10). With the limited extent of tidal wetland, the transition zone is limited to adjacent diked wetlands without much natural elevation gain. In this area, there is a need to restore tidal wetlands first, to create opportunities to reconnect the wetland-upland transition zone. In some places, ecotone levees could provide transition zone along developed edges of the floodplain.

Area A: Areas of rising ground north of Mesa Road are adjacent to existing tidal wetlands. There are opportunities to connect these wetlands to the UCSB mesa and create a connected transition zone. Actions may be limited to management of invasives and drainage of stormwater flows from the mesa.

Area B: Berms adjacent to the existing wetlands and UCSB mesa, south of the slough and away from the airport, could be breached to improve tidal action to the former tidal wetlands. An improved tidal marsh could connect to the gently rising ground running parallel to Mesa Road. This would extend the wetland-upland transition zone along the length of the mesa.

Area C: Tidal action has been restored to some of this area, but there is no naturally rising ground and so flood risk management levees are required to protect development. Here, ecotone levees could be constructed with fill material placed and graded at the landward edge of newly breached areas to create transition zone habitat along South Los Carneros Road.

Restoring wetland and transition zone habitat in this area would better support diverse assemblages of native species found in this region. Newly created upland transition zones at the backs of newly restored tidal wetlands would allow for wetland transgression as sea level rises, as well as the other important ecological linkages and connectivity benefits discussed previously. Restoration of the tidal prism may also reduce costs associated with Slough mouth management, provide increased stormwater storage capacity, and increase resiliency of wetland habitats in this area.

6.3. Los Cerritos Wetlands

The Los Cerritos Wetlands (Figure 11) are located in the large, relatively flat, and easily drained floodplain of the San Gabriel River that has historically been very attractive for development. As in other fragmented river valleys, levees break up the floodplain, separating wetlands from channels and upland (SCWRP 2018). Oil extraction and industrial and residential development have reduced tidal wetlands to a fraction of their former area (Figure 12). Remnants of the floodplain have been dissected into smaller, spatially distinct units. The habitats within these fragments do not necessarily reflect the diversity or proportions of habitats in the relatively undisturbed wetlands of Steamshovel Slough. Wetlands may be completely separated from adjacent uplands. In some parts of the floodplain, drained and diked wetlands create a “faux” transition zone in subsided areas. Recent restoration plans for the Los Cerritos Wetlands are described in the Los Cerritos Wetlands Restoration Plan Program EIR (ESA 2020).

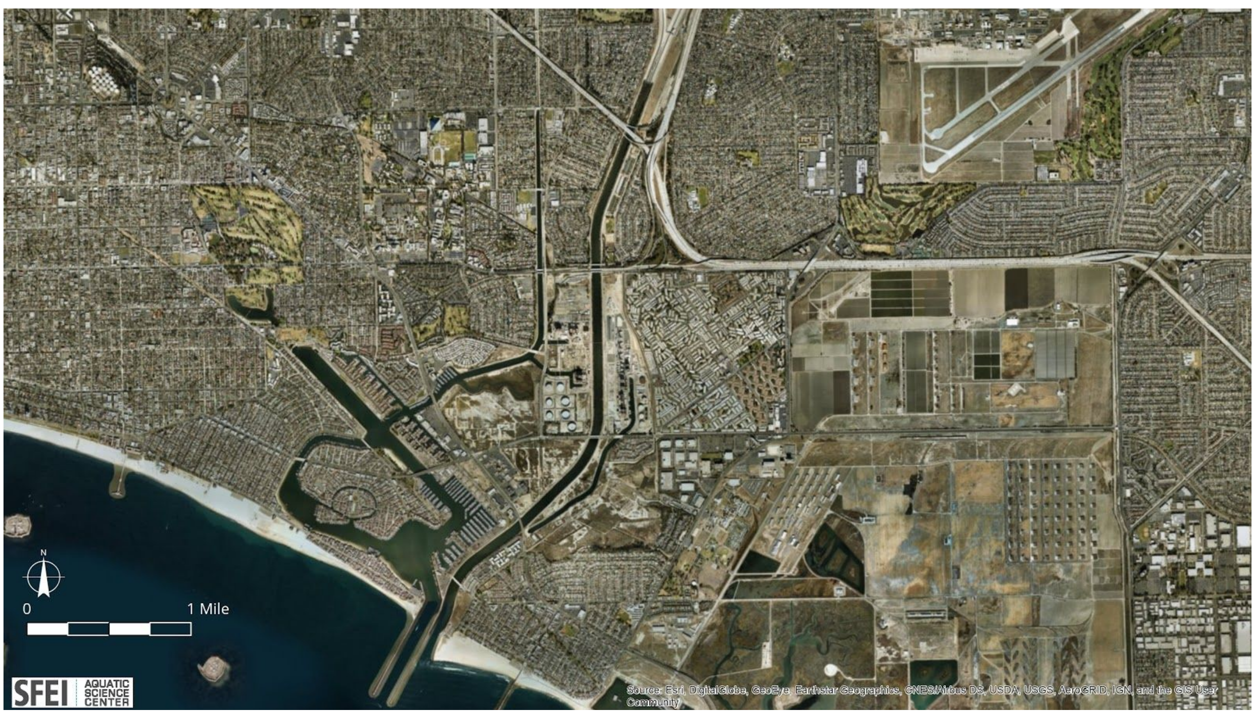

Figure 11. Aerial imagery of the Los Cerritos Wetlands.

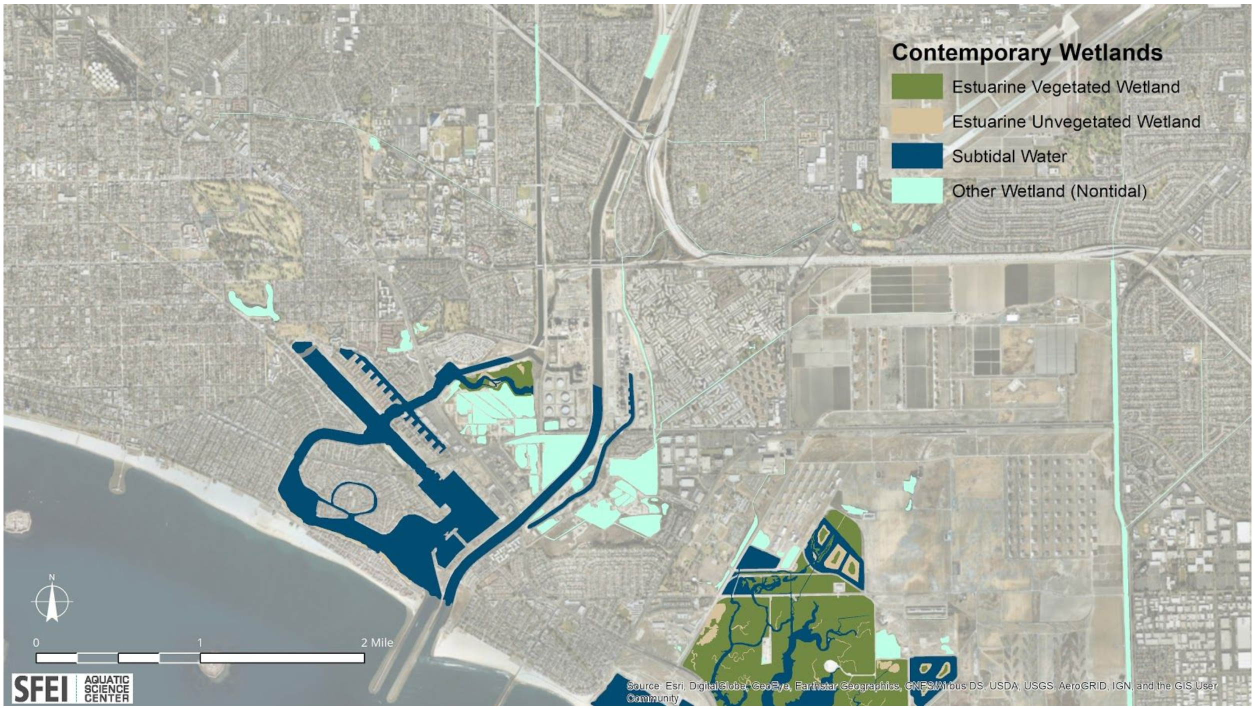

Figure 12. Current wetland habitat in the Los Cerritos Wetlands area.

In the Los Cerritos Wetlands area, there are opportunities for large-scale wetland restoration in the “faux” transition zone of former wetlands, but these are disconnected from the natural transition zone (Figures 13 and 14). Land swaps and rezoning would be required to promote the restoration of both wetland and transition zone habitat. It may be possible to manage for protected transition zone habitat on slopes to the southeast of the power station’s cooling system channel; this would require restoration of adjacent wetlands. In the northern part of the site, the upland habitat is adjacent to roads and is not suitable for natural transition zone restoration, though there may be an opportunity to provide artificial transition zone habitat on constructed levees.

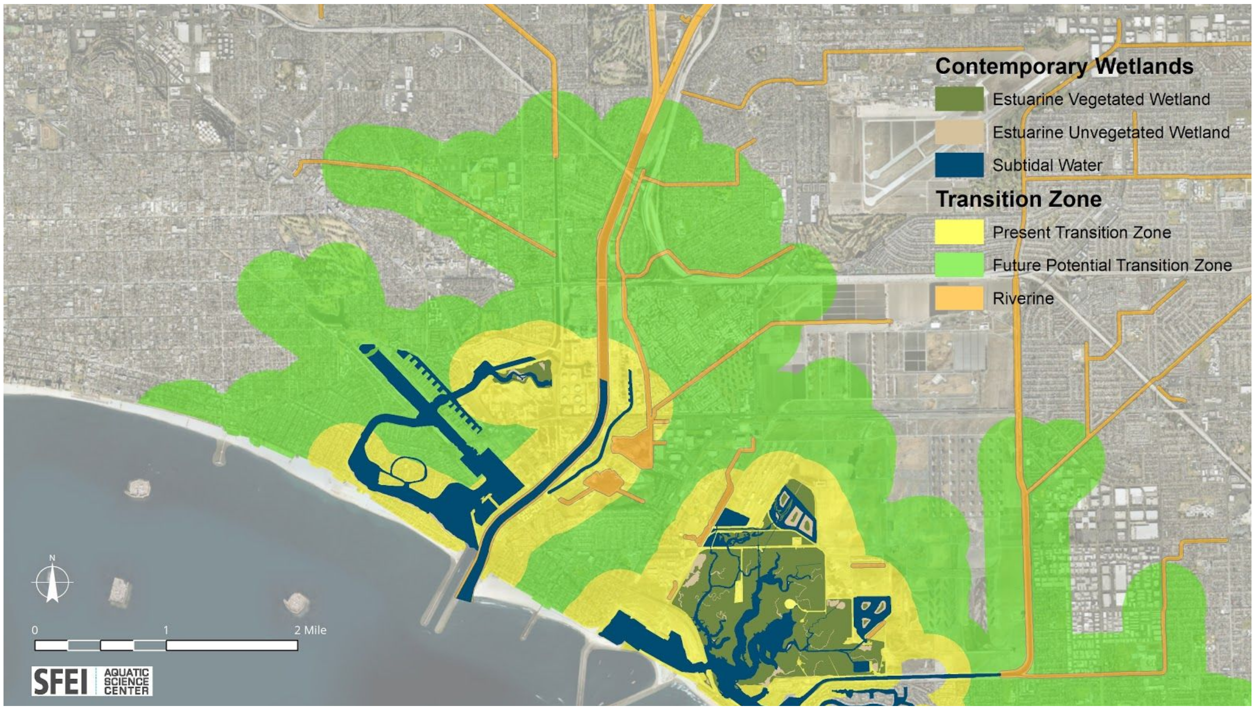

Figure 13. Mapped transition zone habitat in the Los Cerritos Wetlands Area.

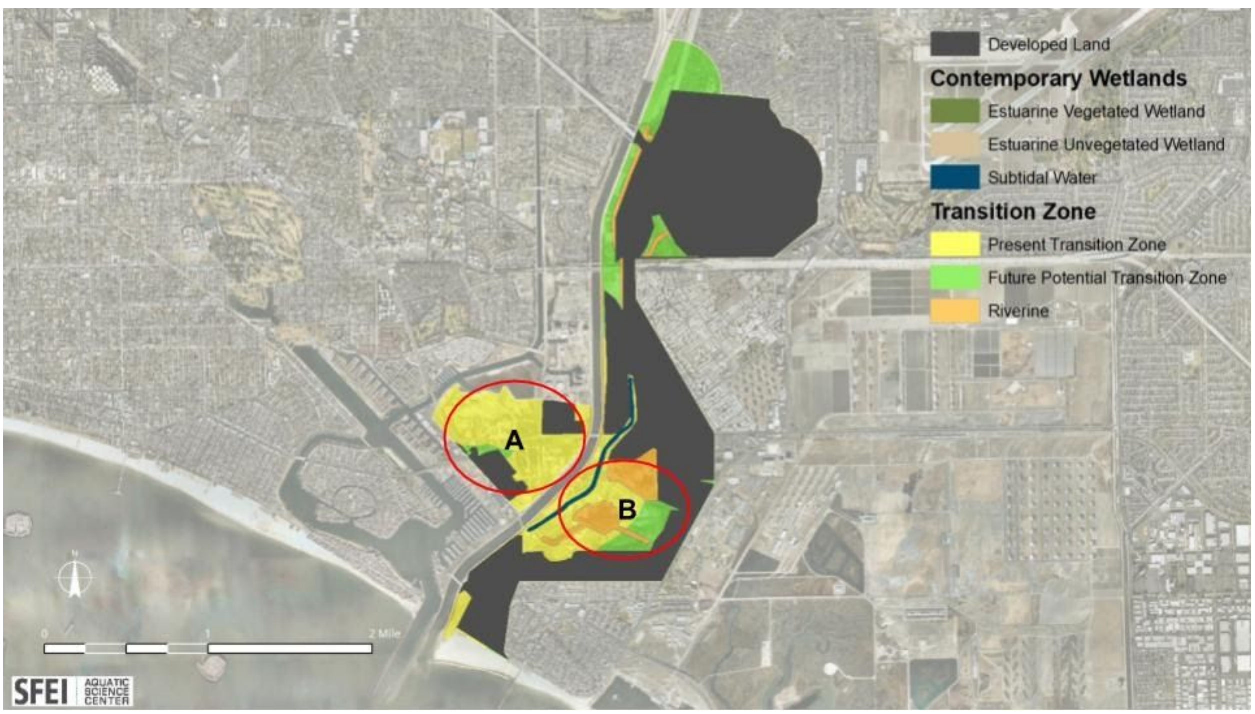

Figure 14. Mapped transition zone habitat for the Los Cerritos Wetlands area, with developed land excluded and opportunity areas labeled.

Los Cerritos Wetlands is an example of a large river valley wetland dissected by levees and berms, with extensive development and industrial activity within the historical wetlands. The San Gabriel River splits the transition zone opportunities in two. To the north of the river, in the middle of the historical floodplain, all the transition zone opportunities require artificial fill and any new opportunities will involve the construction of features such as ecotone levees. In the south there are opportunities adjacent to Marina Hill to connect wetlands to rising land. However, all the transition zone opportunities can only be realized after tidal action has been restored to the adjacent parcels and marsh has been established. This is further complicated by the need to accommodate the constraint presented by oil production facilities and associated access in the central site after restoration.

Area A: Area A is in the middle of the historical floodplain, bounded by the Los Cerritos Channel and San Gabriel River to the north and south, and development to the east and west. It is bisected by East 2nd Street which will require increased protection by raising or levees if the adjacent lands become tidal. Since there is no naturally rising ground, nature-based features such as ecotone slopes could be constructed along any new levees in Area A to provide transition zone habitat after breaching. Similar features could be constructed around the individual oil wells to provide protection and access. Since this is a large area surrounded on three sides by levees (creating a long perimeter), an alternative using less fill would be to create marsh mounds rather than linear ecotone slopes within the wetlands. The slopes of any ecotone levees would be determined by the availability of fill and the available area — which may be limited by the locations of the various oil wells.

Area B: There is a naturally sloping area along the base of the Marina Hill that could provide transition zone habitat. However, at present the adjacent historical wetlands are disconnected from tidal action. Restoration of the wetland-upland transition will require the restoration of tidal action to the Hellman and South LCWA sites. Any stormwater flows from Marina Hill and Island Village will have to be managed. The Isthmus presents its own specific issues as it is a very narrow site that has been filled to quite high elevations with dredge spoils from the San Gabriel River. While there is some tidal wetland restoration on the Isthmus, perhaps a more valuable opportunity is to increase connectivity with the Hellman and South LCWA sites by modifying the Haynes Cooling Channel into more of a tidal slough, with the Isthmus as one bank.

In Los Cerritos Wetlands and other fragmented river valleys, Local Coastal Plans (LCPs) provide an opportunity for collaboration in transition zone management. There is also the potential to coordinate LCP monitoring with SCWRP (Southern California Wetlands Recovery Project) monitoring. Public utilities and transportation entities such as Caltrans are other important agencies to collaborate with to develop transition zone management strategies in heavily developed areas.

6.5. Kendall-Frost Mission Bay

Kendall-Frost Mission Bay Marsh Reserve (Figure 15) is a protected area managed by the University of California Natural Reserve System. Like other open bay and harbors, the edge of most of Mission Bay lacks wetlands; upland habitat is directly adjacent to shallow subtidal habitat, with a vertical wall, riprap, or a beach in between (SCWRP 2018). There are some pockets of wetlands (like the Kendall-Frost Mission Bay Marsh Reserve), which are very constrained by development (Figure 16). The landscape is largely artificially constructed and there is little adjacent undeveloped upland for wetland migration or transition zone. Recent restoration plans for Kendall-Frost Mission Bay are described in the ReWild Mission Bay: Wetlands Restoration Feasibility Study Report (Everest International 2018).

Figure 15. Aerial imagery of the Kendall-Frost Mission Bay area.

Figure 16. Current wetland habitat in the Kendall-Frost Mission Bay area.

While the transition zone area is very constrained by development (Figures 17 and 18), there are small pockets where management for transition zone protection is possible. There are also opportunities to create habitat corridors to connect to other nearby open spaces. It also may be possible to grade upland within the footprint of the Reserve. However, this raises significant regulatory issues because the conversion of habitat from one type to another needs to be justified.

Figure 17. Mapped transition zone habitat for the Kendall-Frost Mission Bay area.

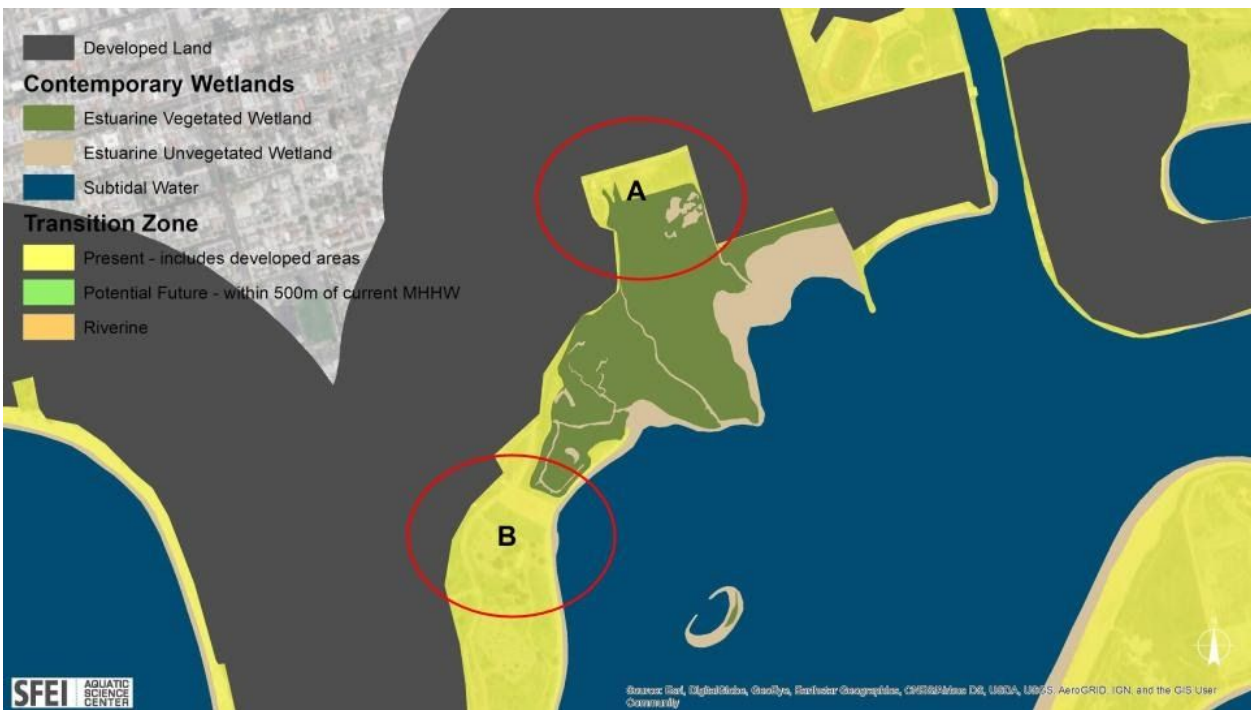

Figure 18. Mapped transition zone habitat for the Kendall-Frost Mission Bay area, with developed areas excluded and opportunity areas labeled.

The Kendall-Frost Reserve is an example of a small wetland within a highly modified system that is very constrained by development. Here upland opportunities are based on artificial fill and are immediately adjacent to shallow subtidal habitat — unlike the previous examples where tidal wetlands and upland are separated by diked historical wetlands. Expanding the area of tidal wetlands will require grading of upland or filling of the subtidal area.

Area A: At the Kendall-Frost Reserve the upland at the back of the existing marsh is construction fill on top of historical marsh, and other areas may be dredged material (Everest 2018). These existing upland areas could be graded to provide appropriate slopes and perhaps have more suitable soil placed on top. Transition zone slopes could be planted with native species at the back of the marsh to enhance habitat quality. The area of upland is limited by the tidal marsh in front and the development behind.

Area B: At Crown Point Park there is space to continue the estuarine habitat band south from Kendall-Frost Reserve. There is upland habitat but no marsh. Creating a marsh by grading down the elevations would mean the loss of upland. This would narrow an already narrow band of upland and reduce the resiliency of the area as sea levels rise. An alternative could be to place fill in the Bay to create marsh at the expense of shallow subtidal habitat. If marsh could be established in Area B then the upland areas could still be accessible to the public but with a modified layout providing more separation from tidal areas. This could include the reconfiguration of the parking lots closer to Crown Point Drive.

Participants at the MTAG workshop identified a number of potential management issues for the Kendall-Frost site. Despite the development that has drastically changed areas like Mission Bay from their historical ecological conditions, it may be possible to “fit all the pieces of the puzzle back together.” Mission Bay was formerly a large wetland that was dredged for recreation and boating; today it is mostly subtidal eelgrass habitat. Filling in some of these subtidal areas to create tidal wetlands and connecting them to wetland-upland transition zone would return the Bay closer to its historical wetland condition.

The harbors and embayments of Mission Bay are important for a variety of human uses, so it will be important to keep people involved in planning processes, allow access, and incorporate recreation and educational components into restoration projects. Where appropriate, natural and built features can be combined. For example, golf courses and parks can include natural features and green infrastructure like bioswales, native vegetation, and ecotone levees. Islands can be built using trapped sediment in managed tributaries; this would create habitat with no net export of sediment.

6.6. Aliso Creek

Aliso Creek is an example of a small creek that has been filled and modified (SCWRP 2018) (Figure 19). At the mouth of the creek there is an inlet with minimal subtidal habitat area and a small area of vegetated tidal wetland (Figure 20). The channel slope is generally steep. Steep watersheds and narrow valleys limit the area available for tidal wetland migration space and future transition zone (Figure 21). Often in small creek valleys, significant portions of the valley have been filled and graded for parking lots, etc. (Figure 22). However, the natural topographic gradient in small creek valleys can provide valuable transition zone restoration opportunities. Recent restoration plans for Aliso Creek are described in the Aliso Creek Estuary Restoration: Conceptual Restoration Plan (ESA 2018).

Figure 19. Aerial imagery of the Aliso Creek watershed.

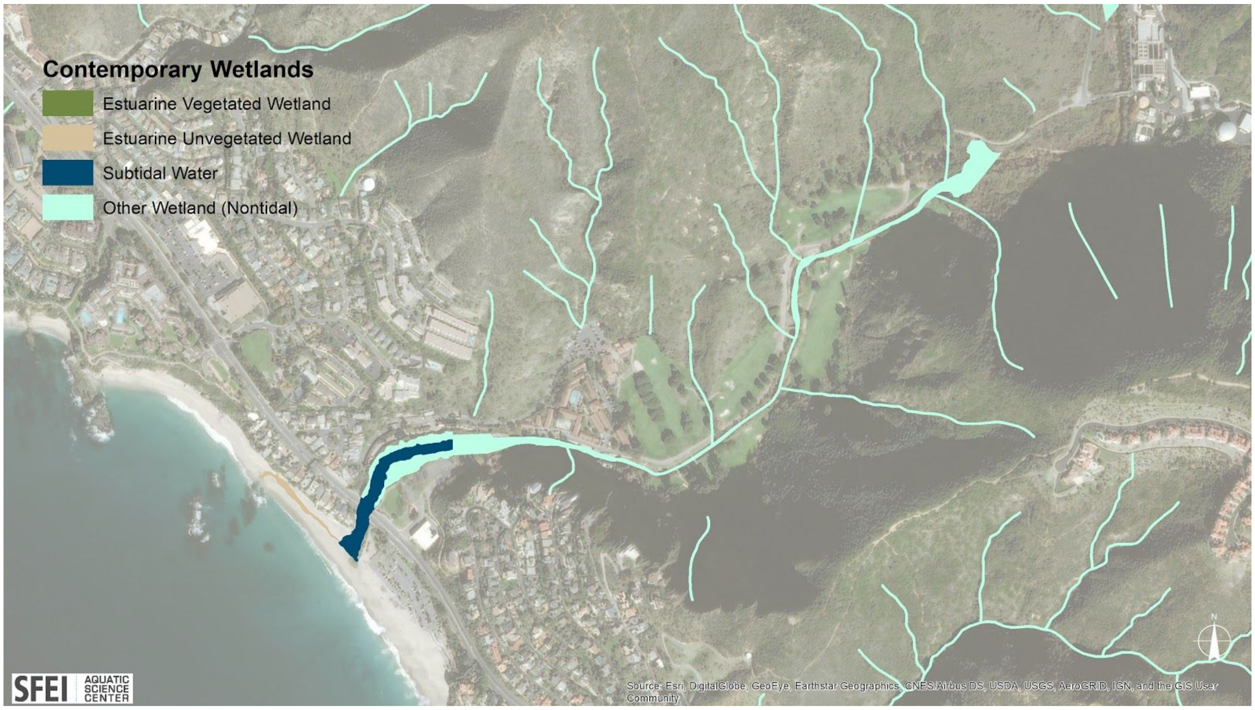

Figure 20. Existing wetland habitat of the Aliso Creek watershed.

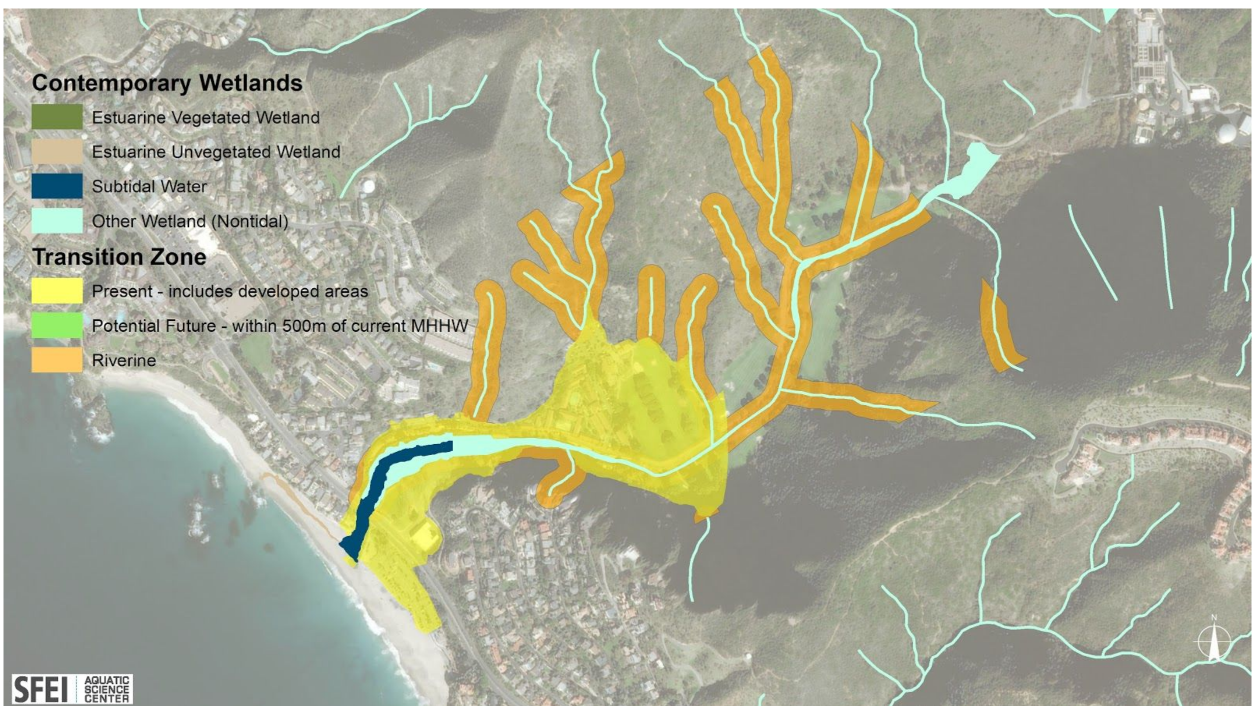

Figure 21. Mapped transition zone in the Aliso Creek watershed.

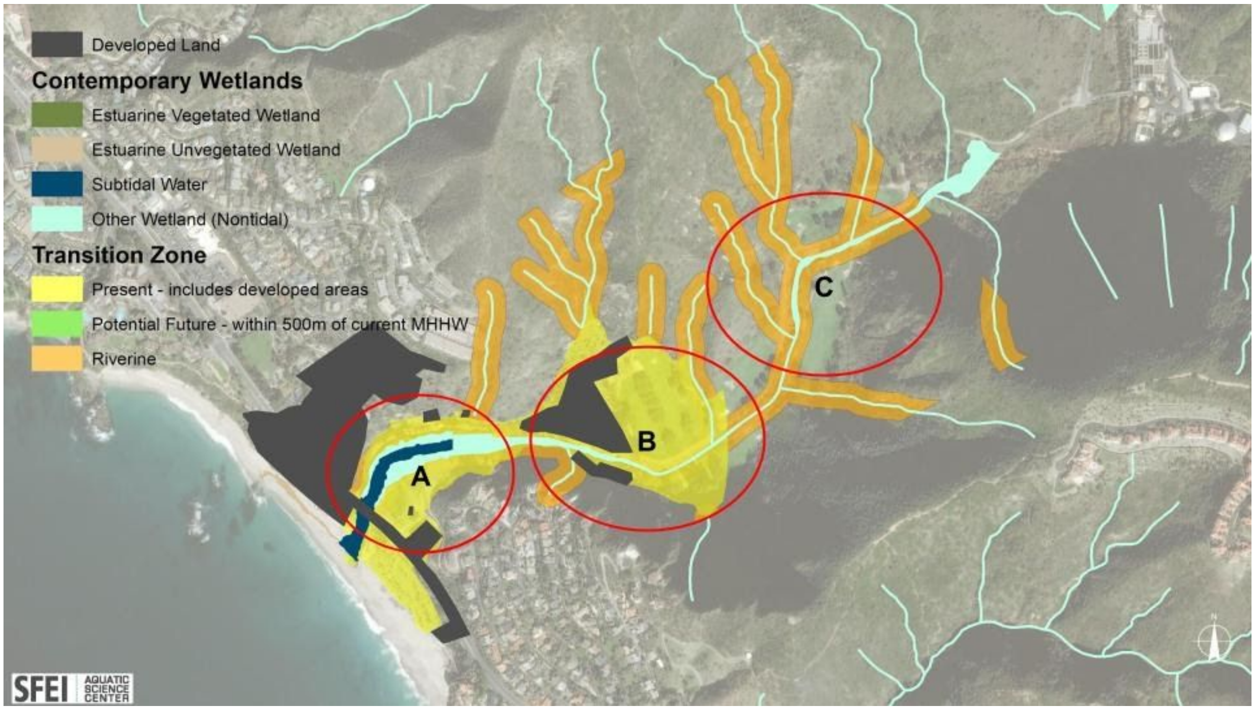

Figure 22. Mapped transition zone in the Aliso Creek watershed, with developed areas excluded and opportunity areas labeled.

Small creeks may offer some of the best opportunities to create resilient systems as sea-level rises along their valleys. However they are limited in area and have often been highly modified, particularly by Pacific Coast Highway road crossings and fill associated with Caltrans parking lots near the mouth. Because areas higher in the watershed are relatively undeveloped, there are multiple opportunities for transition zone restoration further away from the coast.

Area A: Area A is an important site as it connects the coastal system and watershed. However, it is the most heavily impacted today. Regrading and reconfiguring the parking lot south of the creek at Area A could create a significant area of tidal wetland and adjacent transition zone relative to the size of the system. The parking lot would probably need to be retained in some form, or spaces found elsewhere, given the proximity to and popularity of the beach. Opportunities also exist on the north bank if the yard area becomes available. Expanding the tidal area could increase the tidal prism and assist with management of mouth closures. Expansion would also improve ecological connectivity and wildlife corridors between the coast, beach, and the lower watershed.

Area B: Area B offers more opportunities for improving ecological connectivity and wildlife corridors further into the watershed, particularly if more wetlands are established in Area A. The creek banks of the golf course could offer opportunities for laying back the edges and modifying some of the landscaping practises and vegetation. Runoff from golf course irrigation may need to be managed.

Area C: Looking higher up in the watershed there may be opportunities for improving the riverine transition zone in Area C. This may be assisted by the relocation of wastewater pipes that currently run along the creek channel. However, the opportunities decrease higher up, away from the head of tide, as the valley slopes steepen.

Participants at the MTAG workshop identified a number of potential management issues for the Aliso Creek site. Opportunities for restoration in the coastal zone at Aliso Creek are very close to the beach and may be short-lived considering sea-level rise. The smaller size of the floodplain and the steep slopes have some advantages. Typically, fewer players are involved along small creek channels due to their limited area, though Caltrans is a major player in many of the watersheds that the Pacific Coast Highway cuts through. Canyon systems tend to be less intensely developed, and it is feasible to work at the whole watershed scale. There are often fewer flooding issues due to morphology.

There are some disadvantages as well. For example, there is less room for transition zones, due to steep topography, and small creek systems are not as well understood as larger systems. Less research has been done on these types of wetlands, and the work that has been done has typically focused on specific species (e.g., tidewater gobies and steelhead). There is a need to better understand the ecology, geomorphology, and hydrology of small creek systems. Connectivity with adjacent habitats should be considered, especially for upstream areas, with a possible focus on fish passage in accordance with California SB 857.

It is also necessary to consider beach processes and how these may shift in the context of climate change and changes in transition zone management. The lagoons that form at the mouths of some small creeks are very dynamic and have intermittently-open, bar-built estuaries. Beach users will sometimes breach an inlet to surf the resulting wave, which interrupts the natural hydrologic and ecological processes of the creek. More public awareness and educational outreach is needed about these systems to protect the valuable habitat that intermittently-open systems provide.

Public access is vital in places like Aliso Beach Park. In many places along the Southern California coast, natural processes of small creek channels have been impacted by the construction of the Pacific Coast Highway and/or parking lots. Changing the configuration of parking lots is a possibility (this has been proposed for Aliso Creek), but this can constrain already-limited public access. Multi-modal access points should be explored in the future; this may mean migrating parking to more suitable locations and providing shuttles, encouraging ridesharing, and developing infrastructure that promotes pedestrian and bicycle access.

7. Recommendations for future research

Currently, there are few documented examples of the habitat shifts that occur when infrastructure (e.g. levees) is removed or habitat fragments are converted from one type to another. Careful monitoring of changing conditions after these interventions occur will be useful for predicting changes at future restoration sites. More site-specific investigation (in addition to lessons learned from elsewhere) is needed to determine what is appropriate and feasible at individual sites.

There is considerable work being done on nature-based features in California from which lessons can be learned and modifications made to make them applicable to local Southern California conditions. For instance there are a number of ecotone levee pilot projects that may provide useful information.

Managers need better scientific information about the benefits of transition zone habitat restoration. For example, quantifying the carbon sequestration capacity of restored wetlands and transition zones would be particularly useful given recent RFP requirements (e.g. for California Cap and Trade funds). Similarly, knowing more about the flood risk reduction capacity of nature-based features could help managers collaborate with partner agencies and communities to complete multi-benefit restoration projects. Managers also need more information about the adaptability of species, as some species may have more adaptive capacity than previously assumed.

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Appendix A

Appendix 9 of Wetlands on the Edge: The Future of Southern California's Wetlands Regional Strategy 2018

Appendix 9: Transition Zone Background & Methodology

of the *Wetlands on the Edge: The Future of Southern California's Wetlands Regional Strategy 2018*

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Protection and restoration of wetland-upland transition zones are critically important if tidal wetlands are going to persist. Objective 5 provides preliminary recommendations for the preservation of existing transition zone habitats. In order to implement this objective, project proponents need to map existing and proposed transition zones.

The wetland-upland transition zone connects tidal wetlands to adjacent terrestrial habitats, providing flooding refuge for wildlife, space to accommodate marsh transgression with sea-level rise, and other vital ecosystem functions. Much of the historical transition zone habitat in California has been lost due to competing land uses along the shoreline. Accelerating sea level rise increases the challenge of supporting transition zone habitats, and ecosystem services associated with transition zones, especially in heavily developed areas.

Ecosystem Services Provided by Transition Zones

The transition zone provides many important ecosystem services. These areas provide important refuge for marsh wildlife, and allow upland wildlife to access the marsh for food and other resources. These areas support gradients in environmental variables such as salinity, soil moisture, and temperature that can be important to supporting adaptation within wildlife populations, and can also support unique habitat types (e.g. alkali wetlands, salt pannes) that further contribute to landscape complexity.

Protection and restoration of marsh transition zones are critically important if tidal wetlands are going to persist. Objective 5 provides preliminary recommendations for the preservation of existing transition zone habitats.

To implement Objective 5, project proponents need to map existing and proposed transition zones. This document describes a method for defining an upper boundary for the wetland-upland transition zone. It can be used to determine how far up into the watershed to look in order to plan for transition zone management in an aspirational way. Defining an upper boundary for potential transition zone is meant to encourage wetland managers to think outside of the current wetland boundaries, and to consider larger-scale and longer time- horizon planning; think through how restoration and management actions within the region might fit together to restore and maintain transition zone habitats and processes over the long term. This boundary encompasses potential marsh migration area as well as providing an important habitat zone (Figure 1). While the marsh migration zone is defined by elevation (24 inches, see Appendix 4), the upper boundary is determined by extent upslope or upstream (see details below). As sea levels rise and marshes migrate landward the transition zone moves upslope in tandem.

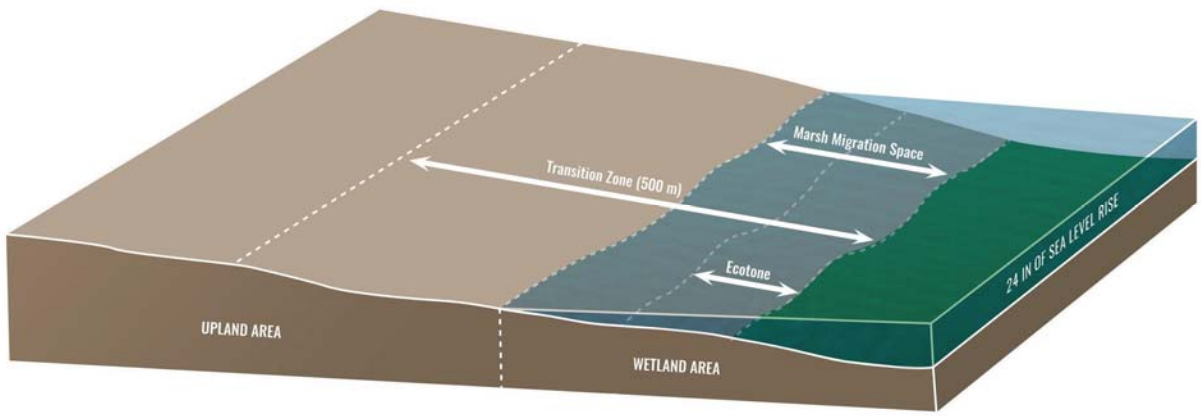


Figure 1. Diagram showing the relationship between "marsh migration space" and "transition zone".

Land use is a major consideration in determining what can be done within this transition zone boundary. Although many developed areas are unlikely to be considered for potential restoration, these areas may still support transition zone functions. For example, some land uses in developed areas (e.g., vacant lots, golf courses) may still provide some buffering functions. Actions taken in developed areas within this boundary can support wildlife movement (e.g., removal of barriers and planting of native vegetation in yards), and affect flood control (e.g., rain gardens and bioswales). Infrastructure realignment within these areas, to protect from increased flooding with climate change, may provide opportunities for transition zone restoration.

The first half of this document explains what the wetland-upland transition zone is, why it's important, and why mapping it is challenging. This context is necessary for understanding the assumptions made in the methodology. The second half of the document describes the proposed methodology for defining an aspirational transition zone boundary.

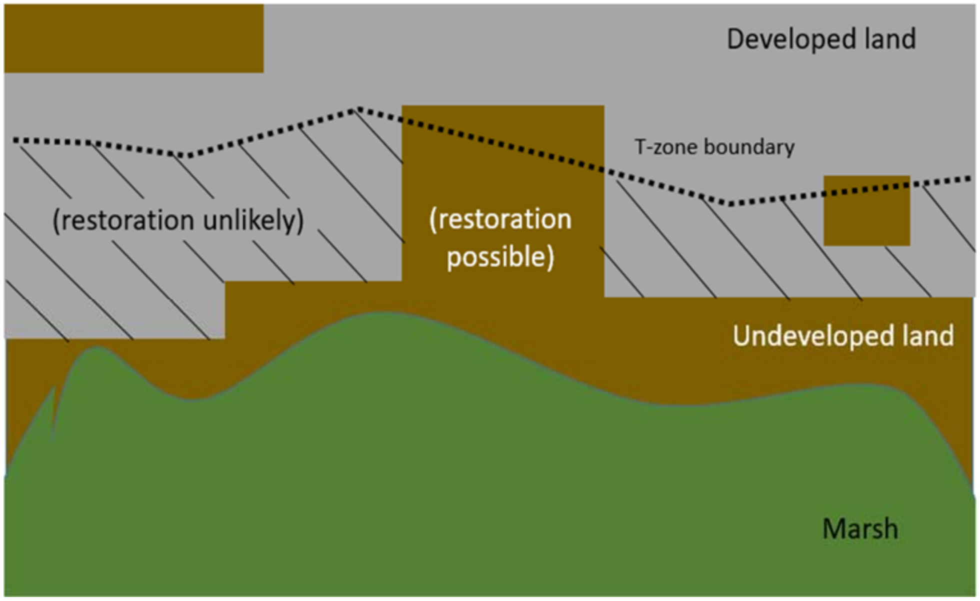


Figure 2. This boundary delineates an upper boundary for the existing and potential transition zone or potential transition zone.

Background on Transition Zones

What is the transition zone?

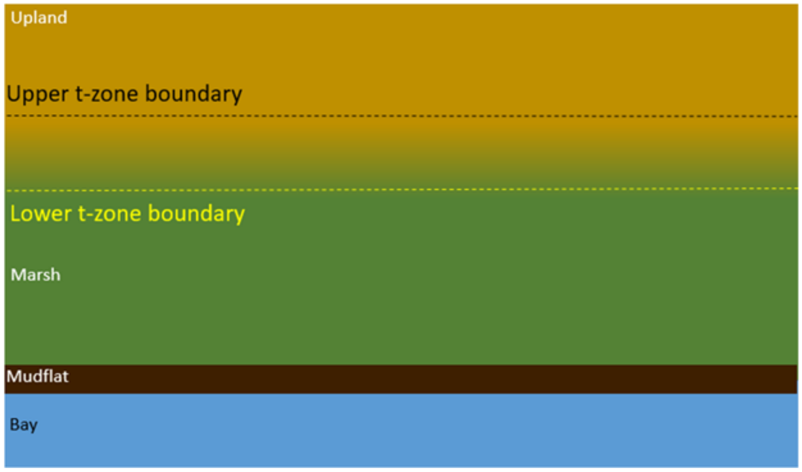
Wetland-upland transition zone definition[1]

The wetland-upland transition zone is the area of existing and predicted future interactions among tidal and terrestrial or fluvial processes that result in mosaics of habitat types, assemblages of plant and animal species, and sets of ecosystem services that are distinct from those of adjoining estuarine, riverine, or terrestrial ecosystems.

Conceptually, the transition zone spans from the upper reaches of land that is influenced by the tides, up to an area of land that is not currently influenced by tides, but may be in the near future with sea level rise. The upper boundary of the zone transitions into upland and a lower boundary that transitions into intertidal wetlands (Figure 2). The type of transition zone (determined by the slope, hydrology, soils and vegetation) can affect its width.

[1] From Bayland Ecosystem Habitat Goals Update (2015)

A)



B)

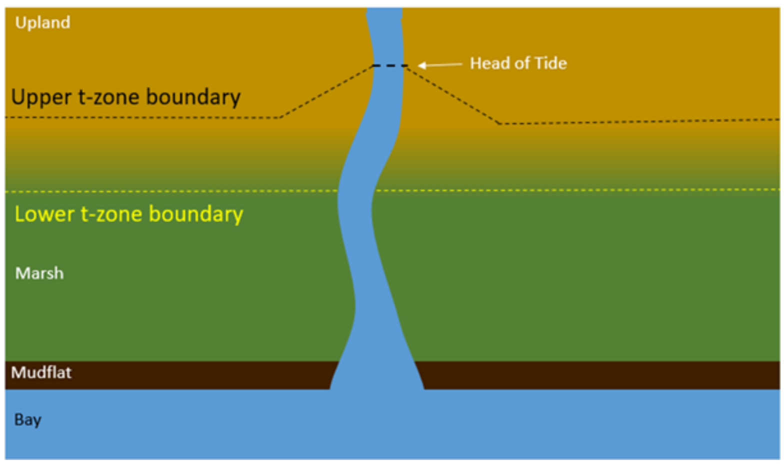


Figure 3. Simplified diagram of a wetland-upland transition zone, showing the lower boundary connecting to tidal marsh and the upper boundary connecting to adjacent upland (A) or streams/rivers (B). Different types of transition zones are shown in Figure 5.

The location of the transition zone moves over time as tidal marshes move with changing sea level (Figure 3). In areas with low gradient slopes, today's transition zone becomes tomorrow's marsh. As rates of sea level rise increase this marsh migration may not be able to offset marsh loss without ensuring adequate sediment supply and other conditions that promote marsh growth. Effective transition zone management can help support this process.

Where the transition zone is, or could potentially be, changes over time. For the methodology described here we specify the time period for which the boundary is being defined.

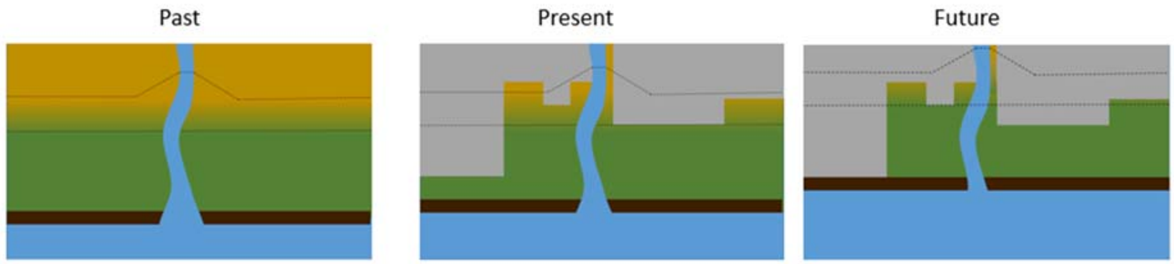


Figure 4. The location of the transition zone changes over time. Today much of the area that could potentially be transition zone has been developed. In this figure the area between the dashed lines is meant to represent transition zone or potential transition zone for different time periods.

What is the value of the wetland-upland transition zone?

The transition zone provides many important ecosystem services. Here we consider the benefits that the transition zone provides to terrestrial wildlife and terrestrial processes, as well as wetland species and processes, taking both an "estuary up" and "watershed down" approach. The value of the transition zone to the current and future health of our wetland ecosystems cannot be overstated. The list of ecosystem services used for this effort is focused on those ecosystem services most relevant to defining the outer boundary - wildlife refuge, wildlife foraging and predation, wildlife and plant movement, evolutionary adaptation, landscape complexity, fluvial flooding, and erosion control.

Buffering is one of the important ecosystem services that the transition zone provides. The transition zone acts as a buffer to prevent stressors from the larger landscape (e.g., contaminants, invasive species) from reaching the wetland. In a regulatory context, buffers are areas of upland surrounding a wetland, generally defined using a fixed width. The buffers defined by regulation will sometimes, but not always, overlap with the ecologically-defined transition zone. There is some regulatory guidance for defining a buffer around wetlands. For tidal marshes this regulatory buffer will overlap with part or all of the transition zone, depending on the site. This buffer may or may not include other important transition zone functions, depending on transition zone condition.

As sea level rises the wetland-upland transition zone provides space for marshes to migrate. Because transition zones areas have the potential to experience tidal flooding in the future, these zones are appropriate places for thinking about sea-level rise adaptation. Even in areas where tides are blocked by levees or seawalls, increasing groundwater levels can cause flooding issues. Sea-level rise adaptation actions might include raising structures out of flood prone areas, building levees to keep water out of low-lying areas and avoiding placement of new structures in vulnerable areas.

The wetland-upland transition zones provides several functions for terrestrial wildlife, both terrestrial and marsh species. Transition zones are especially important as wildlife movement corridors, especially in highly urbanized areas. These wildlife movement corridors can be important for daily movements, seasonal habitat shifts, and juvenile dispersal of both marsh and upland species. Wetland-upland transition zones provide critical support to tidal marsh species such as the Ridgway's Rail by providing areas to escape flood events. Providing access to food is also an important function, as high densities of marsh vertebrates in the transition zone during flood events provide opportunities for native predators such as herons and egrets.

The transition zone can also attract non-native and nuisance predators such as red foxes, rats and feral cats. The degree to which the transition zone supports these less desirable species likely depends on how the zone is managed, and the vegetation it supports, however wider transition zones are generally better at keeping out nuisance non-native species.

The survival of local populations of plants and animals depends on their adaptation to changes in habitat conditions. Such adaption is known to occur at the margins of habitats, including in ecotones. For some species, the transition zone may be critically important as a place for adaptations to changes in habitat conditions caused by sea level rise.

The transition zone contributes to a complex mosaic of estuarine habitat types that increase the local diversity and abundance of plant and animal species across landscapes at a regional scale. Historically this included freshwater wetlands, alkali wetlands, and willow groves. As described for San Diego lagoons historically *"extensive freshwater/brackish wetland complexes were present at the back edge of each estuary, creating a gradual transition zone between estuarine and upland habitat types that in some cases extended several miles inland."*

Different approaches for mapping the wetland-upland transition zone

While the importance of wetland-upland transition zones to support healthy estuarine systems is increasingly recognized, defining the extent of the zone is difficult. Estimates of transition zone extent can vary depending on the ecosystem services considered. There is substantial variation by site in how these functions and services are expressed across the zone, depending on the geomorphology, habitat types, and land uses in areas adjacent to the marsh. Mapping the transition zone boundary is further complicated by existing infrastructure and predicted changes to the extent of the zone over time as sea-level rises.

Recent efforts to map existing and potential transition zone areas for San Francisco Bay (Fulfrost and Thompson 2014) have defined the transition zone based on elevation, with the lower boundary mapped at current Mean Higher High Water (MHHW) plus 0.31m and the upper boundary defined as current Highest Observed Water Level (HOWL) plus 0.27m (note these values are specific to San Francisco Bay). These elevations were chosen to correspond with the approximate location of high marsh vegetation in San Francisco Bay, with an additional area to allow for high tide refuge for wildlife. Such mapping provides a critical resource for land use planning, particularly for managers looking to acquire and protect or restore transition zone sites in the near-term This methodology, however, does not encompass all possible transition zone functions and delineation considerations.

This document proposes a methodology for identifying a more aspirational "outer limit" boundary for wetland-upland transition zone planning in the Southern California Bight that considers climate change and encompasses a broader suite of ecosystem services than previous transition zone mapping efforts. This methodology is geared toward planning at longer time scales for planning at the landscape level, for purposes of protecting undeveloped transition zone areas with a defined outer boundary and identifying currently developed areas within the outer boundary that could be acquired, protected, and restored in the future.

Planning within an aspirational wetland-upland transition zone boundary: Considering landscape resilience

The wetland-upland transition zone “outer boundary” delineation method outlined in this document identifies an area within which transition zone management, and support of associated ecosystem services, should be considered when making land use planning and management decisions. This method is meant to be a quick yet robust way to delineate an inland extent of the transition zone that considers climate change, within which more site-specific considerations (including constraints of developed lands) will be addressed. The approach is meant to be used by planners and regulators to encourage larger-scale and longer-term thinking about incorporating transition zone functions into shoreline planning. The transition zone is a contested zone with both ecological and urban functions. This methodology is not meant to suggest that everything within this boundary remain undeveloped or be restored to open space. Rather, considering sea-level rise and transition zone function more holistically within these areas can help us develop better adaptive and multi-benefit shoreline solutions that improve both ecological and societal benefits over the long term.

The Landscape Resilience Framework (Beller et al., 2015) developed a set of 7 principles that should be considered when trying to achieve ecological resilience at a landscape scale. These principles can help guide actions within this transition zone boundary. More specific guidance for what might be recommended within this transition zone boundary will be provided in other documents.

Below are questions meant as an example on how to assess wetland-upland transition zone considerations using the by landscape resilience principles:

Setting: What habitat types characterized the transition zone in this area historically? Based on how landscape has changed, and projected future changes, are historical habitats still appropriate? What constraints and opportunities result from expected changes in land use and development?

Process: Does conservation/management in this area support conditions that allow marsh migration? Sediment transport to support marsh accretion? Do restoration and management actions match current and projected groundwater conditions? Extent of tidal and fluvial flooding?

Connectivity: How far apart are areas supporting transition zone habitats and processes? Are they close enough to each other and to the marsh to support the services of interest (e.g. wildlife movement, marsh migration?

Diversity: What different types of transition zone habitats are appropriate in this area?

Redundancy: Are there multiple areas where support for critical species and processes is being provided?

Scale: What is the total amount of transition zone habitat conserved/restored within an area, and is this a large enough scale to support the species and processes of interest?

People: Within this “outer limit” boundary some of the proposed actions that would provide biological diversity support (e.g., upland habitat restoration) would provide other societal benefits as well (e.g., recreation, flood protection).

Proposed methodology for mapping an aspirational upper wetland-upland transition zone boundary

For this effort it is helpful to think about different types of wetland-upland transition zone because of the space requirements for different ecosystem services they can provide. Different management opportunities and priorities present themselves within different transition zone types. Here we suggest different methods to determine the inland extent of the transition zone: A) Bluff or Cliff, B) Hillslope, Fan, Valley or Plain, and C) Riverine or Stream. Because we are interested in delineating an “outer boundary” we focus on those ecosystem services that go furthest upslope-watershed. Separate methodologies for delineating the outer boundary for these three transition zone types are detailed below.

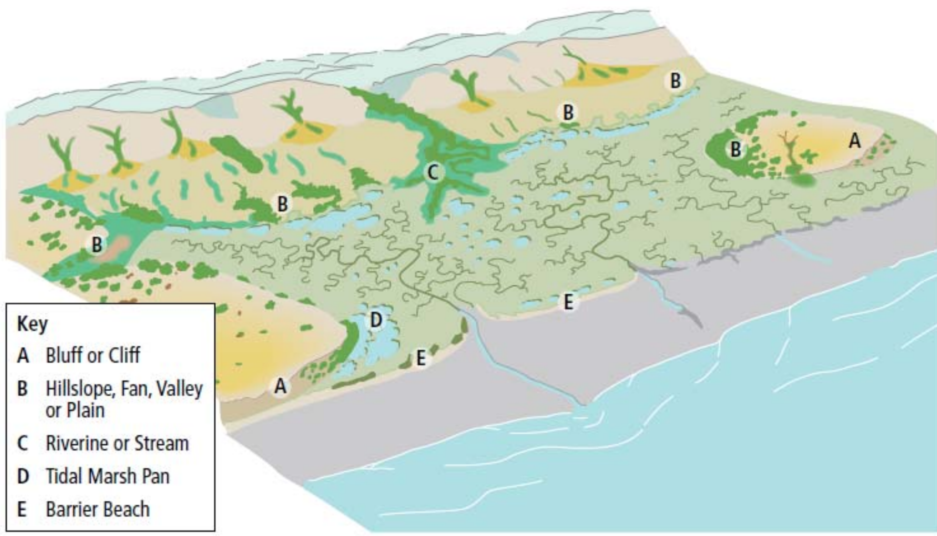


Figure 5. Transition zone types (from BEHGU).

Wetland Archetypes

Different transition zone types are represented to varied degrees in different coastal wetland archetypes. For Southern California, seven wetland archetypes have been identified. The most common archetype is small creeks, where the transition zone would be defined using the riverine/ stream transition zone method below. Small lagoon systems, lacking an associated creek, would be defined using the method for hillslope or cliff transition zone, depending on the topography. Larger systems, such as large lagoons and large river valley estuaries are likely to have multiple types of transition zone, and different methods will be applicable in different parts of the system. Additional guidance may need to be developed for intermittently open estuaries to account for differences in flooding extent between open and closed conditions.

Defining a lower boundary for the transition zone

For the hillslope and cliff transition zone types we must first define the lower transition zone boundary before we can define an upper transition zone boundary. This lower boundary can be determined using Highest Observed Water Level (HOWL) or similar methods. Alternatively MHHW can be determined from projections of future sea-level such as OCOF.

Upper boundary definitions by transition zone type

Determining the Upper Boundary for Hillslope Transition Zone

Hillslope, Fan, Valley or Plain (hereafter, hillslope) transition zone span gradual slopes that provide opportunities to support wide habitat gradients, biological diversity, and landscape complexity. These transition zones are also important for accommodating sea-level rise and allowing marshes to migrate upslope. For defining an outer boundary for transition zone planning we focus on biodiversity support and assumed that other ecosystem services associated with hillslope transition zone (e.g. buffering) would fall within a boundary set by these functions.

Supporting biological diversity within the transition zone includes 1) providing areas for wildlife refuge and predation, 2) facilitating wildlife movement, 3) supporting areas important for evolutionary adaptation, and 4) contributing to landscape complexity. How exactly the transition zone supports biodiversity can vary significantly by site, and is influenced by elevation, slope, soils, vegetation, and land use. To develop a coarse transition zone delineation method that would be broadly applicable across sites we focused on determining a zone width that would likely provide enough area for key ecological processes such as dispersal and adaptation to occur.

Table 1 shows a summary of widths over which these ecosystem services would be expected to occur. Most of the biological diversity support functions associated with the transition zone are captured within a range of tens to hundreds of meters, as shown below. To capture these functions to a high degree, without using the most extreme distances, we recommend a transition zone width of 500m.

Table 1. Summary of values from the literature which informed our methodology for hillslope transition zone.

Ecosystem Service	Width/Measurement	Notes and References
Wildlife refuge	20-50m	Refuge for Salt Marsh Harvest Mouse in SF Bay. Collins et al. 2007
Wildlife foraging and predation	150m	Distance of ground squirrels that forage in the marsh occasionally, Collins et al., 2007
Wildlife and plant movement	10-400m	Based on a variety of movement corridor values from the literature, including, on the upper end, Alexander et al., 2016
Evolutionary Adaptation	50-500m	Assumes gradients likely to support evolutionary adaptation (e.g., Collins and Collins 2007) likely play out on a scale of tens to hundreds of meters
Landscape complexity	50-1000m	Transition zone associated habitats could extend hundreds of meters historically, Beller et al. 2013

Mapping Guidance:

- Determine existing wetland boundary and add 500m from this boundary to determine the present day existing transition zone.
- Determine the future MHHW with sea-level rise contour and add 500m from this contour to determine the potential transition zone with sea-level rise and with the restoration of former tidal areas.
- Overlay land use layer to identify undeveloped transition zone that could be restored or conserved.

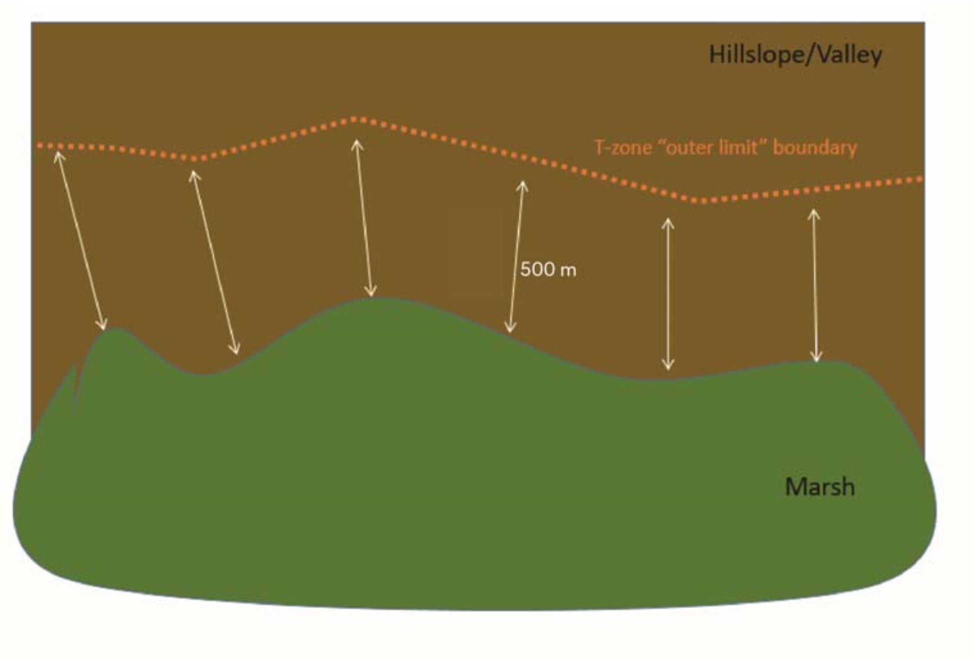


Figure 6. Method for defining an upper boundary for hillslope transition zone.

Outer Boundary for Riverine/Stream Transition Zone

Riverine transition zone transition between fluvial and tidal processes and conditions. The inland extent of tidal influence within streams, called the "head of tide", is primarily a function of the stream bed gradient, with lower gradient streams having head of tide locations that can be miles inland from the shoreline. This transition zone area can be important for floodwater storage and retention, as well as supporting a unique assemblage of plant and wildlife species. To define the outer transition zone boundary, both tidal and fluvial flooding need to be considered along with wildlife support functions. We add additional space (50m) beyond that tidal flooding extent to allow wildlife space to escape flooding and enough width to support riparian habitat for wildlife. For fluvial flooding, the 50-yr flood extent downstream of head of tide is used (i.e., the 50-yr flood on top of the tidal water in the channel).

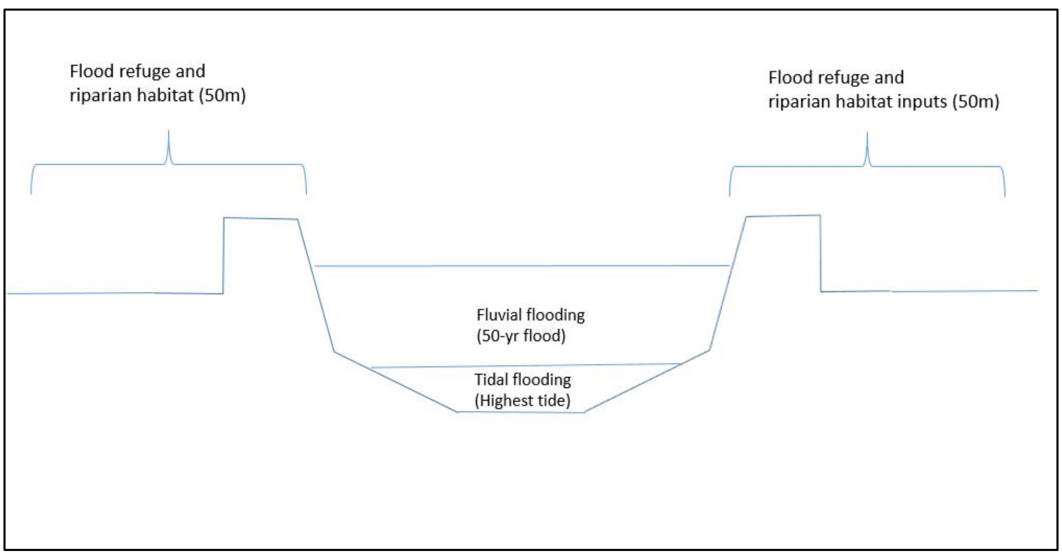
Table 2. Summary of values from the literature which informed our methodology for riverine transition zone.

Ecosystem Services	Width/Measurement	Notes and References
Flood control	Flooding extent for 50 year storm event	Likely high flooding within a relevant management time horizon
Wildlife refuge	50m	Guidance for flood refuge in Collins et al. 2007

Mapping Guidance:

- Add 50m width beyond river/stream boundary to determine current transition zone, or add 50m width beyond extent of flooding to determine future transition zone area that incorporates sea-level rise.
- Overlay land use layer to identify undeveloped transition zone areas that could be restored or conserved to support transition zone habitats.

An example of applying the transition zone mapping methodology can be found in Figure 7.



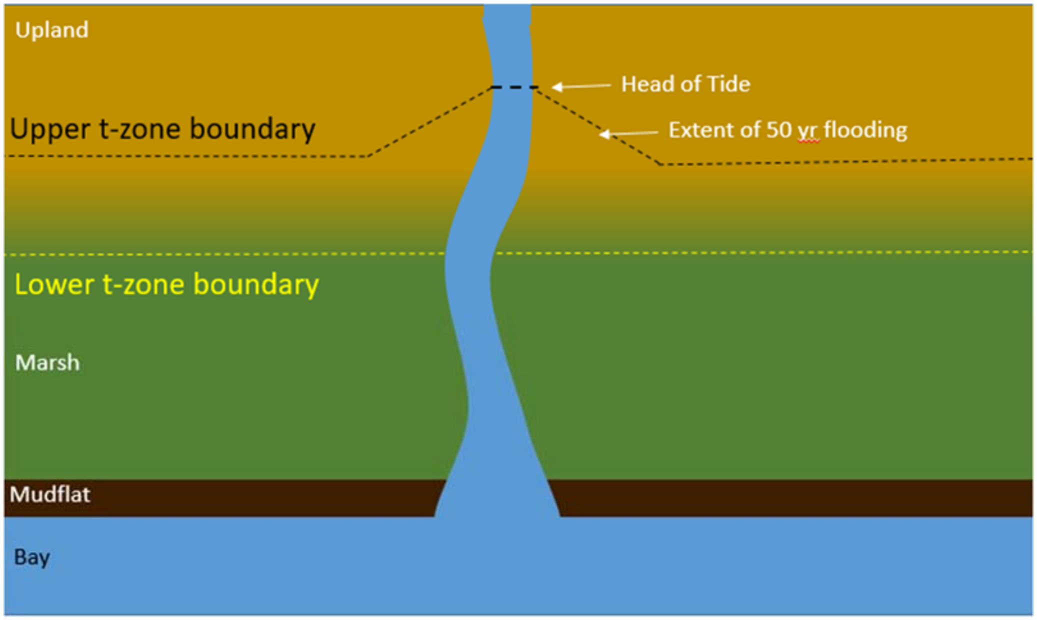


Figure 7. Method for defining an upper boundary for riverine transition zone.

Outer Boundary for Bluff Transition Zone

For bluff transition zones, the area at the top of the bluff is unlikely to provide the same flood control, habitat gradient, and movement corridor benefits as hillslope transition zones. Therefore we focus on erosion control to determine the extent of the transition zones, as this ecosystem service is more critical for these systems.

The transition zone was limited to slopes less than 15% and elevations less than 30m NAVD. Areas steeper than this are likely to be dominated by slope processes such as mass wasting, rather than fluvial or wetland processes.

Mapping Guidance:

- If the change in slope that marked the start of the bluff is more than 500m from the lower extent of the transition zone (as defined for hillslope transition zone above) then the transition zone should be determined using the hillslope method.
- If the change in slope is less than 500m from the lower extent of the transition zone, the hillslope transition zone layer is constrained to the area with a slope of less than 15%, or an elevation of less than 30m NAVD.
- Overlay land use layer to identify undeveloped transition zone areas that could be restored or conserved to support transition zone habitats.

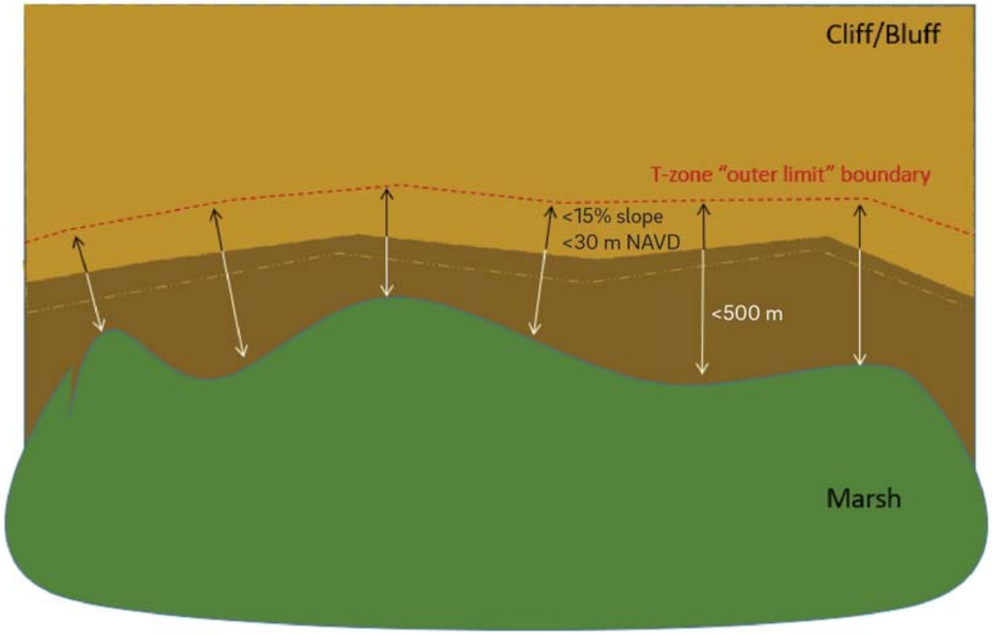


Figure 8. Method for defining an upper boundary for hillslope transition zones.

Setting Objectives and Targets

This aspirational approach can be used in tandem with a narrower mapping approach (e.g., Fulfrost method) to set targets for wetland-upland transition zone management and restoration in the near and long term, conservatively or aspirationally. A land development layer can be overlaid on this area as a coarse filter for identifying different types of opportunities. Objectives for the transition zone could relate to the amount of upland habitat/open space within the zone, the connectivity of open space, or the percent of the developed area where management actions such as low impact development (LID) /green infrastructure approaches are implemented.

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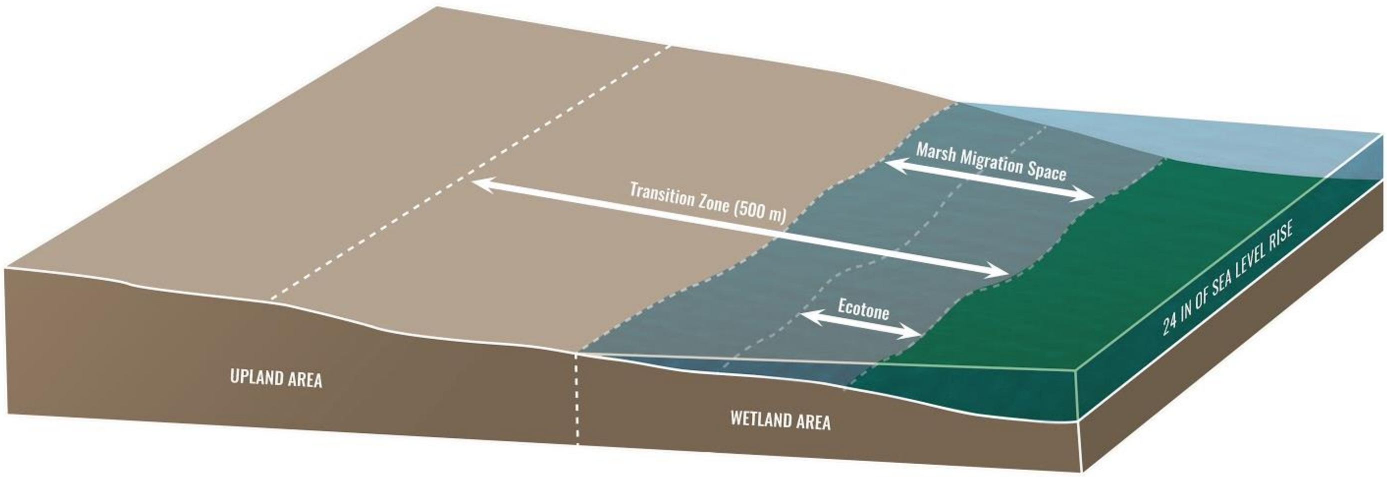
Appendix B

MTAG Participant Workbook

Transition Zones & the Future of Restoration

MTAG WORKBOOK 8/14/18



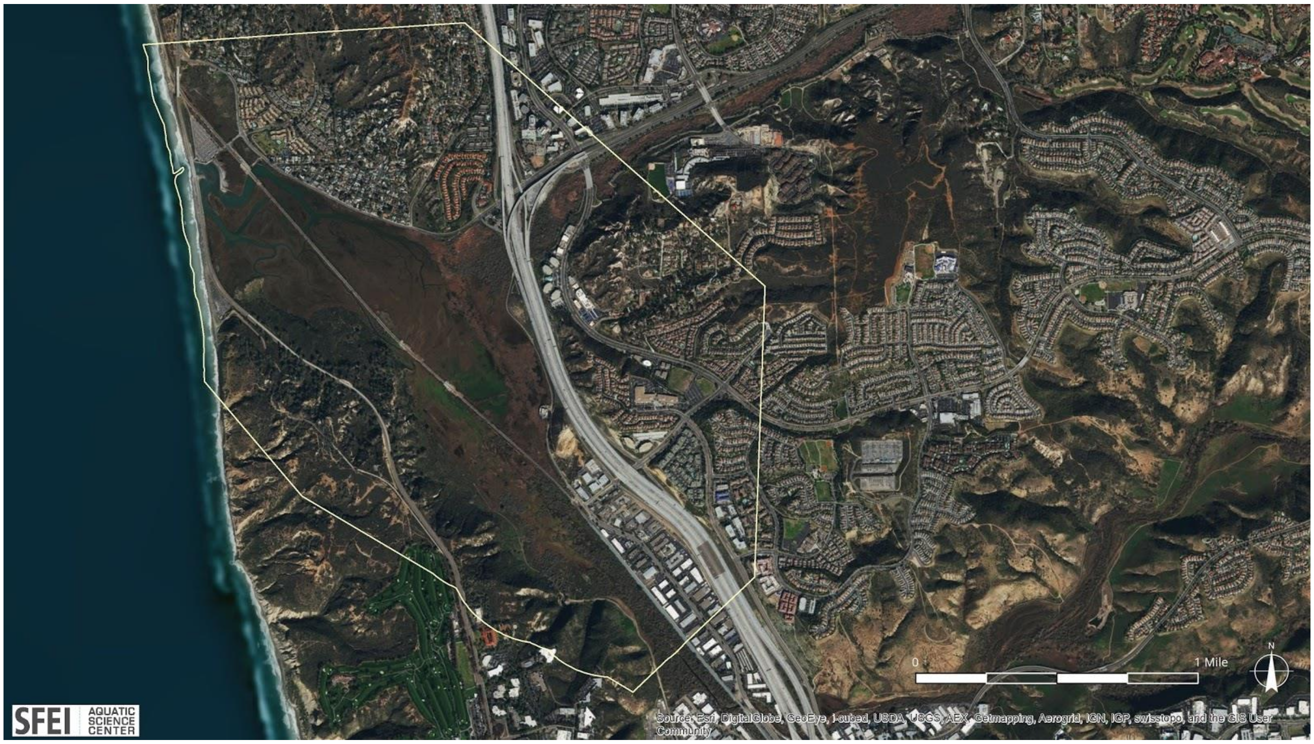
Conceptual diagram depicting wetland area, ecotone, upland area, marsh migration zone and transition zone.

SFEI SAN FRANCISCO ESTUARY INSTITUTE
Tijuana River National Estuarine Research Reserve
Sea Grant University of Southern California
NOAA
Coastal Conservancy

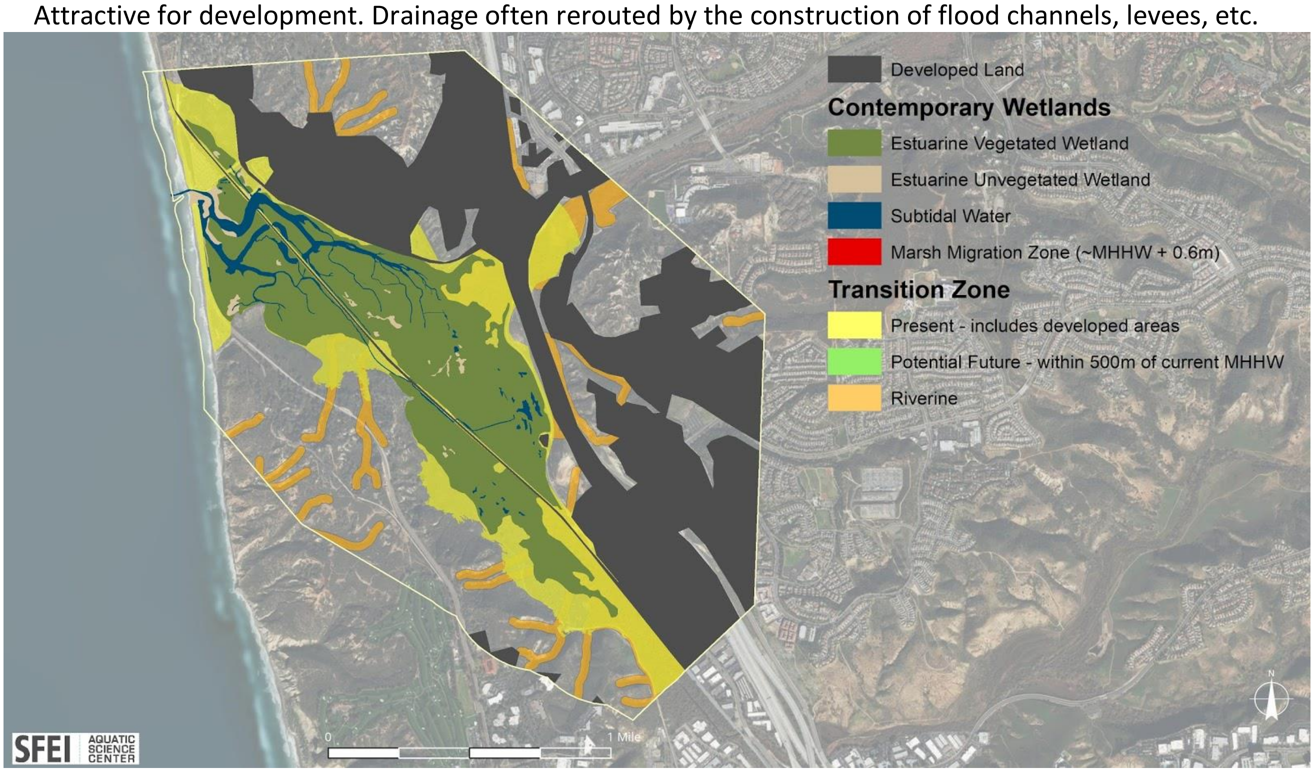
NAME: ____

August 14, 2018

Station 1: Large River Valley Estuary/Lagoon – example Los Peñasquitos



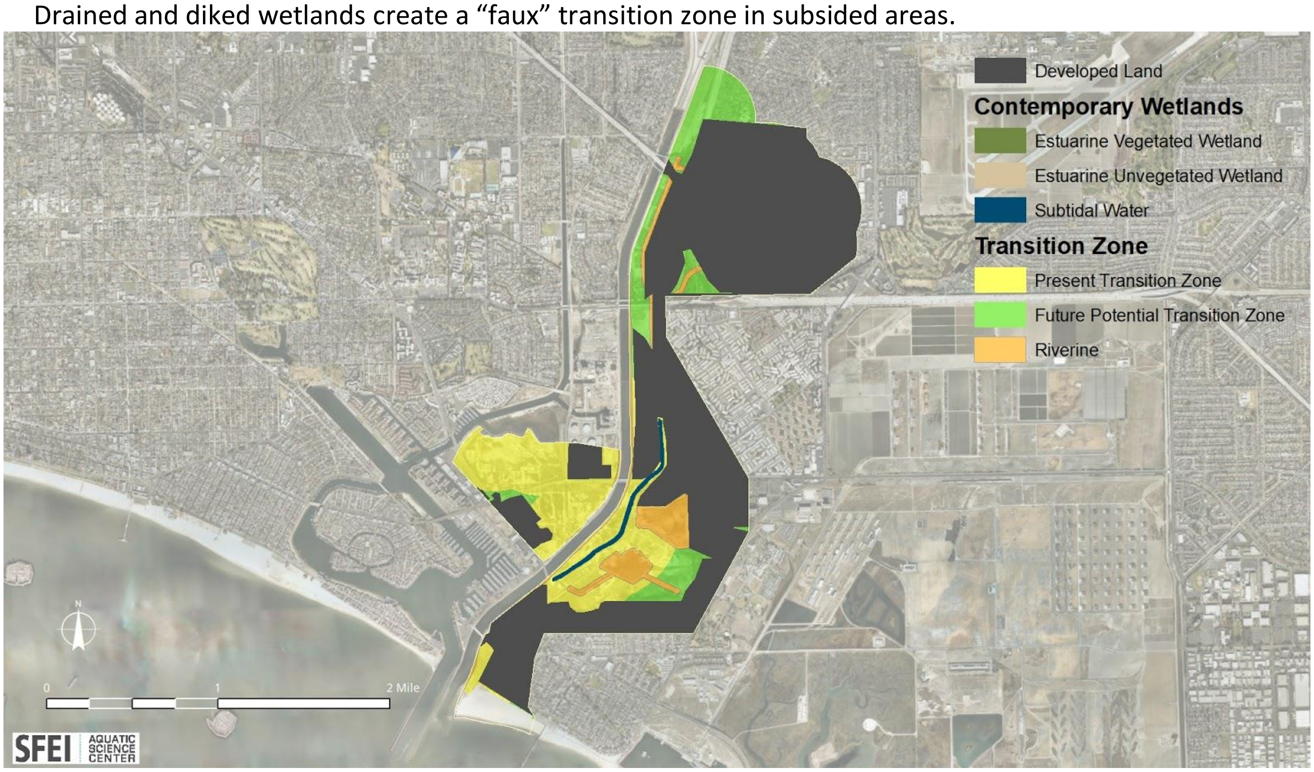
- Large flat, depositional floodplain. Often topographically confined by rising ground, steep bluffs, and mesas.
- River flow may be relatively small and intermittent resulting in inlet closure.
- Sedimentation from the watershed may be limited and deposited as an alluvial fan.
- Attractive for development. Drainage often rerouted by the construction of flood channels, levees, etc.



- Constrained by steep bluffs on the south side and by urban development to the north and east.
- Migration zone limited due to steep slopes, most potential up the channels.
- Opportunities for transition zone may be undeveloped gentler slopes to the north, the alluvial fans to the east, and along the channels to the east and south.
- Potential for artificial transition zone along railroad?

Station 2: Fragmented River Valley - example Los Cerritos

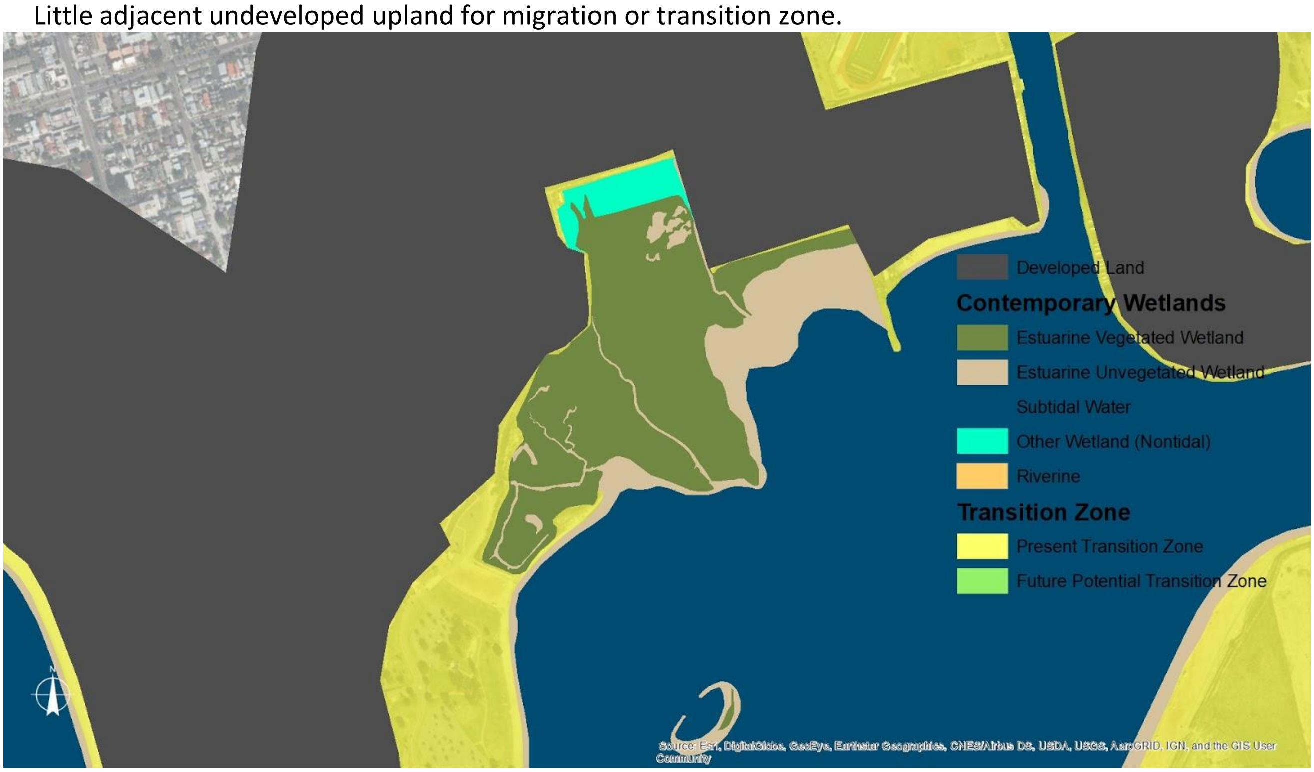
- Large, relatively flat, and easily drained plains have been very attractive for development.
- Levees fragment the floodplain, separating wetlands from channels and upland.
- Drained and diked wetlands create a “faux” transition zone in subsided areas.



- Opportunities for large-scale wetland restoration in former wetlands but disconnected from natural transition zone. Requires land swaps and rezoning to make it happen.
- Manage transition zone on slopes to the south, requires restoration of adjacent wetlands.
- Maybe opportunities for creating nature-based features such as ecotone slopes along levees in presently diked areas.
- Creation of islands of upland in middle of wetlands to provide some ecosystem services.

Station 3: Open Bay/Harbor - example Kendall-Frost Mission Bay

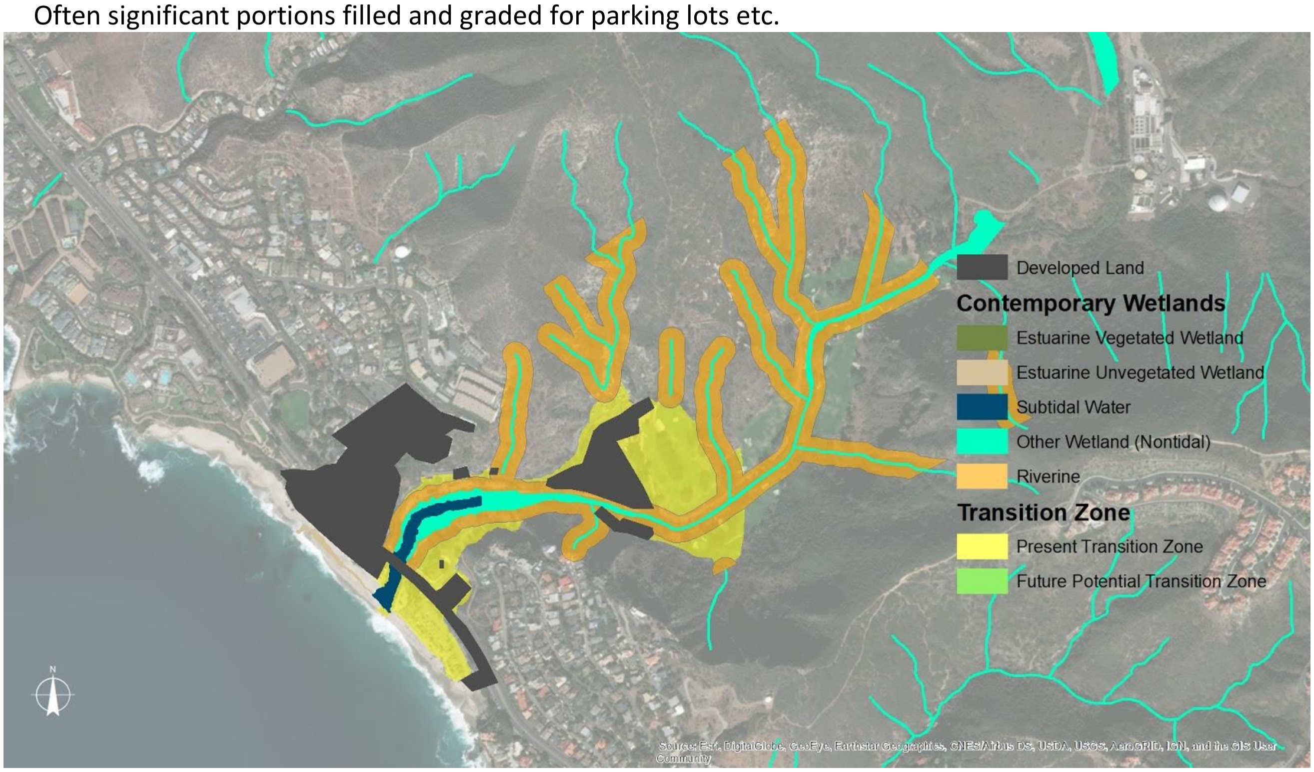
- Most edges lack wetlands, upland adjacent to shallow subtidal with a vertical wall, riprap or a beach.
- Some pockets of wetlands, very constrained by development.
- Little adjacent undeveloped upland for migration or transition zone.



- Maybe opportunities in Crown Point Park to the south for grading slopes and planting of natives.
- Few opportunities to create habitat corridors to connect to other open spaces.
- Maybe opportunities to grade upland within the footprint of the Reserve. However, this raises significant regulatory issues and the conversion of habitat, from one type to another, needs to be justified.

Station 4: Small Creek - example Aliso Creek

- Small inlet with minimal subtidal habitat area, a small area of vegetated marsh at the inlet, and a generally steeper channel slope.
- Steep watersheds and narrow valleys control the area available for wetlands and migration zone.
- Often significant portions filled and graded for parking lots etc.



- Opportunities close to the ocean occur close to the beach and may be short-lived with sea level rise.
- Maybe opportunities east of the Coast Highway through the golf course for grading slopes and planting of natives to create a riparian corridor.
- Most opportunities along channels east of the coastal development.

<u>Discussion: Opportunities & Solutions</u>

Examples

	Location	**Examples**
Management	Existing transition zone. Also in "faux" transition zone.	Invasive species management
		Modify or remove infrastructure
"Light Touch"	Open space within developed areas	More appropriate land use - greenhouses, ball fields, solar panels
		Provide more wildlife connectivity around parcels (e.g. plant native plants hedgerows, modify fences, widen bands of riparian vegetation)
		Allow for occasional flooding by using green infrastructure, such as swales, and flood proofing.
		Leave green corridors for wildlife, which could incorporate public access.
		Where appropriate, protect undeveloped and underdeveloped parcels with appropriate development.
Nature-based features	In diked wetlands and adjacent to levees.	Habitat islands
		Horizontal levee
		Sediment augmentation
Land use strategies - financial	In diked wetlands to restore wetlands and in uplands to connect to transition zone.	Buyout programs
		Conservation easements
		Transfer of development rights
		Land swaps
Land use strategies – legal and regulatory	In diked wetlands to restore wetlands and in uplands to connect to transition zone.	Development moratoria
		Overlay zones
		Redevelopment restrictions

Other ideas?

Discussion: Making our Solutions a Reality

Policies, Laws, & Regulations	**Funding**
• *Think about all the different agencies you need permits from. How could the overall process be improved?* • *What fundamental policy shifts from national, state, or local agencies would allow you to make progress?*	• *What are your funding gaps or opportunities for restoring or creating transition zones?* • *How can funding agencies facilitate innovation?*
Logistics & Design • *When creating or restoring new transition zones, what needs to be considered in the design phase? (e.g., elevation, space)* • *When designing projects what can we do differently on-the-ground to increase resilience?*	**Research** • *What gaps in science are preventing certain solutions from being implemented?*