ENVIRONMENTAL IMPACT
ENVIRONMENTAL IMPACT STA

# TIJUANA ESTUARY TIDAL RESTORATION PROGRAM
# VOLUME I: DEIR/EIS

LEAD AGENCIES

California Coastal Conservancy
U.S. Fish and Wildlife Service

Prepared by:

ENTRIX, Inc.
Pacific Estuarine Research Laboratory
Philip Williams & Associates, Ltd.

October, 1991

# TIJUANA ESTUARY TIDAL RESTORATION PROGRAM

~~DRAFT~~ FINAL

# ENVIRONMENTAL IMPACT REPORT/ ENVIRONMENTAL IMPACT STATEMENT

Lead Agencies:

California Coastal Conservancy

U. S. Fish and Wildlife Service

Cooperating Agency:

U. S. Army Corps of Engineers

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## TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## PROGRAM BACKGROUND

This document is a programmatic environmental impact report/environmental impact statement (EIR/EIS) prepared for the Tijuana Estuary Tidal Restoration Program. The Tijuana Estuary is the southern-most estuary in the United States on the Pacific Coast. The Tijuana Estuary is within the Tijuana River National Estuarine Research Reserve (Reserve), which was established in 1982 by the National Oceanic Atmospheric Administration. The primary goal of the Tijuana Estuary Tidal Restoration Program is to protect the estuarine environment and resources within the Reserve in a manner consistent with the policies of land owners and regulatory agencies concerned with resources of the Reserve.

## PROJECT SUMMARY

This EIR/EIS constitutes the foundation document for the restoration project. Because of the large scale of the project proposed and a recognition of the present rudimentary knowledge of the art and science of wetland restoration, the project will be undertaken in increments. Restoration of the Tijuana Estuary will begin with a Model Project consisting of three actions: (1) construction of a 20-acre experimental marsh; (2) widening of a portion of Oneonta Slough; and (3) construction of a channel to connect Oneonta Slough with the tidal lagoons. The full tidal restoration program presented in this report consists of an additional 495 acres of tidal marsh restoration and other important related actions. To ensure that the proposed project results in maximum restoration benefits and minimal adverse environmental impacts, phased implementation is proposed with a carefully designed adaptive management monitoring protocol and design review process. The EIR/EIS serves as a first step in the permitting process for the Model Project.

The 495-acre Restoration Project will be implemented as a series of modules. The early modules will benefit from information generated from the Model Project. The later modules will benefit from information generated in the earlier modules. Supplemental

impact assessments providing more detailed information will be required under NEPA and CEQA before proceeding with construction of project modules.

An adaptive management approach was selected to guide the restoration program. Adaptive management begins by recognizing what is unknown or too variable to be predicted. It involves a process whereby alternatives can be suggested and tested, often in small scale before undertaking full-scale projects. The management activities for which results are uncertain become the experimental treatments of a pilot program. Results of initial experiments or trials are then evaluated to select the approach for later projects. Inherent in adaptive management is the need for long-term, ecosystem-level monitoring.

## PROJECT SETTING

The Tijuana River basin has a watershed area of approximately 1,700 square miles, with 455 square miles occurring in the United States and 1,245 square miles in Mexico. The Tijuana River is formed by the confluence of the Rio de las Palmas and Rio Alamar Rivers in Mexico and then flows for 17 miles to the Pacific Ocean. The Tijuana River crosses the border just north of the city of Tijuana, Baja California, approximately five miles from the mouth of the estuary. The Reserve occurs within a Mediterranean-type climate that has rainfall and runoff restricted to brief periods within the cooler seasons. It is subjected to high interannual variations in rainfall and runoff. The project area includes the lower Tijuana River Valley that lies in the United States.

## PROJECT PURPOSE AND NEED

The purpose of the restoration project is to define and implement a program that will assure the long-term protection of the valuable Tijuana Estuary ecosystem. A key element in the restoration of Tijuana Estuary has always been to return the estuary to an earlier historic state when tidal flushing was self-maintaining. Another important element is to develop a restoration plan based on what has been learned of the estuary's historic condition and what can be achieved under existing constraints.

The tidal prism in the estuary has decreased from 1,550 acre-feet in 1852 to 290 acre-feet in 1989. In 1852, the tidally-influenced portion of the estuary was approximately

870 acres compared to the current 330 acres of intertidal wetlands. The 1852 tidal slough channels extended into the estuary over 3,000 feet east, 5,000 feet north and 2,000 feet south of the tidal inlet. While these tidal channels still extend into the east, north and south portions of the estuary, the northern channel is migrating eastward into an erosion-resistant headland and the southern channels are constricted due to sedimentation. In addition, the marsh plain dissected by the southern arm is approximately two feet higher in elevation than that of the north arm. The mouth of the estuary was estimated to be 1,000 feet wide in 1852, when the ebb-flow velocities were strong enough to scour away sand deposited by wave action in the tidal inlet, and to keep the mouth open. The mouth is now about 100 feet wide, and the reduction in tidal prism has substantially reduced the tidal scouring of the entrance channel, making it unstable and susceptible to closure.

## TIJUANA ESTUARY TIDAL RESTORATION PROGRAM (PREFERRED ALTERNATIVE)

The Tijuana Estuary Tidal Restoration Program is designed to increase salt marsh habitat and restore tidal flushing to areas that have been silted-in over the past few decades. The Tijuana Estuary Tidal Restoration Program consists of two related projects: (1) the Model Project (Figure ES-1); and (2) the 495-acre Restoration Project (Figure ES-2). The Model Project will be implemented first and consists of three components: (a) Oneonta Slough Widening; (b) construction of the Connector Channel; and (c) construction of a 20-acre experimental marsh.

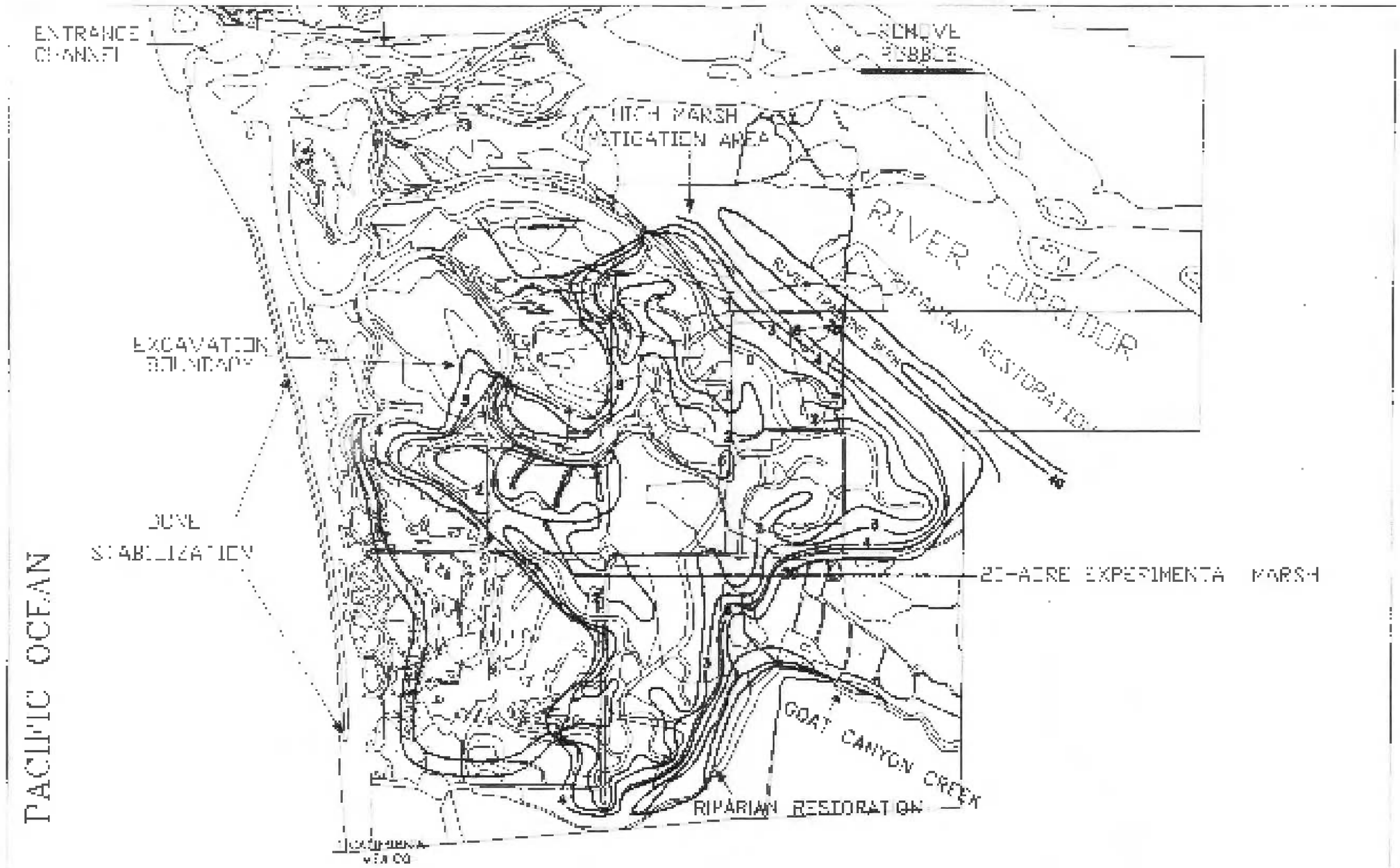
The datum for elevation measures used in this report is NGVD (National Geodetic Vertical Datum). This datum is used because it is constant for the United States. In the Tijuana Estuary mean lower low water (MLLW) is equal to -2.8 NGVD.

### ONEONTA SLOUGH WIDENING

Widening of Oneonta Slough is intended to keep the north arm of the Tijuana Estuary open as the barrier beach migrates inland through time. The slough/barrier beach system will react naturally to accommodate the barrier beach migration, with Oneonta Slough migrating to the east. However, a hardpan currently prevents eastward migration of the slough channel. As a result, the channel cannot presently accommodate the eastward


TIJUANA ESTUARY TIDAL RESTORATION PROGRAM

| | | |
|---|---|---|
| CHK. | PROJECT NO. 359000 | FIGURE EE-1 |
| | SAN DIEGO STATE UNIVERSITY FOUNDATION SAN DIEGO, CA | MODEL DOMAIN |




TIJUANA ESTUARY TIDAL RESTORATION PROGRAM

| | | | |
|---|---|---|---|
| DRAWN BY: DNL | CHECKED BY: CPW | PROJECT NO 300000 | FIGURE TS-2 |
| DATE: 2/26/01 | APP'D: 8/20/01 | SAN DIEGO STATE UNIVERSITY FOUNDATION SAN DIEGO, CA | 195-ACRE RESTORATION PROJECT |
| SCALE: 1"=1.0mi | | | |

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WALNUT CREEK, CALIFORNIA

migration of the barrier beach and will become increasingly susceptible to being filled in by migrating beach sediments.

To counter the problem of the hardpan barrier to channel migration and avoid eventual constriction of the channel, the east shoreline of Oneonta Slough will be excavated to remove the hardpan layer. A minimum of 26,000 cubic yards of materials will be removed from the site initially. If the hardpan layer is found to extend further inland, up to 7,000 cubic yards of additional material will be removed. If these borings indicate that the hardpan does not extend past the initial removal area, then no further excavation will occur and the channel will be allowed to migrate at a natural pace.

## CONNECTOR CHANNEL

The connector channel will provide a tidal connection between the northern part of Oneonta Slough and tidal lagoons along the northeastern part of the north arm. This channel will accomplish several purposes, including: (1) stabilizing the channel system in the northern arm and reducing sedimentation in the tidal channels; (2) controlling access to the northern arm; (3) providing additional wetland habitat (salt marsh); (4) assimilation of low-flow street runoff near the Visitor Center prior to reaching the salt marsh; and (5) providing an interpretive opportunity immediately adjacent to the Visitor Center.

A stormwater channel will be constructed to absorb street runoff. It will be approximately 985 feet long and approximately 5 feet wide. The slough channel will be approximately 1,120 feet long and have a bottom elevation of -2 NGVD, and a 2:1 sideslopes. Intertidal benches will be built adjacent to the channel for establishing tidal marsh habitat. Approximately 2,000 yards of materials will be excavated for construction of the connector channel and ditch. A 30-foot long timber bridge will be constructed over the connector channel and stormwater channel.

## 20-ACRE WETLAND RESTORATION

The 20-acre experimental marsh will consist of two components: (1) construction and monitoring of an experimental tidal marsh; and (2) construction and monitoring of an

experimental dredge material berm. The 20-acre experimental marsh will be designed to address the hypothesis that ecosystem development can be accelerated by increasing topographic heterogeneity. The experimental berm study will address the suitability of using dredge materials for construction of the river training structure, especially the suitability of the material to support growth of native upland vegetation. Excess dredged material will be used for roadbed construction for realigning Monument Road upon conformation of its suitability in preconstruction soils analyses.

## 495-ACRE RESTORATION PROJECT

The 495-acre Restoration Project consists of four components: (1) restoration of 495 acres of tidal marsh in the south arm; (2) construction of a river training structure; (3) stabilization of sand dunes; and (4) restoration of riparian habitat. Restoration of the tidal marsh will proceed in modules. This will facilitate the learning process because early modules will generate information about how well procedures work, what problems develop, and what unforeseen benefits might be capitalized upon in designing future modules. The river training structure will protect the restored tidal marsh, thus reducing the risk of closure of the mouth and loss of tidal flushing by protecting against the loss of tidal volume due to sedimentation. The total footprint of the 495-acre Restoration Project with a river training structure will be between 507 and 540 acres depending on the alternative design for the river training structure selected.

**Tidal Marsh Restoration.** Restoration of the tidal marsh will involve the excavation of a series of tidal channels, lowering of the tidal marsh plain, and construction of either a river training berm or levee. The channel depths will range from -2.0 NGVD in the deepest part of the channel to 0.0 feet NGVD at the banks. The marsh plain will slope gradually from the channel edges up to an elevation of 4.0 feet NGVD. There will be a higher plain between 4.0 feet and 8.0 feet NGVD as replacement for the high marsh disturbed or lost as a result of implementation of the project. The volume of material removed for the total tidal marsh enhancement project will be approximately 6 million cubic yards of material.

The mean diurnal tidal prism in the estuary after implementation of the project will be approximately 845 acre-feet, which will be smaller than the 1852 tidal volume estimated

to have been 1,550 acre-feet. It is expected that the mean diurnal prism of 845 acre-feet will be sufficient to maintain an open entrance channel.

The specific design of the tidal channel and tidal marsh plain adjacent to the larger tidal channels will be based on the information obtained from the Model Project and other ongoing studies in the Reserve. A specific site development and planting plan will be developed as an initial step in the planning for a particular module or series of modules and the basic monitoring plan modified, as necessary, to document development of the constructed modules. Biological, hydrological, chemical, and physical data will be collected as part of the monitoring program.

**River Training Structure.** Construction of a river training structure is necessary to prevent the river channel from migrating into the south arm of the estuary and depositing sediments in the restored tidal marsh. The location and orientation of the river training structure is determined by the need to maximize restorable area in the estuary while not constricting the existing active river channel and keeping adverse impacts to sensitive biological resources to a minimum. The river training structure would extend from Spooner's Mesa into the estuary in a west-northwest direction (Figure ES-2).

There are two alternative river training structures: An erodible berm or a rip-rapped levee. The erodible berm would be 5,000-feet long, 25-feet high, and 400-feet wide at the base. The eastern slope would be 3:1 and the western slope 12:1. The berm footprint would be 46 acres. The erodible berm is designed to accommodate 100 years of average erosion rates (3 feet per year) with a reasonable safety factor built in (Appendix F). Both slopes would be vegetated with native coastal sage scrub plant species.

The rip-rapped levee would be an erosion-resistant structure that is high enough to prevent overtopping. The levee would be 5,000-feet long, 10-feet high, 100-feet wide at the base, and 12-feet high at the crest to accommodate a maintenance road. The eastern slope would be 3:1 and armored with rip-rap to prevent erosion. The rip-rap would extend 10 feet below ground to prevent undercutting of the levee. The western slope would be 5:1. The levee footprint would be 12 acres. The western surface and, to the extent possible, the eastern surface would be vegetated with native coastal sage scrub plant species.

**Sand Dune Stabilization.** A dune stabilization program will be designed for the barrier beach south of the tidal inlet to Tijuana Estuary. This dune system has been progressively destabilized by disturbance from human trampling and horse traffic. Unless stabilized by fencing and vegetation, the sand will remain mobile and able to move into nearby channels, either through the action of winds or storm washovers. Accumulation of dune sand in channels would decrease the tidal prism and increase the likelihood that the estuary mouth would close to tidal flushing.

**Riparian Restoration.** A minimum of 100 acres of willow-dominated riparian habitat will be restored in the area located between the east side of the river training structure and the active channel of the Tijuana River. This area is now devoted to sod farming. Another 15 acres adjacent to the mouth of Goat Canyon will be revegetated.

## DISPOSAL OF EXCAVATED/DREDGED MATERIALS

Four disposal alternatives have been considered: (1) onsite disposal in a river training structure; (2) ocean dumping; (3) beach disposal; and (4) other offsite disposal (Appendix E). Sediment quality will be assessed prior to construction of any project component according to a plan approved by the U.S. Army Corps of Engineers, the Environmental Protection Agency, the California Coastal Commission, and the San Diego Regional Water Quality Board (RWQCB).

## IMPLEMENTATION PROCEDURES

The 495-acre Restoration Project will be implemented in a sequential, modular format, with information gained during the construction and monitoring of each module being used to refine techniques for subsequent modules. A monitoring protocol has been developed to provide information to project designers and decision-makers over a possible 30-year implementation period. After a minimum of one year of assessment of the completed Model Project and upon approval by the Management Authority and permitting agencies, subsequent project modules may be implemented. The project will include a series of at least 16 modules of varying size and complexity. The timing of any one module will be influenced by: (1) location of sensitive habitat; (2) hydrologic connections of the tidal channels; (3) heavy equipment access to the excavation site, to

the river training structure or Monument Road (if offsite disposal is required); and (4) property acquisition.

## ENHANCEMENT ALTERNATIVES CONSIDERED

Two major constraints were identified early in the planning process that were used to judge the acceptability of potential restoration alternatives: (1) land ownership and (2) the projected impacts on existing biological resources. One of the earliest ideas was to construct a channel and embayment system on the site of the U.S. Navy Outlying Landing Field. This approach was eliminated because the land is owned by the U.S. Navy. However, considering the recent trend to decommission government facilities, this idea may need to be reconsidered in the future.

Another approach considered was dredging a channel through the upland/coastal sage between the southern tidal pond and the main river channel to maintain tidal flushing. This was eliminated for further consideration due to value of habitat to the California gnatcatcher and to maintain biodiversity in the estuary.

Another option considered early in the planning process was a "central estuary" restoration approach with a larger channel and embayment upriver. This idea would have created a large embayment east of the mouth. The option was dismissed because the hydrology and geomorphology of the estuary are too dynamic. One major flood flow could wash out the entire project. Therefore, lasting benefits from such a project design could not be assured.

The north arm of the estuary was not considered for extensive restoration activities because it already performs critical functions as endangered species habitat. It was felt that only if future studies identified beneficial enhancement opportunities that would not have damaging impacts should additional restoration work be undertaken in the north arm.

## NO PROJECT ALTERNATIVE

The reduction in tidal prism has significantly reduced the tidal scouring of the entrance channel, causing it to become unstable and more susceptible to closure. Historically, the tidal inlet was primarily open, including storm periods with large-scale movements of sediment. When the entrance channel closed in 1984, tidal flows were eliminated and the hydrologic systems changed dramatically. Reduced circulation resulted in a deterioration of water quality, including changes in salinity and increased algal blooms. The major habitat for the endangered light-footed clapper rail was eliminated. Public nuisance problems, such as odor and mosquitos, become more likely without tidal flow.

The future loss of tidal circulation in the north arm would probably be permanent. The north arm of the estuary currently contributes approximately 50 percent of the total tidal prism of the estuary. Without tidal circulation and with no avenue for river flows to reach the north arm, the north arm likely would turn into a system of stagnant hypersaline channels and dry hypersaline soils.

With closure of the entrance channel, ponded water would become brackish in the wet season. The entrance channel would be open for short periods of time when flood flows in the Tijuana River were able to scour an opening through the barrier beach. However, depending on the magnitude of the flood flows, the mouth would open only briefly and close when the flood flows abated.

The presence of brackish water in the south and central arm would change the nature of the vegetation from salt marsh to brackish marsh. The loss of pickleweed would be especially significant since this area supports a large population of the state endangered Belding's Savannah sparrow. Extended periods of high water also would adversely affect the sensitive species that currently occur throughout the estuary, including the federally-endangered salt marsh bird's beak, light-footed clapper rail and its habitat (cordgrass), and other species unable to escape or survive the high water.

## EARLY RESTORATION DESIGNS CONSIDERED

**Restoration Of Wetlands In Central Estuary.** This alternative would minimize disturbance of remnant wetlands in the south arm. The south arm supports a number of

special status species, including the Belding's Savannah sparrow, and several species of insects. Under this alternative, approximately four million cubic yards of substrate would have been excavated to create approximately 300 acres of wetlands. This would have required the construction of a river training berm 8,000-feet long extending upstream to Hollister Street, at the north end of the Tijuana River Valley, near Nestor. This levee would have been required to prevent flood flows from discharging directly into the restored wetland and filling it with sediments.

This alternative was eliminated for the following reasons: (1) it would have required proportionately a greater amount of excavation per unit area than alternatives in the south arm; (2) the area restored would be limited in size; (3) the river training berm would have tended to deflect flood flows to the south arm, increasing deposition of sediments in the wetland areas in the south arm; (4) the river training berm would have been extremely long and would have been tied into upland bluffs at its upstream end and been susceptible to failure during an extremely large flood; (5) the restoration site would have overlapped areas that are potentially restorable to high-value riparian habitat; and (6) it would have required the purchase of considerable areas of private land outside the present boundaries of the Reserve.

**Restoration of 250-Acres in the South Arm.** Approximately 250 acres of intertidal marsh and high marsh would have been restored in the south arm of the estuary. Tidal flow would have been enhanced by deepening the existing south slough channel up to the tidal inlet to a depth of -3 feet NGVD. Approximately two million cubic yards of material would have been excavated for the tidal marsh and high marsh restoration and an additional tenth of a million cubic yards dredged to deepen the tidal channel. This alternative was eliminated because: (1) it did not provide sufficient tidal prism to ensure long-term maintenance of tidal flushing; (2) it did not maximize the area of restorable wetlands; and (3) it was susceptible to a greater percentage of future loss of wetland due to the eastward migration of the barrier beach

**Restoration of 500-Acres in the South Arm.** This alternative included the phased excavation of two large areas in the south arm and a limited area in the north arm, to create sufficient tidal prism to maintain an open entrance channel. The excavation of these areas would have been done so as to maximize acreage for the restoration of mudflat and salt marsh habitat. To protect the restored areas in the south arm from sedimentation during large floods, two large training berms would have been constructed

during each phase of the project to deflect the main course of the river to the central part of the estuary.

Construction of the latter two phases would have impacted most of the marsh habitat in the south and resulted in the loss of marsh habitat equal to the footprint of the two river training berms. This would have resulted in unacceptable impacts to the sensitive resources in the south arm.

## MINIMUM DREDGING ALTERNATIVE

The Minimum Dredging alternative was a modification of the 500-acre alternative. The goal of the Minimum Dredging alternative was to restore the 1852 tidal prism in the Tijuana Estuary with minimum dredging. The Minimum Dredging alternative would restore 560 acres of marsh in the south in three phases. Phase I would have created a 20-acre experimental marsh and also included widening of Oneonta Slough and construction of the connector channel. Phase II would have restored 270 acres of tidal marsh, and Phase III would have restored an additional 290 acres of tidal marsh.

This alternative had several constraints. The Phase II river training berm would have covered the location of one of the two alternative sites for the 20-acre tidal wetland marsh enhancement site. The values developed in this experimental marsh would have been lost. The Phase III river training berm may have affected the Tijuana River floodway and constrained flow in its present course on the north side of the floodplain. This could have lead to a long term increase in the erosion rate on the bluff adjacent to the Naval Air Station. Preliminary analyses indicated that the Phase III river training berm could have increased base flood levels immediately upstream of the berm in excess of one foot. This would have required a revision to the existing FEMA map for the Tijuana River. The alternative was redesigned to include only one berm in a second phase of construction.

However, the biggest constraint of this alternative was that it would have intruded too much on existing wildlife resources in the south arm. In order to have constructed this alternative, virtually all of the salt marsh and salt panne resources in the south arm would have had to be sacrificed. In light of the considerable habitat for Belding's Savannah

sparrow in the south arm, this cost was considered too high relative to the benefits that would have resulted.

## ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

The Tijuana Estuary Tidal Restoration Program will have a number of significant beneficial impacts as summarized in Table ES-1. Significant impacts and proposed mitigation measures to offset the significant impacts are summarized in Table ES-2. Significant adverse impacts remaining after implementation of the proposed mitigation measures (residual impacts) also are summarized in Table ES-2.

The Model Project will provide a significant beneficial impact to biological resources of the estuary, especially endangered species habitat, water quality, and surface water hydrology. Scientific knowledge gained from project monitoring also will be a significant beneficial impact. The Model Project will result in potentially significant residual impacts to cultural resources and will significantly impact transportation and circulation on roadways in Imperial Beach, San Diego, and the County of San Diego.

The 495-acre Restoration Project would provide a significant beneficial impact to biological resources of the estuary, especially endangered species, water quality, and surface water hydrology. The increase in tidal marsh and willow-dominated riparian habitat acreage also would be a significant beneficial impact of the larger project. Finally, scientific knowledge gained from project monitoring would be a significant beneficial impact. Based on the initial assessment of impacts of the 495-acre Restoration Project, there would be significant residual impacts to water quality, biological resources, cultural resources, land use, transportation and circulation, aesthetics, and recreation.

## CUMULATIVE IMPACT ASSESSMENT

The project will have a significant beneficial cumulative impact by: (1) maintaining local and regional biodiversity; (2) contributing to an overall goal of the state and federal Endangered Species Act of increasing habitat for threatened or endangered species; (3) contributing to the national goal of "no net loss of wetlands; and (4) contributing to the goal of the State of California of increasing wetland habitat by 50 percent by the year 2000. The Model Project will not have an adverse cumulative impact. The 495-acre

**Table ES-1. Summary of Significant Beneficial Impacts of the Proposed Project.**

## MODEL PROJECT

Surface Water Hydrology

- increased tidal volume will decrease periods when the mouth is closed
- removal of hardpan along Oneonta Slough will allow channel to migrate east and maintain tidal flushing in the north arm as the barrier sand dunes migrate east

Water Quality

- increased tidal flushing will help maintain proper salinity in the estuary

Biological

- increase in local and regional biodiversity
- increase in habitat for light-footed clapper rail, Belding's Savannah sparrow, and sensitive insect species
- increase in tidal salt marsh habitat
- increase in shallow subtidal habitat for fish
- increase in knowledge on how best to restore tidal salt marsh habitat
- increase in knowledge on how to best vegetate dredged materials with upland plant species
- serve as a model in application of adaptive management to the management of sensitive biological system

Land Use

- modify land uses surrounding sensitive biological resources to make those uses more compatible with the wise management of biological resources.

## 495-ACRE RESTORATION PROJECT

Surface Water Hydrology

- increased tidal volume will decrease periods when the mouth is closed

Water Quality

- increased tidal flushing will help maintain proper salinity in the estuary

Biological

- increase in local and regional biodiversity
- increase in habitat for light-footed clapper rail, Belding's Savannah sparrow, least bells's vireo, and sensitive insect species
- increase in tidal salt marsh habitat
- increase in willow-dominated riparian habitat
- increase in shallow subtidal habitat for fish

**Table ES-1. Summary of Significant Beneficial Impacts of the Proposed Project. (continued)**

- stabilization of sand dunes along west side of Reserve
- increase in knowledge on how best to restore tidal salt marsh habitat
- increase in knowledge on how to best vegetate dredged materials with upland plant species
- serve as a model in application of adaptive management to the management of sensitive biological system

Land Use

- modify land uses surrounding sensitive biological resources to make those uses more compatible with the wise management of biological resources.

**Table ES-2. Summary of Potential Significant Adverse Impacts, Mitigation Measures, and Residual Adverse Impacts of the Proposed Project.**

| SIGNIFICANT IMPACTS | MITIGATION | RESIDUAL IMPACTS |
|---|---|---|
| **GEOLOGY, TOPOGRAPHY AND SOILS** | | |
| **Model Project** | | |
| No significant adverse impacts. | | |
| **495-acre Restoration Project** | | |
| An erodible berm or rip-rapped levee will substantially change the existing topography by creating visual relief in a relatively flat landscape. The berm will be 25-feet high from the ground surface. The levee will be 10 feet high. | The slopes of the erodible berm will be revegetated with native coastal sage scrub species so that the berm will appear to be an extension of the nearby coastal bluffs. The western slope of the levee will be vegetated with coastal sage scrub species. The eastern rip-rapped slope will be vegetated, to the extent possible. Alternative methods to vegetate the rip-rapped slope will be investigated. Alternative disposal options will be investigated. | Potentially significant |
| **SURFACE AND GROUNDWATER HYDROLOGY** | | |
| **Model Project** | | |
| No significant adverse impacts. | | |
| **495-acre Restoration Project** | | |
| An increase in surface water elevations could result from the river training structure | A possible increase in surface water elevations upstream necessitates a revised FEMA floodway assessment to ducment anticipated elvations resulting from the proposed project. | Potentially signifcant |
| **WATER QUALITY** | | |
| **Model Project** | | |
| No significant adverse impacts | | |

**Table ES-2. Summary of Potential Significant Adverse Impacts, Mitigation Measures, and Residual Adverse Impacts of the Proposed Project. (continued)**

| SIGNIFICANT IMPACTS | MITIGATION | RESIDUAL IMPACTS |
|---|---|---|
| **495-acre Restoration Project** | | |
| The larger project could increase surface and groundwater salinity in the eastern end of the Reserve, resulting in the loss of riparian habitat. This riparian habitat is potential habitat for the endangered least Bell's vireo. | The potential magnitude of the impact to least Bell's vireo habitat will be directly related to the amount of flow in the Tijuana River, which will be controlled by the proposed sewer projects upstream of the Reserve. Mitigation measures will need to be developed in conjunction with the sewer project proponents and involve release of treated effluent down the Tijuana River. The first step should be development of a regional surface water and groundwater model for the Tijuana River watershed in the U.S. The project will be designed to have no significant adverse impact to the least Bell's vireo. | Potentially Significant |
| **AIR QUALITY** | | |
| **Model Project** | | |
| No significant adverse impacts. | | |
| **495-acre Restoration Project** | | |
| No significant adverse impacts. | | |

**Table ES-2. Summary of Potential Significant Adverse Impacts, Mitigation Measures, and Residual Adverse Impacts of the Proposed Project. (continued)**

| SIGNIFICANT IMPACTS | MITIGATION | RESIDUAL IMPACTS |
|---|---|---|
| **BIOLOGICAL RESOURCES** | | |
| **Model Project** | | |
| **Vegetation.** Widening of Oneonta Slough will result in the short-term loss of 0.2 acres of intertidal pickleweed marsh and 2.4 acres of high marsh. Construction of the Connector Channel will result in the short-term loss of 0.1 acre of cordgrass and 0.1 acre of pickleweed marsh. Construction of the 20-acre marsh will result in the short-term loss of 1 acre of pickleweed marsh and 1.2 acres of high marsh. Additionally, project-related activities (access roads) will result in the short-term loss of marsh vegetation. | **Vegetation.** Vegetation will be salvaged from the areas to be impacted by the Oneonta Slough widening and construction of the Connector Channel and transplanted along the Connector Channel and at other suitable locations. The constructed 20-acre marsh will be allowed to develop into a tidal marsh system, which will result in an increase in intertidal marsh habitat. Areas impacted by construction-related activities (access roads) will be rehabilited after construction. To the extent possible, repeated impacts to the marsh will be avoided. | Insignificant |
| **Wildlife Species.** Widening of Oneonta Slough will result in loss of nesting and foraging habitat for Belding's Savannah sparrow, foraging habitat for clapper rails, habitat for the wandering skipper butterfly and tiger beetles, and adversely affect foraging of the California least tern and brown pelican. Construction of the Connector Channel will result in the loss of clapper rail foraging habitat and affect foraging and nesting behavior of the clapper rail and Belding's Savannah sparrow. Construction of the 20-acre marsh will result in the loss of clapper rail foraging habitat, habitat for the tiger beetle, and foraging and nesting behavior of Belding's Savannah sparrow. | **Wildlife Species.** Sensitive habitat (i.e., coastal salt marsh, riparian) will be replaced at a *minimum* of 3:1. The replacement habitats will be developed in the Connector Channel, which will be expanded to accommodate additional marsh habitat, and at the 20-acre marsh. In addition, areas of marsh, such as in the vicinity of the Oneonta Slough widening, that are degraded and would benefit from rehabilitation, will be rehabilited. The timing of construction will be restricted so as to avoid affecting nesting and foraging behavior of special status species. Widening of Oneonta Slough and construction of the Connector Channel will be restricted to the months of November through the first half of February. | Insignificant |

**Table ES-2. Summary of Potential Significant Adverse Impacts, Mitigation Measures, and Residual Adverse Impacts of the Proposed Project. (continued)**

| SIGNIFICANT IMPACTS | MITIGATION | RESIDUAL IMPACTS |
|---|---|---|
| **495-acre Restoration Project** | | |
| **Vegetation.** Excavation of the tidal marsh will affect approximately 495 acres, including 252 acres of transitional habitat, 152 acres of disturbed lands, 14 acres of mulefat-dominated riparian habitat, 37 acres of salt marsh/salt panne habitat, and 35 acres of mixed transition/disturbed habitat. Construction of the erodible berm would affect approximately 46 acres including 16 acres of disturbed habitat, 7 acres of transitional habitat, 14 acres mulefat-dominated riparian habitat and 9 acres of coastal sage scrub located south of the Reserve boundary on Spooner's Mesa. Construction of the levee would affect approximately 12 acres including 4 acres of disturbed habitat, 2 acres of transition habitat, 3 acres of mulefat-dominated riparian habitat, and 3 acres of coastal sage scrub located south of the Reserve boundary on Spooner's Mesa. Project-related activities (access roads) will result in the short-term loss of marsh vegetation. Because of the modular construction approach, there may be areas that are periodically impacted by construction of each module. | **Vegetation.** The project will create 399 acres of intertidal salt marsh habitat, 44 acres of coastal sage scrub (if the erodible berm is constructed), 91 acres of mudflats, and 60 acres of tidal channels. Additionally, over 115 acres of willow-dominated riparian habitat will be created. Up to 10 acres of coastal sage scrub would be created if the levee is constructed. Areas impacted by construction-related activities (access roads) will be rehabilited after construction. To the extent possible, repeated impacts to the marsh will be avoided. | Potentially significant |
| **Wildlife Species.** The 495-acre Restoration Project will impact habitat, including nesting habitat, for clapper rails and Belding's Savannah sparrow. Several special status species will be disturbed during construction. Habitat for insect species of concern will be disturbed during construction. | **Wildlife Species.** Sensitive habitat (i.e., coastal salt marsh, riparian) will be replaced at a *minimum* of 3:1 ratio. The 495-acre tidal marsh will provide the area to develop the mitigation habitat. Riparian habitat will be developed east of the river training structure and at the mouth of Goat Canyon. This habitat will mitigate for the loss of mulefat-dominated riparian habitat and disturbance (noise) to least bell's vireo habitat. Habitat for insect species of concern will be created at the 495-acre tidal marsh. The timing of construction will be limited to the months of November through the first half of February to avoid disturbing special status species. | Potentially significant |

**Table ES-2. Summary of Potential Significant Adverse Impacts, Mitigation Measures, and Residual Adverse Impacts of the Proposed Project. (continued)**

| SIGNIFICANT IMPACTS | MITIGATION | RESIDUAL IMPACTS |
|---|---|---|
| **CULTURAL RESOURCES** | | |
| **Model Project** | | |
| Archaeological remains were found in the area of Oneonta Slough that will be widened and at the western boundary of the 20-acre experimental marsh. | The significance of the two sites will have to be assessed using the appropriate guidelines. Based on the results of this assessment, additional mitigation measures will be identified. If additional sites are uncovered during construction, construction activities will be halted until the extent and value of the site can be assessed. Specific mitigation measures will be developed after the full extent of the site is known and the significance of the site assessed. | Potentially significant |
| **495-acre Restoration Project** | | |
| The initial studies indicate that there is a high potential for previously unrecorded archaeological sites within the project. | If sites are uncovered during construction, construction activities will be halted until the extent and value of the site can be assessed. Specific mitigation measures will be developed after the full extent of the site is known and the significance of the site assessed. | Potentially significant |
| **LAND USE** | | |
| **Model Project** | | |
| No significant adverse impacts. | | |
| **495-acre Restoration Project** | | |
| The larger project will result in losses to existing agricultural production present in and adjacent to the Reserve. | Implementation of an agricultural relocation program upstream of the project area. | Potentially significant |

**Table ES-2. Summary of Potential Significant Adverse Impacts, Mitigation Measures, and Residual Adverse Impacts of the Proposed Project. (continued)**

| SIGNIFICANT IMPACTS | MITIGATION | RESIDUAL IMPACTS |
|---|---|---|
| **TRANSPORTATION AND CIRCULATION** | | |
| **Model Project** | | |
| Construction will result in a significant short-term increase in truck traffic on the surface streets from trucks hauling excavated materials offsite. This will result in a significant impact on traffic using the affected streets as well as increased degredation of the surface streets. | Truck travel routes and time of travel will be determined in consultation with the City of Imperial Beach and the City and County of San Diego. Compensation for increased wear of the surface streets will need to be determined with the affected city and county governments. | Significant |
| **495-acre Restoration Project** | | |
| Construction will result in a significant short-term increase in truck traffic on the surface streets from trucks hauling excavated materials offsite. This will result in a significant impact on traffic using the affected streets as well as increased degredation of the surface streets. | Truck travel routes and time of travel will be determined in consultation with the City of Imperial Beach and the City and County of San Diego. Compensation for increased wear of the surface streets will need to be determined with the affected city and county governments. | Significant |
| **UTILITIES** | | |
| **Model Project** | | |
| No significant adverse impacts. | | |
| **495-acre Restoration Project** | | |
| No significant adverse impacts. | | |
| **HUMAN HEALTH** | | |
| **Model Project** | | |
| No significant adverse impacts. | | |
| **495-acre Restoration Project** | | |
| No significant adverse impacts. | | |
| **AESTHETICS** | | |
| **Model Project** | | |
| No significant adverse impact. | | |

**Table ES-2. Summary of Potential Significant Adverse Impacts, Mitigation Measures, and Residual Adverse Impacts of the Proposed Project. (continued)**

| SIGNIFICANT IMPACTS | MITIGATION | RESIDUAL IMPACTS |
|---|---|---|
| **495-acre Restoration Project** | | |
| The erodible berm or levee will disrupt the present visual aesthetics of the river valley flood plain. | If the erodible berm is constructed, it will be vegetated with native coastal sage scrub species to make it blend in with the adjoining bluffs. The size of the berm will be kept to a minimum. Under the levee alternative, the upstream side of the levee will be vegetated to the extent possible. If the levee is constructed, alternative designs will be explored that would allow establishment of vegetation on the rip-rapped east slope to reduce the visual impact of the levee. The size of the levee will be kept to a minimum. | Potentially significant |
| **RECREATION** | | |
| **Model Project** | | |
| No significant adverse impact. | | |
| **495-acre Restoration Project** | | |
| Recreational use of the south arm will be limited by development of the tidal marsh and the need to isolate the sensitive resources that will be present in association with the newly developed tidal marsh habitat. Development of the tidal marsh in the south arm will eliminate several trails used for horseback riding in the south arm. The total area available for recreational use will be less than currently available. | New trail routes will be developed and fences put in place to guide horseback riders and other recreational users. | Significant |

Restoration Project would result in a potentially significant adverse impact to water quality and biological resources. The increased tidal volume would result in higher salinity waters further upstream in the Tijuana River because of the anticipated elimination of current flows of sewage water in the river. The increased salinity coupled with the elimination of surface water flow in the river may adversely impact willow-dominated riparian habitat that is potential habitat for the endangered least bell's vireo.

## RELATIONSHIP BETWEEN SHORT-TERM USES OF ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The Tijuana Estuary currently provides habitat for a number of species, including several that are either listed as endangered or threatened species by the federal and state government, are candidate species for listing, or are otherwise considered to be sensitive. However, in recent years the quality of the habitat has been threatened by the deterioration of water quality and reduction in the tidal prism. The estuary also is important in maintaining regional biodiversity because of the number of species that are dependent upon the estuary as a habitat. Short-term losses will be minimized by salvaging plant material and using to restore impacted or newly constructed marsh.

The long-term productivity of the Tijuana Estuary will be enhanced by implementation of this project. There will be short-term adverse impacts to the resources of the estuary as a result of implementation of the project, but after completion of the project there will be opportunities for the affected resources to recover resulting in a long-term beneficial impact.

## GROWTH-INDUCING IMPACTS

The Tijuana Estuary Tidal Restoration Program does not contain any elements that will increase development in the region. The Reserve is an impetus to additional public land acquisition adjacent to its boundaries for open space and parklands uses.

## IRREVERSIBLE AND IRRETRIEVABLE IMPACTS

The commitment of general resources to the project is irreversible. The capital expended to purchase the land and fund the studies is lost to other potential investments. Additional commitment of funds for implementing the project also represents irreversible loss once project implementation is undertaken. An irretrievable loss will be the loss of energy associated with the fuel used to run the construction equipment and human energy to perform the latter tasks. Construction of the river training structure will result in a long-term loss of lands but the impact will neither be irreversible or irretrievable.

# 1.0
# INTRODUCTION

## 1.1 PROGRAM BACKGROUND

The Tijuana Estuary is the southern-most estuary in the United States on the Pacific Coast. The Tijuana Estuary is within the Tijuana River National Estuarine Research Reserve, which was established in 1982 by the National Oceanic Atmospheric Administration. The Reserve encompasses approximately 2,531 acres of tidal and non-tidal land extending north from the border between the United States and Mexico. The Tijuana Estuary Management Plan was developed in 1986 to provide a framework for future enhancement of the estuary and to address the physical changes that were adversely affecting the estuary. The primary goal of this plan is to protect the estuarine environment and resources within the Reserve in a manner consistent with the policies of land-ownership and the agencies regulating land use in the Reserve. The Tijuana Estuary Tidal Restoration Program was developed in response to the 1986 plan and subsequent analyses that have documented the decline in resource values and the need for restoration in the Reserve.

### 1.1.1 PROJECT SUMMARY

This document is a programmatic environmental impact report/environmental impact statement (EIR/EIS) prepared for the Tijuana Estuary Tidal Restoration Program. The lead agencies in the project, the California State Coastal Conservancy and the U.S. Fish and Wildlife Service, have undertaken restoration planning and this analysis at the request of the Tijuana Estuary Management Authority. The local, state and federal agencies that make up the Management Authority acted in response to a series of hydrological and biological studies of the estuary. These studies indicated that a rapid and perhaps catastrophic loss of resource values could occur at the Tijuana Estuary unless action was taken to reverse trends that were currently underway. This deterioration includes loss of significant endangered species habitat.

This EIR/EIS constitutes the foundation document for the restoration project. Because of the large scale of the proposed project and a recognition of the present rudimentary knowledge of the art and science of wetland restoration, the project will be undertaken in increments. This approach to restoration, termed "the modular approach", will begin with "the Model Project". The Model Project, consisting of a 20-acre marsh restoration and other actions that are described herein, is subjected to a more rigorous level of impact analysis in this document than is the overall 495-acre Restoration Project. The EIR/EIS serves as a first step in the permitting process for the Model Project.

Supplemental impact assessments providing more detailed information will be required under NEPA and CEQA before proceeding with subsequent project modules. These assessments and other permitting activity may proceed once the Model Project has been constructed and assessed for a minimum of one year. An extensive monitoring protocol has been developed to assess project components over several years. Details of the project design may be expected to change based on these analyses in a fine-tuning process described herein as the "adaptive management" approach.

The project area is within the Tijuana River National Estuarine Research Reserve and includes land owned by federal, state and local governments as well as private owners. Oversight of the project including long-range monitoring and review of the adaptive management design process will be undertaken by the Management Authority. The Coastal Conservancy and the U.S. Fish and Wildlife Service have assumed the lead agency roles in the preparation of this document and the implementation of the Model Project. Development of the full 495-acre Restoration Project, including the assumption of the lead agency role and the preparation of supplemental environmental impact assessments, will be determined in the future based upon available funding, recommendations of the Management Authority and decisions of the Management Authority member agencies.

### 1.1.2 LANDSCAPE PERSPECTIVE

Wetland losses are a National and International concern, in part because of economically valuable functions that wetlands provide and in part because of their esthetic value to a growing populace that appreciates our natural heritage. California leads the Nation in the proportion of wetlands that have been destroyed over the past 200 years (Dahl, 1990).

The loss of 91 percent of our fresh and saline wetlands areas has taken its toll in reducing the variety and abundance of our wetland-dependent species. Reacting to these losses, Senate Concurrent Resolution No. 28 (Chaptered at 92, Statutes of 1979) directed the Department of Fish and Game (CDFG) to prepare a plan that would include a goal of increasing wetland habitat by 50 percent. CDFG followed through with a plan to accomplish that goal by the year 2000 (CDFG, 1987).

It is within this broader context that early ideas for the protection of Tijuana Estuary developed. Tijuana Estuary is one of a wide variety of wetland, upland, marine and freshwater habitats that determine what species inhabit the globe. Many birds that migrate from Alaska to South America are in part dependent on this estuarine system for their survival. Selected fishes and invertebrates move along the coast, either by swimming or floating in the plankton; they are drawn to the shallow waters of Tijuana Estuary by instincts that shaped their evolution. Plant seeds, algal spores and microbes connect our Pacific coastal wetlands, and their ability to germinate, grow, and persist determines the similarity of the region's gene pools. Tijuana Estuary is thus a part of the global and regional biosphere--it is both a determinant of what can persist within this biogeographic region and a product of what occurs throughout it. The southwesternmost estuary of the conterminous United States is inextricably linked to environmental modifications at the global scale--the most notable being global warming and accelerated rates of sea level rise. Tijuana Estuary is also linked to environmental conditions along the Pacific Coast, within the Southern California Bight, which encompasses southern California and the Baja California coast, within San Diego County, and within the Tijuana River Valley.

Southern California coastal wetlands support a rich biota of birds, small mammals, reptiles, fishes, insects, aquatic invertebrates, vascular plants, seaweeds and microscopic algae, and tiny microbes. Many of the species are restricted to the coasts of the Southern California Bight. When too much habitat has been lost, when habitat quality declines too much, and when these damages occur in concert, some species become threatened with extinction. A long list of sensitive, threatened and endangered species is presented in this document; each is testimony to the status of the coastal resource in southern California.

The region's biodiversity is in jeopardy because of past habitat losses, permanently altered hydrology, and continued degradation of the environmental setting. Several

refuges and reserves have been set aside to protect what remains and many plans are underway to improve and enhance natural resources. As resource agencies have long understood, the protection and maintenance of the species that use any single reserve cannot be accomplished by preservation, enhancement, or restoration at that site alone. Nor can it be accomplished by a single, one-time management action. Ecosystems and populations are dynamic entities that continually respond to events within the region.

### 1.1.3 A REGIONAL VIEW OF TIJUANA ESTUARY

San Diego County's coastal wetlands were recently described in a booklet prepared by the State Coastal Conservancy (Marcus, 1989). How Tijuana Estuary relates to other systems along the southernmost 76 miles of California's coast has helped guide plans for its restoration. This regional perspective is what led to a plan to conserve and enhance the estuarine biota, by increasing tidal flows within approximately 550 acres of Tijuana Estuary.

Tijuana Estuary shares a number of historical problems with other coastal wetlands in southern California (Zedler and Nordby, 1986). It occurs within a Mediterranean-type climate that has rainfall and runoff restricted to brief periods within the cooler seasons. It is subjected to high interannual variations in rainfall and runoff. It has been filled and developed around its periphery. It is influenced by urban land uses and is downstream from a major metropolis; it receives runoff from agricultural fields. It receives heavy recreational use and is subject to considerable trampling. It has suffered off-road vehicle damage in the past. Its natural adjacent upland has been developed; its protective dune system has been destabilized. Its upstream rivers have been dammed for several decades. It has been invaded by exotic species of plants and animals. It has experienced impacts from accelerated erosion due to disturbance of soils and slopes within its watershed. Its historic tidal prism has been diminished by episodic and chronic sedimentation. It has closed to tidal flushing for at least one period that was long enough to cause significant damage to its native biota. It will be affected by increased rates of sea level rise, since large areas of the adjacent landscape are no longer open to the inland migration of wetlands.

The estuary is also unique in some historic attributes. Major highways and railroads were built well inland of the ocean inlet. Thus, Tijuana Estuary escaped dissection by

linear fills that have cut off tidal channels at other coastal wetlands within the region. Less filling and dissection has allowed this system to remain tidally flushed for the most part. The only other county wetlands that remain tidally flushed are the remnant San Diego Bay marshes. Another unusual feature is that several endangered species persist within the estuary.

Not all the differences are positive. On the negative side, Tijuana Estuary occurs downstream from Tijuana, Baja California, a rapidly growing city of about one million people, but which has minimal sewage treatment capability. Over the past decade, occasional sewage spills have become continuous flows and now total 10 to 12 million gallons per day. An international sewage treatment plant is now being planned and interim emergency measures are being pursued to eliminate the flows until the plant is completed. However, sewage flows have resulted in multiple impacts but only a few have been characterized. Freshwater influx alone may be the cause of major declines in the fishes and invertebrates of the tidal channels (Nordby and Zedler, 1991). Toxic materials are known to be present in the water, sediments and biota, but their effects are not easily documented. Chemical analyses of contaminants and the experimental tests of species- and community-level responses to them are very costly and have not been undertaken. Another unique problem for this estuary is its location adjacent to an international border, which is crossed by hundreds of undocumented immigrants every day and which is a point of importation for illegal substances. The problems caused by foot traffic through the estuary are compounded by the impacts of the enforcement agencies who must police the border.

Key individuals and citizen groups waged a successful fight to acquire Tijuana Estuary for the public in the 1970's. A productive partnership of concerned public agencies, conservationists, and local scientists secured the estuary's designation as a National Estuarine Research Reserve in 1982. Agreements initiated in the 1970's between the U.S. Fish and Wildlife Service (USFWS), U.S. Navy, and San Diego State University concerning research on endangered birds led to a long-term research program at the estuary. The early research activity and the designation as a Research Reserve in 1982 resulted in successful competition for increasingly scarce research funding for the Reserve from the National Oceanic and Atmospheric Administration in the 1980s. Also in the 1980s additional funding for land acquisition, resource management, public access, and restoration planning was provided by the USFWS, California Department of Parks and Recreation and State Coastal Conservancy. As a result of this activity, an extensive

data base exists for the resources of the Tijuana Estuary, the most extensive in the biogeographic region. Much has been learned about the function of the estuary and the decline that has occurred there.

### 1.1.4 MANAGEMENT NEEDS

For many reasons, protection of resources at Tijuana Estuary must go well beyond setting aside the land as a refuge, park, or reserve. A policy of non-intervention would not meet the goal of maintaining biodiversity. First, because the estuary's hydrology has been altered, the environmental factor that is most important in controlling the distribution and abundance of coastal wetland species is different from what produced the ecological communities at Tijuana Estuary. The system no longer has a large tidal prism or a high likelihood of remaining open to tidal flushing. The system no longer has the type of streamflows that characterize watersheds of Mediterranean-type climates. When the riverbed would normally be dry, sewage flows are present. When rainstorms occur, floods are delayed and flow volumes are reduced by upstream dams. Second, because the region's biodiversity has been impaired by habitat reductions, habitat modifications, and exotic species invasions, there is no guarantee that species have enough propagules to repopulate sites that succumb to extreme events or local disturbances. Third, it has lost many of its natural linkages with the adjacent uplands. It no longer has a broad connection to its upstream riparian habitats because the braided streambed has been confined to a narrow corridor. It no longer has sufficient high ground next to the best salt marshes; hence, the high-tide refuges for birds and arthropods are scarce.

Active management is needed to keep up with local problems, such as dune washovers, channel sedimentation, foot and vehicle traffic, street runoff, sewage spills, mosquito outbreaks, health hazards, tern nest site protection, domestic and feral animal access, and protection of people and property from crime and vandalism. All of these problems have stimulated specific management actions over the past decade. The Management Authority of the Reserve recognized early on that reactive management would not be enough to solve all the threats to the biota of Tijuana Estuary. The need for proactive management was clear by the mid-1980s, and planning for a long-term, broad-based restoration program began.

### 1.1.5 ADAPTIVE MANAGEMENT

An adaptive management approach was selected to guide the restoration program. It is a mechanism for dealing with uncertainty in managing renewable resources, which was developed to help manage fisheries in the Pacific Northwest (cf. Walters, 1986). The recommendations of Walters and his colleagues have been tailored for a model restoration program at Tijuana Estuary.

Adaptive management begins by recognizing what is unknown or too variable to be predicted. It involves a process whereby alternatives can be suggested and tested, often in small scale before undertaking full-scale projects. The management activities for which results are uncertain become the experimental treatments of a pilot program. Results of initial experiments or trials are then evaluated to select the approach for later projects. Inherent in adaptive management is the need for long-term, ecosystem-level monitoring.

We acknowledge significant uncertainties in the field of salt marsh restoration that have direct implications for the proposed project. Among the uncertainties are: (1) what resources occurred in the south arm; (2) how to best structure tidal channels so they will persist; (3) how large a tidal prism will maintain tidal flushing in perpetuity; (4) how to improve restoration of cordgrass marshes; (5) how important tidal creeks are to cordgrass marsh functioning; (6) how food chains are influenced by topography; (7) how to restore pickleweed marshes; (8) how to reestablish mid- and high-marsh communities; (9) how to salvage marsh sod; (10) how to prevent a recurrence of major sedimentation events; (11) how to vegetate and stabilize a dredge spoil berm; (12) what other beneficial uses might arise for use of spoils; (13) how to prevent exotic species dominance at restored sites; and (14) how large a habitat module must be to attract and support the desired wetland communities.

The process of filling these knowledge gaps has already begun. Initial dredging trials were undertaken after the hydrologic plan was developed (Appendix D). Some of the questions were explored during the planning process, using the expertise of hydrologists and ecologists who developed this EIR/EIS. Earlier biological studies had concentrated on the north arm of the estuary, where most of the critical endangered species habitat for the light-footed clapper rail occurs. The area designated for restoration had received little attention until this impact assessment project began. Thus, several field studies were

undertaken in 1989, with a focus on the south arm. Vegetation was mapped in detail. Insects using the estuary were quantified for the first time. Habitats of high value for native species were identified. A geographic information system (GIS) was developed to serve the project's mapping needs. Several students and faculty at SDSU contributed to the knowledge base. Additional research will be undertaken in experimental mesocosms designed for pickleweed marsh establishment under three tidal flushing and two freshwater inflow regimes (funding for studies pending).

A second feature of the adaptive management approach proposed for Tijuana Estuary is the planning of habitat restoration as modules, to be implemented in a specific sequence. This will facilitate the learning process, because early modules will generate information about how well procedures work, what problems develop, and what unforeseen benefits might be capitalized upon (i.e., the establishment of native species that are valued but not expected to use the restoration site). At the same time, a modular approach will allow managers to work within funding constraints. No single agency is likely to have funds for the entire restoration program. Yet opportunities need to be pursued as they develop. Agencies may be able to implement complementary projects more easily than collaborating on a single, larger project.

A third feature of the adaptive management approach is the inclusion of salvage and transplant operations to reduce risks to the biota. Habitat restoration at Tijuana Estuary will involve some damage to existing resources. To create new tidal wetlands, channels must be excavated into non-tidal areas and then connected with existing tidal channels. At the connection point between existing tidal channels and the excavated channels there will be some damage to habitats along the periphery of existing channels. Since new habitats are not likely to attract all the desired species, any native species that will be displaced by construction are a valuable resource for the restoration site. From work at Sweetwater Marsh (PERL, 1990), it is clear that the success of a vegetation transplantation program is dependent on the quality of the substrate. Thus, the salvage program would include both vegetation and substrates. Wherever native vegetation holds the soil, the blocks of sod would be moved intact. An integrated salvage and transplant program will help solve two problems – resource losses would be minimized and ecosystem development at the restoration site would be accelerated.

### 1.1.6 PHASED RESTORATION OF TIJUANA ESTUARY

Restoration of the Tijuana Estuary will begin with a Model Project consisting of three actions: (1) construction of a 20-acre experimental marsh; (2) widening of a portion of Oneonta Slough; and (3) construction of a channel to connect Oneonta Slough with the tidal lagoons. The full tidal restoration program presented in this report consists of an additional 495 acres of tidal marsh restoration and other important related actions (Section 1.2.4.4). To address the magnitude of the proposed restoration with certainty concerning both its environmental impacts and benefits, a phased implementation is proposed which makes use of a carefully designed adaptive management monitoring protocol and design review process.

The experimental marsh is the significant Model Project feature for determining the final design of the 495-acre Restoration Project. A physical and biological monitoring program will be undertaken for the 20-acre marsh to determine, among other things, if excavation elevations are optimum and if marsh creek channels are developing as planned. An experimental protocol will assess 3-acre subunits for ecosystem productivity in relation to physical design variables. Assessments will include a range of plant and animal species.

Experience in the field of wetland restoration indicates that restored ecosystems change rapidly during the first five to ten years and that their rate of change slows in succeeding years. An accurate assessment of the functional equivalency of a restored marsh to a natural one must necessarily entail a decade or more of analysis. Monitoring protocol developed for the Tijuana Estuary restoration project recognizes the necessity for long-term assessments and provides necessary guidelines for conducting them. A number of variables will dictate the time frame for the restoration of the Tijuana Estuary, notably, the outcome of initial assessments of the first components constructed and available funding.

Public agencies initiated planning for restoration of the Tijuana Estuary in response to reports indicating critical and progressive deterioration of its resource values. The phased approach to the project was developed to allow reasoned assessments of the outcome of the actions taken so as to protect existing resource values and to ensure a likelihood of a successful restoration. Clearly, the pace of restoration must balance the need for reasoned assurances of restoration success with the responsibility to act to

protect the declining resources of the estuary. Assuming funding availability, the actual pace of the project will be determined by the Management Authority, land owners, and key environmental regulatory agencies. The adaptive management modular design approach was developed to ensure that decision-makers have detailed scientific assessments to serve them in making decisions.

We recognize that significant costs may be incurred as a result of the phased approach to restoration simply as a result of repeated mobilization and demobilization of necessary equipment, personnel and support functions. However, we believe there is a compelling need for careful monitoring to assure that the needs of the resource outweigh any need for human expediency. The close proximity of valuable endangered species habitat to the project area underscores this concern. The phased restoration program was developed to respond to the complex planning milieu inherent with the project. This programmatic EIR/EIS with subsequent supplemental reports was conceived as the appropriate framework for timely assessments of the project's environmental impacts as the phased implementation proceeds.

### 1.1.7 RETURNING TO THE LARGER PERSPECTIVE

Several other restoration programs are underway or are being planned in southern California. These projects should be assessed so that new information, opportunities, and constraints can contribute to the adaptive management approach at Tijuana Estuary. The construction of an international sewage treatment plant upstream of the estuary, estimated for completion in 1995, will benefit the estuarine and wetland habitats of the Tijuana Estuary by eliminating large, continuous inflows of non-saline water, but at the same time could result in adverse impacts by eliminating fresh water for existing riparian vegetation in the Reserve. Treatment also may provide opportunities for beneficial uses of treated wastewater (e.g., maintenance of riparian habitat upstream of Tijuana Estuary). Sand and gravel excavation sites, such as the gravel excavation site at the base of Spooner's Mesa, may provide opportunities for dredged material deposition. Land uses may change and make new properties available for restoration of wetland habitat. Although not foreseen at this time, the military lands adjacent to the estuary could some day be decommissioned. An adaptive management process provides the capability for responding to new opportunities or unforeseen problems which may arise.

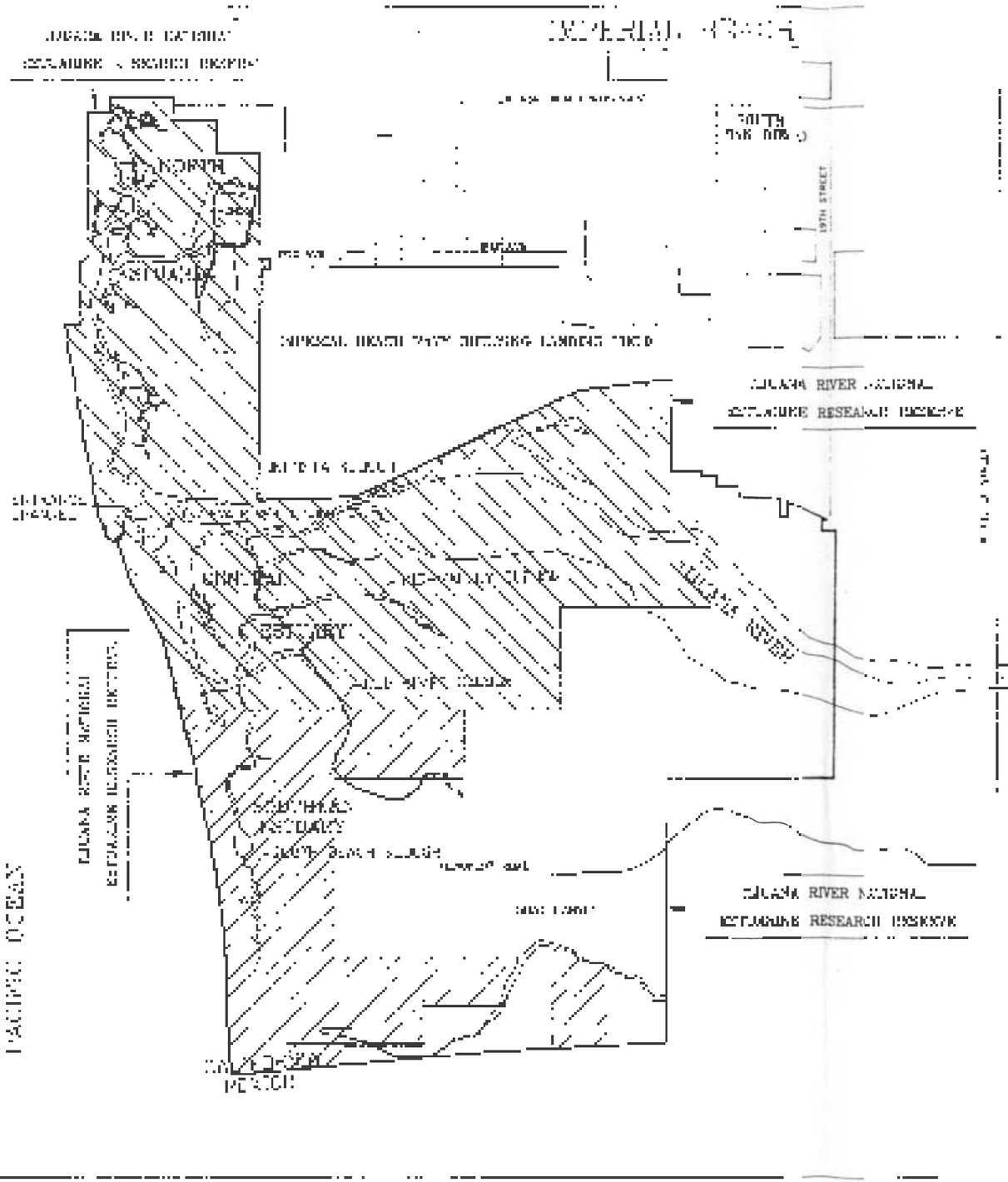
It is expected that techniques for restoring and assessing wetland and estuarine habitats will be more clearly understood as more experience is gained through this project, other projects in the region, and projects elsewhere in the world. Other projects in the bioregion are especially important. The collective knowledge of several monitoring programs needs to be integrated and used throughout the restoration program. Only by understanding how both natural and constructed wetlands change through time will we be able to separate out the effects of particular restoration techniques from the effects of interannual variations in the region's environment. Finally, an understanding of the changes in the status of regional biological resources also will be needed to guide actions at Tijuana Estuary. Should individual species edge closer to extinction, opportunities for their enhancement at Tijuana Estuary may need to be reexamined. While the intent of the project is restoration at an ecosystem scale, we must continually assess the status of endangered species and other species of special concern to assure that the implementation of the project is compatible with their protection and enhancement of their particular habitats.

The expertise of many biologists and hydrologists will be needed for the continual reassessment of the restoration program. It is expected that the adaptive management approach will generate many meetings, workshops, symposia, and literature contributions over the next three decades. The Tijuana Estuary Tidal Restoration Program will certainly help to fulfill the original intent of the National Estuarine Research Reserve Program, namely to facilitate research and "to improve the technical understanding of estuaries and thereby improve our ability to manage these areas."

## 1.2 PROJECT DESCRIPTION

### 1.2.1 PROJECT SETTING

The site of the Tijuana Estuary Tidal Restoration Program is located within the present boundaries of the Tijuana River National Estuarine Research Reserve (Reserve) (Figure 1-1). The Tijuana River basin has a watershed area of approximately 1,700 square miles, with 455 square miles occurring in the United States and 1,245 square miles in Mexico. The Tijuana River is formed by the confluence of the Rio de las Palmas and Rio Alamar Rivers in Mexico and then flows for 17 miles to the




TIJUANA RIVER NATIONAL

WILDLIFE REFUGE

BORDER FIELD STATE PARK

N

FIGURE 1-

LOCATION OF THE TIJUANA RIVER NATIONAL ESTUARINE RESEARCH RESERVE

Pacific Ocean. The Tijuana River crosses the border just north of the city of Tijuana, Baja California, approximately five miles from the mouth of the estuary. The project area includes the lower Tijuana River Valley that lies in the United States.

The western side of the Reserve is bounded by a barrier beach (Figure 1-1). This beach is slightly greater than two miles long and the beach and dune complex varies in width from 100 to 500 feet. A tidal inlet through the unconsolidated sand beach barrier connects the Tijuana Estuary to the open ocean; the precise location and configuration of the inlet vary over time. A system of four main tidal sloughs extend from the tidal inlet into the north and central part of the estuary. Oneonta Slough extends northward from the tidal inlet, parallel to the barrier beach, and connects with the tidal marsh in the northern arm of the estuary (Figure 1-1). Central slough channels extend through the lower Tijuana River floodplain, and include the Tijuana River Slough, Mid-Valley Slough, and Old River Slough (Figure 1-1). South Slough extends south from the tidal inlet and is parallel to the barrier beach south of the mouth (Figure 1-1).

### 1.2.2 PROJECT PURPOSE AND NEED

The purpose of the restoration project is to define a program that will assure the long-term protection of the valuable Tijuana Estuary ecosystem. One of the key elements in the restoration of Tijuana Estuary has always been to return the estuary to an earlier historic state when tidal flushing was self-maintaining. Another important element is to develop a restoration plan based on what has been learned of the estuary's historic condition and what can be achieved under existing constraints. While we've gained a good understanding of the historic state of the estuary and have extensive data on its current biology and hydrology, a principal constraint associated with the project is our limited knowledge of techniques for successfully restoring southern California coastal wetlands.

The tidal prism in the estuary has decreased from 1550 acre-feet in 1852 to 290 acre-feet in 1989. In 1852, the tidally-influenced portion of the estuary was believed to be approximately 870 acres, as compared to the current 330 acres of intertidal wetlands. The 1852 tidal slough channels extended into the estuary over 3,000 feet east, 5,000 feet north and 2,000 feet south of the tidal inlet. While these tidal channels still extend into the east, north and south portions of the estuary, the northern channel is migrating

eastward into an erosion-resistant headland and the southern channels are constricted due to sedimentation. In addition, the marsh plain dissected by the southern arm is approximately two feet higher in elevation than that of the north arm. The mouth of the estuary was estimated at 1,000 feet wide in 1852, when the ebb-flow velocities were strong enough to scour away sand deposited by wave action in the tidal inlet, and keeping the mouth open. The mouth is now about 100 feet wide, and the reduction in tidal prism has substantially reduced the tidal scouring of the entrance channel, making it unstable and susceptible to closure.

### 1.2.3 PROJECT GOAL AND GENERAL OBJECTIVES

The primary goal of the Tijuana Estuary Tidal Restoration Program is to restore to as near natural conditions as possible parts of the Reserve that have been subject to ongoing deterioration. Over the past 50 to 100 years, the Tijuana Estuary has experienced large scale sedimentation events, incipient sedimentation, dune overwash and channel constriction, localized diking and filling and long-term renegade sewage flows. Over the last 15 years, the estuary has been extensively studied to provide information on salt marsh functioning, the role of altered hydrology on salt marsh ecosystems, and the effect of unexpected hydrologic events on the channel organisms. As one of the most studied wetlands in the region, the restoration program has been designed to rely on and incorporate the results of scientific research and the understanding of the entire estuarine ecosystem and its relation to the watershed. This is consistent with one of the specific objectives stated in the Tijuana Estuary Management Plan (James Dobbin Associates Incorporated, 1986): "[R]estore to natural conditions parts of the Sanctuary (sic) that have been disturbed, relying on the results of scientific research and an understanding of the entire system and its watershed." In designing the restoration program, the following objectives were defined by those responsible for managing the Reserve to support the overall project goal:

(1) Restore tidal prism to approximately the size that existed under natural conditions in order to minimize entrance channel closure.

(2) Restore the functioning of the tidal hydrodynamic system to a state similar to what existed under natural conditions.

(3) Allow for continued functioning of a tidal hydrodynamic system with future anticipated geomorphic changes, including sea level rise, migration of the barrier beach, and changing river channel locations.

(4) Minimize future loss of wetland area due to inland migration of the barrier beach by restoring dune vegetation.

(5) Minimize future loss of restored and existing wetland area from Tijuana River sedimentation.

(6) Minimize future loss of restored or existing wetland area from sedimentation down Goat Canyon.

(7) Restore areas of former salt marsh affected by sedimentation to the maximum extent possible.

(8) Restore areas of former mudflat affected by sedimentation to the maximum extent possible.

(9) Minimize the disturbance of marsh plain areas in the north arm of the estuary.

(10) Minimize the potential year-round reduction in salinity in the marsh plain and intertidal areas due to possible future wastewater flows, while preserving the ability of flood flows to lower salinity for short periods in the winter.

(11) Minimize trampling of the barrier beach dune and vegetation by restricting public access.

(12) Provide the same area of high marsh and transition zone as exists presently.

(13) Identify existing resources so that a salvage operation can be planned and carried out prior to implementing the enhancement plan.

(14) Integrate research findings into the restoration effort.

(15) Incorporate a phasing program in the enhancement plan.

(16) Minimize impact on privately-owned parcels.

(17) Protect and enhance endangered species habitat.

(18) Provide habitat that will help maintain regional biodiversity.

In addition to these design objectives for the estuary, objectives also were developed for enhancement of the river corridor that occurs in the Reserve:

(1) Provide for the restoration of a continuous extensive riparian woodland corridor.

(2) Ensure that flood hazards are not increased.

(3) Minimize property damage due to channel migration.

(4) Allow for continuation of gravel extraction and agricultural operations where consistent with enhancement objectives.

(5) Utilize gravel pits as open water habitat and groundwater recharge areas.

(6) Maximize use of wastewater flows through evapotranspiration by riparian woodland.

(7) Consider future groundwater management in riparian corridor management.

(8) Enhance riparian endangered species habitat.

### 1.2.4 TIJUANA ESTUARY TIDAL RESTORATION PROGRAM

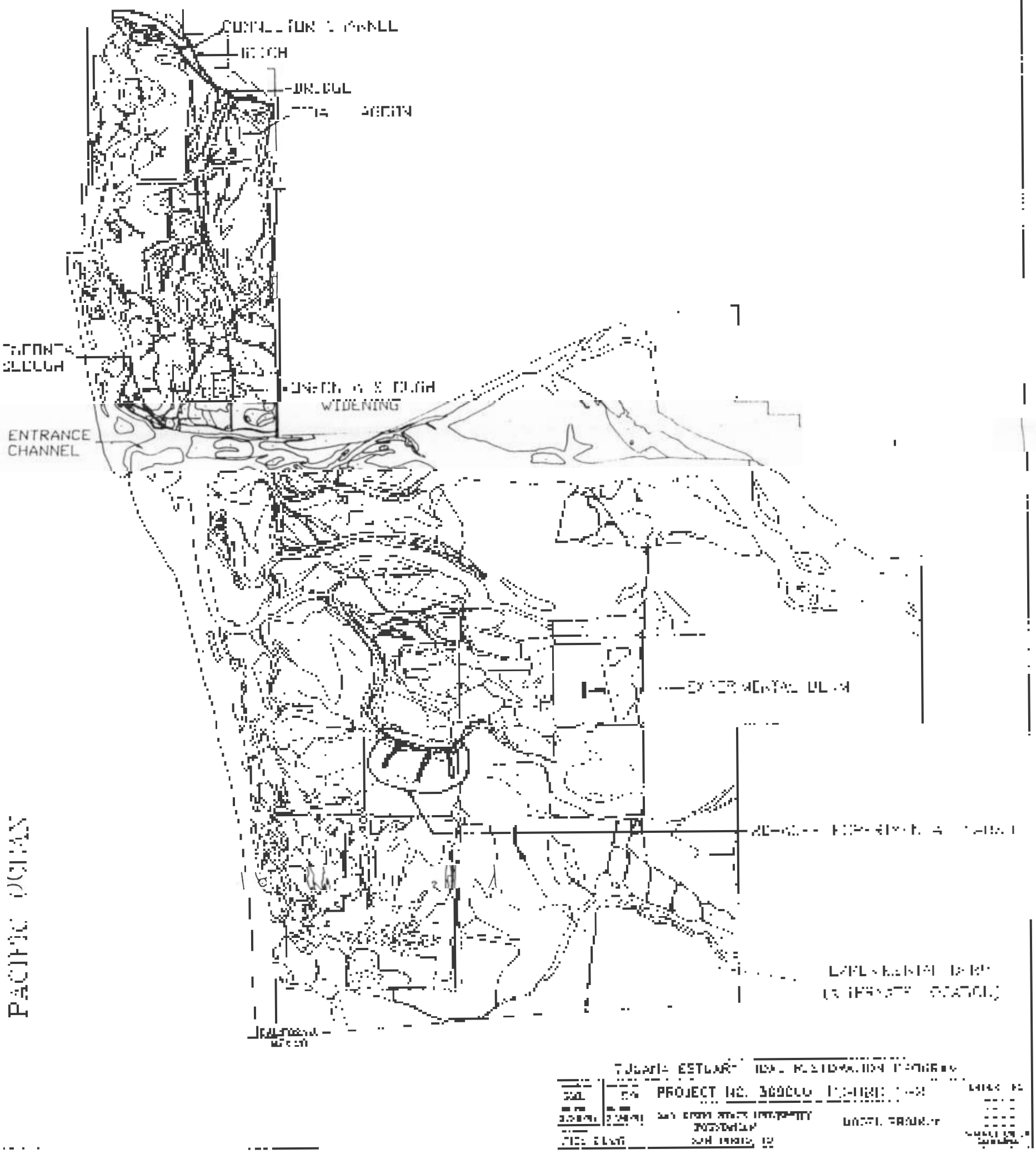
The Tijuana Estuary Tidal Restoration Program is designed to increase salt marsh habitat and restore tidal flushing to areas that have been silted-in over the past few decades. In the planning and design of the restoration program, the specific restoration objectives were based on what is best for the natural resources of the estuary. This principle is manifested in the overall project design and the adaptive management approach to implementation of the project. This principle must also be followed in the construction of the various components of the project by planning construction to create the least possible impact on the resource.

The Tijuana Estuary Tidal Restoration Program consists of two related projects: (1) the Model Project; and (2) the 495-acre Restoration Project. The Model Project will be implemented first and consists of three components: (1) Oneonta Slough widening; (2) construction of the Connector Channel; and (3) construction of a 20-acre experimental marsh (Figure 1-2). Construction of the 20-acre experimental marsh is a key element of the Model Project in that it forms the basis for the adaptive management approach for restoring the habitat values in the Reserve.

The datum for elevation measures used in this report is NGVD (National Geodetic Vertical Datum), which represents the 1929 mean sea level (MSL) datum. This datum is used because it is a constant for the United States. Other datum measures, such as mean lower low water (MLLW) vary by location. In the Tijuana Estuary MLLW is equal to -2.8 NGVD.

Design of the Tijuana Estuary Tidal Restoration Program is based on detailed geomorphic and hydrologic studies completed by Philip Williams & Associates, Ltd. The studies are presented in Appendix A. These studies provide justification for the design of the preferred alternative and describe other alternatives considered. The deposition of the excavated materials have not been determined because required sediment analyses have not been completed. A study to determine sediment quality has been developed and approved by the Regional Water Quality Control Board and the USFWS and is presented in Appendix G.

Under the current configuration of the 495-Acre Restoration Project, some components of the preferred alternative would directly impact wetlands subject to the U.S. Army


WIDENING
ENTRANCE
CHANNEL
PACIFIC OCEAN

Corps of Engineers jurisdiction, pursuant to its authority under Section 404 of the Clean Water Act (see Section 3.5.2.2). As such those components will need to be assessed for compliance with the guidelines that have been developed to implement Section 404(b)(1) of the Clean Water Act. Under these guidelines only the least environmentally damaging practical alternative can be permitted.

#### 1.2.4.1 Model Project

**Oneonta Slough Widening**

Widening of Oneonta Slough is intended to keep the north arm of the Tijuana Estuary open as the barrier beach migrates inland through time. Presently, the rate of barrier beach migration is approximately 2.2 feet/year. At this rate of migration, the barrier beach will migrate eastward over 20 feet in the next ten years and more than 100 feet in the next 50 years. The forces at work in the barrier beach migration include both accelerated beach erosion and sea level rise.

The slough/barrier beach system will react naturally to accommodate the barrier beach migration, with Oneonta Slough migrating to the east. However, a hardpan currently prevents eastward migration of the slough channel. As a result, the channel cannot presently accommodate the eastward migration of the barrier beach and will become increasingly susceptible to being filled in by migrating beach sediments. Over time, the channel will lose its capacity to flush these sediments and periods of reduced tidal flushing will increase, ultimately resulting in the complete cessation of tidal flushing in the north arm, and in the entire estuary (Appendix E). The result would be the accelerated loss of valuable salt marsh habitat.

To counter the problem of the hardpan barrier to channel migration and avoid eventual constriction of the channel, the east shoreline of Oneonta Slough will be excavated to remove the hardpan layer. Eventually the channel must be able to accommodate an expected eastward migration of over 100 feet. A minimum of 26,000 cubic yards of materials will be removed from the site initially (Area A in Figure 1-3). This amount will immediately forestall the threat of constriction due to the hard pan layer.

The extent of the hardpan beyond this area is not yet known, and will be investigated during construction. If borings collected during construction indicate that the hardpan layer is above -3 feet NGVD, up to 7,000 cubic yards of additional material will be removed (Area B in Figure 1-3). If these borings indicate that the hard pan does not extend past the initial removal area, then no further excavation will occur and the channel will be allowed to migrate at a natural pace. The channel bottom after construction will be at -4.0 feet NGVD, the bottom width approximately 150 feet, and the side slopes of the channel approximately 2:1. The area affected by the excavation of both area A (2 acres) and B (0.6 acres) will be 2.6 acres.

Access to the construction site will be routed to avoid unnecessary vehicular traffic in the marsh. The preferred access route would be through the U.S. Navy Outlying Landing Field facility and then onto the marsh surface. The alternative route would be to enter the marsh at the western end of Iris Street, proceed south along an existing road adjacent to the U.S. Navy facilities, and then turn west to the construction site. The roadway on the marsh surface will only be wide enough to accommodate a single dump truck (approximately twelve feet wide) and restricted to existing disturbed areas, to the extent possible. Travel to and from the construction site will be coordinated so that only one vehicle is traveling the road on the marsh surface at any time to minimize the direct impact of vehicle travel.

The construction staging area will be situated away from the marsh surface. The preferred staging area would be on the U.S. Navy facility adjacent to the access point onto the marsh. The alternative staging area would be the vacant lot at the western end of Iris Street.

All roadways and other areas in the marsh impacted by construction activities will be restored after construction has been completed. Restoration will be accomplished by first spot loosening the compacted soil (with a post-hole digger or backhoe) and immediate replanting at the loosened areas with plugs of appropriate vegetation.

The preferred plan for disposing of dredged materials is to use it as a roadbed for a realigned Monument Road. A small amount of material may be used for construction of an experimental berm to study revegetation of dredge materials with upland plants. An extensive preconstruction sediment analysis will be performed to assure that dredged materials meet state and federal standards for disposal. Should contaminants be found,

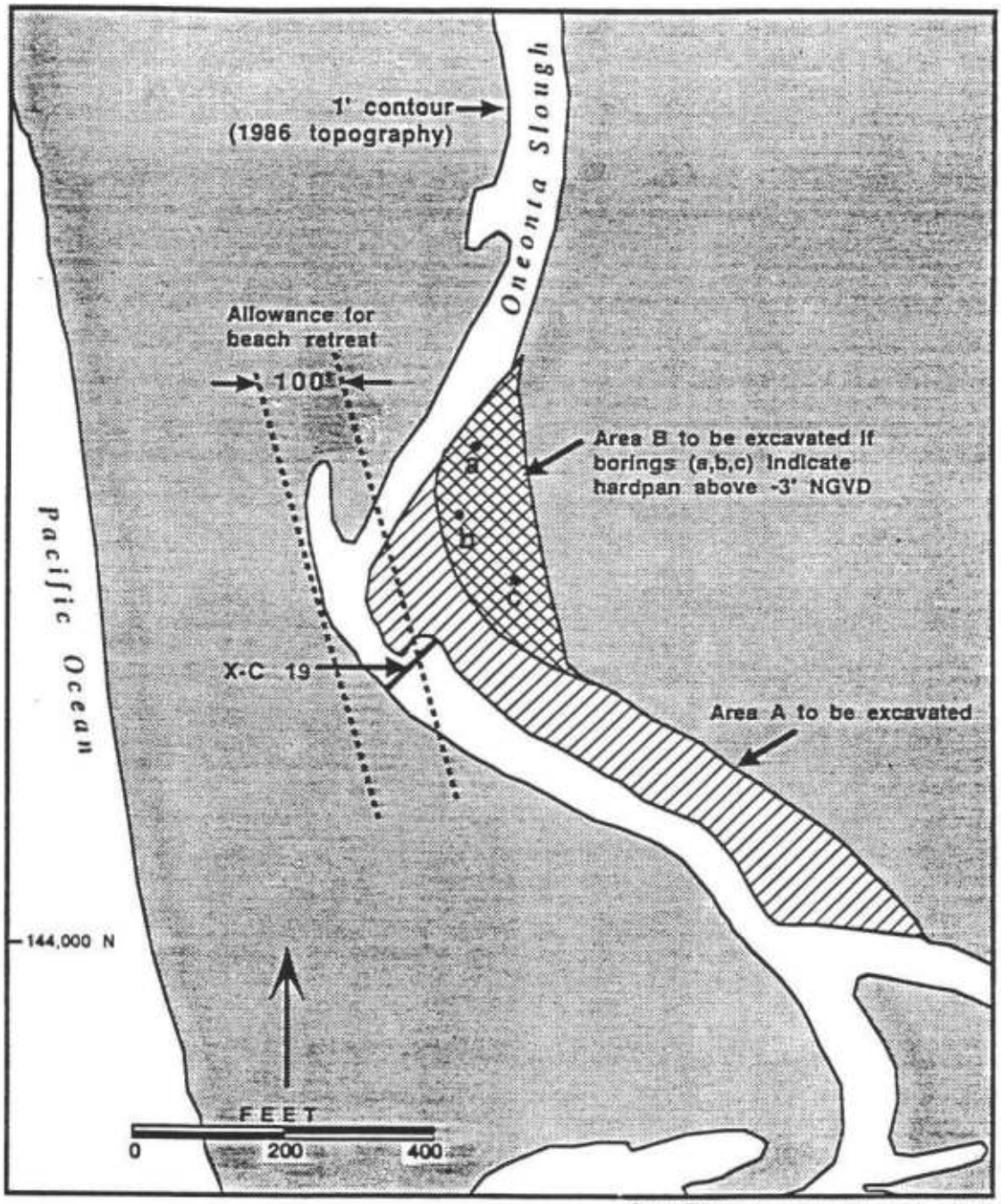



Figure 1-3. Oneonta Slough Widening

supplemental environmental documentation will be prepared assessing the range of other disposal options.

**Connector Channel**

The connector channel will provide a tidal connection between the northern part of Oneonta Slough and tidal lagoons along the northeastern part of the north arm (Figure 1-4). This channel will accomplish several purposes, including the following: (1) stabilizing the channel system in the northern arm and reducing sedimentation in the tidal channels; (2) controlling access to the northern arm, which supports San Diego County's largest population of the endangered light-footed clapper rail; (3) providing a gradient of additional wetland habitat (salt marsh); (4) providing a filter for low-flow street runoff near the Visitor's Center prior to reaching the salt marsh, thus minimizing the impact of freshwater and potentially harmful substances from urban runoff on the salt marsh in the northern arm of the estuary; and (5) providing an interpretive opportunity immediately adjacent to the Visitor's Center.

The connector channel will have two components. One component will be a stormwater ditch that extends from the southern end of 3rd Street to the connector channel, *per se* (Figure 1-4). The purpose of this ditch will be to filter sediments and materials prior to the runoff water in the ditch reaching the connector channel. The connector channel itself will extend from the northeastern extent of Oneonta Slough to the tidal lagoons (Figure 1-4). The purpose of the connector channel will be to improve tidal flushing in the tidal lagoons.

The stormwater channel will be approximately 985 feet long and not wider than approximately five feet throughout its length. The connector channel will be a relatively narrow, sinuous channel with intertidal benches built adjacent to the channel at two to three locations along the channel. The channel will be approximately 1060 feet long and have a bottom elevation of -2 feet NGVD, and 2:1 sideslopes. The slopes at the edge of the channel will be at 3:1 up to the unexcavated ground surface (Figure 1-5). Approximately 18,000 cubic yards of materials will be excavated for construction of the connector channel and the ditch. A 30-foot long timber bridge, will be constructed over the connector channel to accommodate and control access (Figure 1-4). The exact dimension of this bridge will be determined by the USFWS refuge manager, but probably

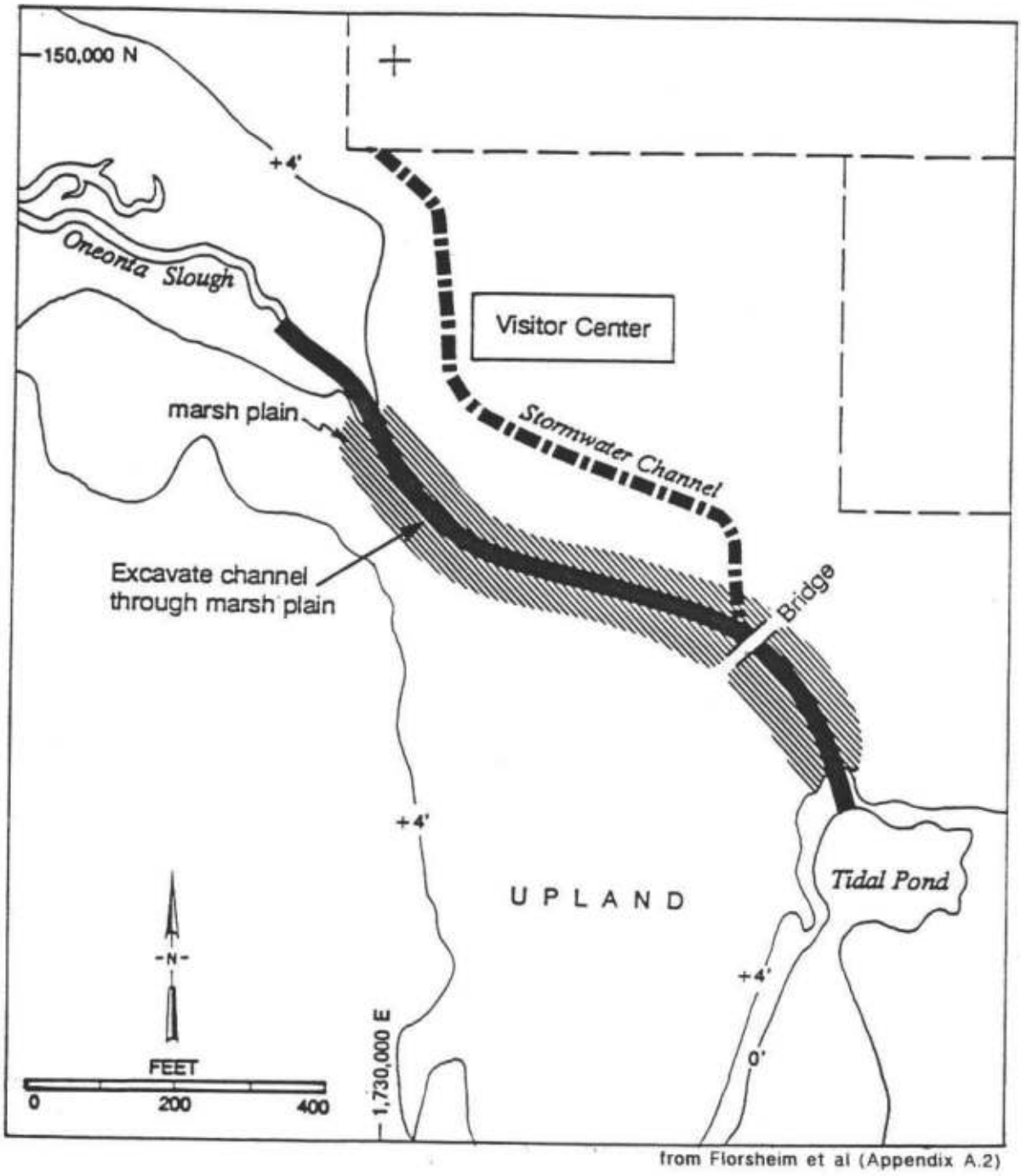
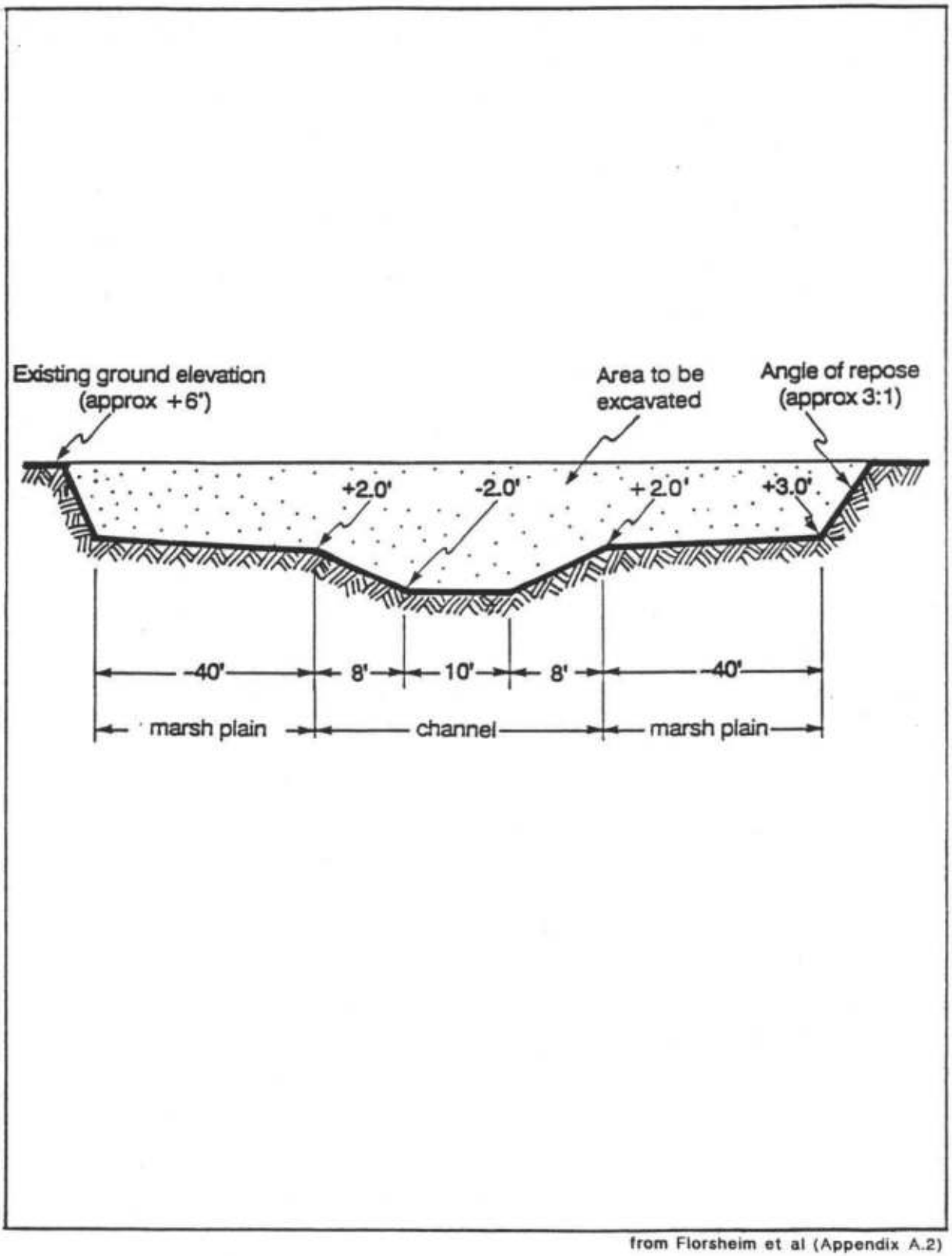



Figure 1-4. Conceptual Connector Channel and Ditch.




from Florsheim et al (Appendix A.2)

Figure 1-5. Connector Channel Profile.

will be wide enough to accommodate emergency/maintenance vehicle access. The area affected by construction of the connector channel (1.4 acres) and stormwater ditch (0.1 acres) will be approximately 1.5 acres.

Access to the connector channel construction site will need to be coordinated with and approved by the USFWS refuge manager since the channel will be constructed on refuge lands. Project construction in areas affecting habitat occupied or utilized by the California least tern, light-footed clapper rail, and Belding's Savannah sparrow will occur between September 16 and February 14. The construction staging area, which could include area for temporarily stockpiling of excavated materials, will be located in disturbed upland in the northeastern corner of the Reserve. Areas affected during construction will be restored using the same procedures described for the widening of Oneonta Slough.

The preferred plan for disposing of dredged materials is to use it as a roadbed for a realigned Monument Road. A small amount of material may be used for construction of an experimental berm to study revegetation of dredge materials with upland plants. An extensive preconstruction sediment analysis will be performed to assure that dredged materials meet state and federal standards for disposal. Should contaminants be found, supplemental environmental documentation will be prepared assessing the range of other disposal options.

Construction of the connector channel will provide an opportunity to test the ability to effectively salvage salt marsh sod for transplantation as habitat and to test the ability of tiger beetles to invade suitable intertidal flats. This information will be used along with information gained from the 20-acre experimental marsh to design the initial modules for the larger 495-acre Restoration Project. The following describes the two major experimental programs that will be part of the construction and monitoring of the connector channel. These experiments will be assessed and the findings incorporated in subsequent project components as part of the adaptive management approach that is an integral part of the proposed program.

**Testing the Ability to Salvage Salt Marsh Sod For Transplantation as Habitat**

**Rationale.** The constructed channel will abut salt marsh vegetation and soils at both its eastern (primarily *Salicornia virginica* and disturbed soils) and western (*Spartina foliosa*, *Salicornia virginica*, and other salt marsh species) ends (Figure 1-6). Previous studies (PERL, 1990) have shown that the natural marsh substrate is a key factor in promoting good plant growth; it should be salvaged along with the vegetation. Techniques for transplanting sod blocks need to be developed and tested.

**Proposed Set-up.** Depth of sod blocks and different types of vegetation will be important variables. Equipment will be a limiting factor. Some of the excavation work can be done with hand tools, but a Bobcat may work at low tide. If substrate at the eastern end is contaminated with asphalt or concrete, any plants at the surface should be salvaged and transplanted individually, retaining as much soil as is possible. No experimental program would then be anticipated for these plants; research would proceed with sod blocks from the western end of the channel.

The range of depths that need to be excavated will allow classification of sod blocks as shallow or deeper blocks. Replicate blocks of lower salt marsh (shallow and deeper) and of upper salt marsh vegetation (shallow and deeper) will be removed and relocated along designated sections of the connector channel, taking care to plant them at appropriate intertidal elevations.

Surviving vegetation will be censused as presence per block for each replicate after one month and then at 6-month intervals. After one year, plant heights and cover will be measured for comparison of shallow and deeper blocks. Invasive exotics will be noted and seedling establishment of native plants recorded for each block.

**Data analyses and Reporting.** Summaries of data will serve to demonstrate the strongest patterns. Results may not lend themselves to statistical analyses, owing to high variability among the transplanted blocks at the time of removal. After long time periods, the larger blocks of lower salt marsh should show the greatest growth of cordgrass, and the larger blocks of upper salt marsh should show greater species diversity and higher cover. A report will be prepared that will include recommendations for salvage and transplantation of salt marsh sod.

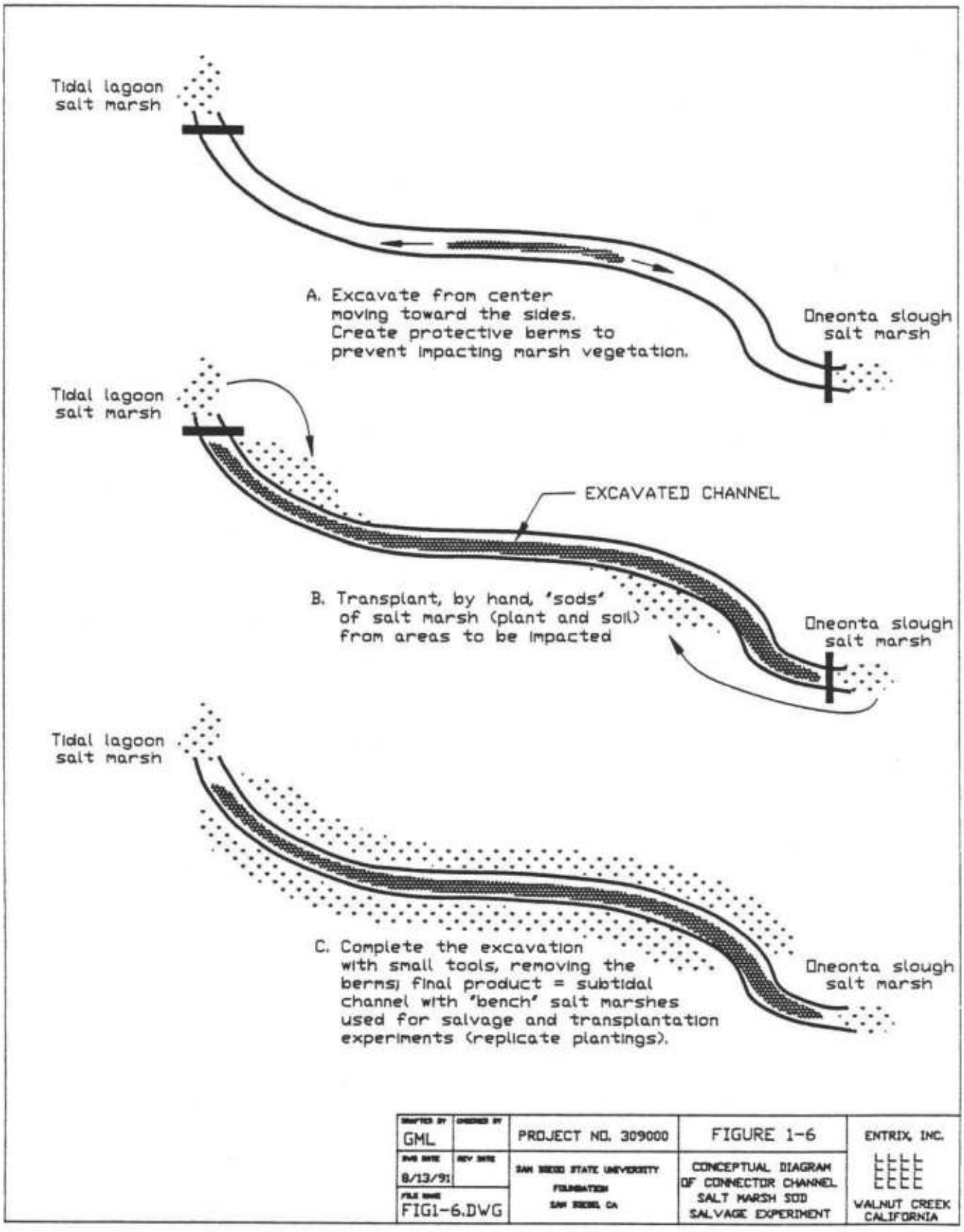



Figure 1-6. Conceptual Diagram of Connector Channel Salt Marsh Sod Salvage Experiment

**Testing the Ability of Tiger Beetles to Invade Suitable Intertidal Flats**

**Rationale.** Sensitive species should be encouraged to use intertidal sand- and mudflats. It is not clear whether or not species such as tiger beetles can invade available substrates on their own. More knowledge about habitual preferences of tiger beetles, and other sensitive insect species, is needed to better manage potential habitat for these species.

**Proposed Set-up.** Most of the connecting channel will be fine substrate. At least three sections of the channel (each four yards in length along the channel edge) should have a 1-foot layer of beach sand placed on top. Elevations should match three sections of similar length that are made up of finer sediments. Suitable sources for the sand would be clean-up from beach overwash events.

Visual surveys of the entire intertidal flat area should be undertaken annually at the times of year most likely to locate tiger beetles (late summer). Special attention should be paid to the three mud and three sand sections described above. Sightings of insects or their characteristic burrows should be related to substrate type and intertidal elevation. Different species would be expected on sand versus mud.

**Data analyses and Reporting**. There may be no sightings or insufficient data for analysis. In the event that many insects invade, the numbers of sightings and/or burrows should be compared for areas with finer and coarser substrate at lower and upper intertidal flat elevations. A report will be prepared that will include recommendations for habitat conditions considered most attractive for tiger beetle establishment.

**20-Acre Marsh Restoration**

The 20-acre experimental marsh will consist of two components: (1) construction and monitoring of an experimental tidal marsh; and (2) construction and monitoring of an experimental dredged material berm. The 20-acre marsh will be divided into six segments, three with and three without tidal channels. The surface of the marsh will be graded relatively flat at an elevation of 0.0 to 2.0 feet. NGVD throughout the six segments and grade upwards towards the boundaries of the marsh. The bottom of each tidal channel will be dug to a depth of approximately -1.0 feet NGVD with a bank

elevation of 0.0 feet NGVD. The tidal channels will be dug with a backhoe after the surface of the 20-acre marsh has been graded.

The outer portion of each slough channel will be graded so that side slopes upward from the edge of the slough channels to an elevation of approximately 5.0 feet NGVD at the margin of the marsh. The sloping topography will replicate the design of later phases of the 495-acre Restoration Project and will be used in conjunction with the monitoring program to guide dredging in later modules.

Construction of the Model Project will generate approximately 210,000 cubic yards of material. The experimental berm would require approximately 3,600 cubic yards of materials leaving approximately 206,400 cubic yards of materials to be disposed of elsewhere.

The preferred plan for disposing of dredged materials is to use it as a roadbed for a realigned Monument Road. A small amount of material may be used for construction of an experimental berm to study revegetation of dredge materials with upland plants. An extensive preconstruction sediment analysis will be performed to assure that dredged materials meet state and federal standards for disposal. Should contaminants be found, supplemental environmental documentation will be prepared assessing the range of other disposal options.

The 20-acre marsh will be designed to address the hypothesis that ecosystem development can be accelerated by increasing topographic heterogeneity. The experimental berm study will address the suitability of using dredged material for construction of the river training structure, especially the suitability of the material to support growth of native upland vegetation. The rationale and proposed setup for each of these two components is described below.

**20-acre Experimental Salt Marsh: Accelerating Ecosystem Development by Increasing Topographic Heterogeneity**

**Rationale.** Hydrology is the primary forcing function of wetlands. For tidal systems, the degree of streamflow and tidal flushing determines the nature of the sediment, the topographic contours, and the salinity, and these factors in turn strongly influence the

composition of the flora and fauna. To provide the appropriate hydrologic setting, careful attention must be paid to the grading of restoration sites. While many natural tidal wetlands are dissected by a network of tidal channels and creeks, most constructed marshes begin with smoothly graded terrain. Observations of such wetlands in southern California suggest that functioning is impaired by topographic homogeneity. Recent experiments were carried out in Texas by Tom Minello and Roger Zimmerman of the Galveston Laboratory of the National Marine Fisheries Services (personal communication). They dredged channels into transplanted marshes and found increases in densities of brown shrimp, blue crabs, grass shrimp, and small forage fish, along with increased densities of benthic infauna and epifauna. Increasing the "edge" seems to increase the secondary productivity of salt marshes.

Tidal creeks have long been recognized as important to the functioning of salt marshes. Creek banks have high nutrient influx, greater aeration and higher sediment redox, reduced sulfide concentrations, all of which seem to be important in producing the tallest cordgrass. With taller plants and more plant biomass, there should be more detritus production and greater productivity of consumers. Creeks are known to be productive of fishes and invertebrates, especially benthic molluscs and crustaceans. The benthic and creekside habitats are closely linked due to interchanges of organisms and materials with daily tidal flooding. These "edges" are also suitable foraging sites for birds, such as rails, that find both food and cover, in close proximity.

Constructed tidal wetlands typically have broad deep channels, with no tidal creeks dissecting the areas designated for salt marsh. It is not clear whether these marshes could develop tidal creeks after the vegetation has stabilized the sediments. Some of the shortcomings of constructed marshes (see PERL, 1990) may be correctable by excavating tidal creeks. New sites would be easiest to modify. The problem is that the benefits of adding topographic complexity to constructed marshes have not been documented, so the need is not clear and the increased construction costs are not easily justified.

A total ecosystem experiment will quantify the effects of adding a network of tidal creeks to restored wetlands and provide recommendations for this new management tool. The objective is to test the role of habitat heterogeneity in accelerating food chain support functions. We hypothesize that the topographic complexity is important for:

- development of diverse populations of invertebrates,

- improved access for fishes and invertebrates to feed in marsh areas,
- food chain support for birds that use the marshes,
- increased populations of crabs that burrow and aerate marsh soils,
- improved drainage of intertidal soils,
- improved growth of vascular plants, and
- improved tidal flushing of marsh vegetation.

**Proposed Set-up.** The excavation of an 8-ha (20-acre) intertidal wetland will take place early in implementation of the Model Project. The site will be graded to create a lower-intertidal salt marsh with two topographic treatments (and 3-fold replication):

- smooth marsh plain (characteristic of most wetland construction projects), and
- dissected with multiple tidal creeks (expected to accelerate ecosystem development).

Each treatment plot will be approximately 1.35 ha (3.3 acres) in area, allowing ample room for prey and predator populations to develop. The main creek in each of the three treatments with a network of tidal creeks will be approximately two meters wide at the mouth to the Old River Channel, meandering and tapering to one meter width at the inland extent. These could be constructed with a Bobcat. Side channels will be excavated with a backhoe, ranging from about one meter wide to the width of the backhoe bucket at the inland extent. Exactly the same pattern would be produced in each of the three treatment replicates.

Prior to opening the site for tidal flow wells to collect pore-water samples from the sediments will be installed in replicate in each of the six plots (three with tidal creeks, three without). Access to the experimental marsh surface will be via portable boardwalks to reduce trampling of the marsh surface. The boardwalks will be removed to reduce unauthorized access to the experimental marsh surface. Baseline studies will begin soon

after all plots have been planted and tidal flows are provided. Assessments should continue over a long-term monitoring program (ten years). Soils will be collected for particle-size analysis. A layer of white sand will be placed on the sediment as a baseline marker to measure accretion rates. Wells will be sampled monthly for salinity and nitrogen content (Total Kjeldahl Nitrogen, nitrate, ammonia). Soil organic matter will be measured at the beginning and end of each growing season.

The lower marsh elevations will be planted with cordgrass (*Spartina foliosa*). Mid-marsh species (pickleweed [*Salicornia virginica*] and associates) will be salvaged from the channel edge that will be disturbed during excavation. Blocks of sod will be transplanted to appropriate elevations within the experimental marsh. All planting will be done in an attempt to create a homogeneous setting, with the presence or absence of tidal creeks being the main difference between subsections of the marsh.

Cover of algal mats and vascular plants will be determined twice per year. Assessments should continue over a long-term monitoring program (ten years). Epibenthic invertebrates within the cordgrass marsh will be assessed quarterly using the litterbag trap method of Rutherford (1989). Crab holes and snails (dominant=*Cerithidea californica*) will be counted in replicate quadrats within each plot. Benthic infauna along the lower marsh margin will be assessed using replicate cores taken with a clam gun (15 cm diameter). Seines can be used to collect fishes in the tidal creeks of the heterogeneous plots, but an alternative method will be needed to compare the smooth and dissected marsh areas. Flumes have been installed at Tijuana Estuary but have not been effective for assessing marsh use by fishes. We will explore trapping methods (either baited minnow traps or drop traps). Bird use (resting and/or feeding) will be quantified by timed observations for each plot. A more detailed discussion of the proposed monitoring program is presented in Section 3.5.2.3.

**Data Analyses and Reporting.** Results will be compared statistically to test for differences between treatments (simple vs. complex topography). Changes between sampling dates, as well as conditions during individual sampling dates will be evaluated. Annual reports will be prepared, including recommendations for construction of salt marshes. The recommendations will be used to guide the larger restoration program. A comprehensive monograph will be prepared for the peer-reviewed literature. It is likely that graduate student theses would focus on this experiment.

**Berm Stabilization Experiment to Test the Suitability of Dredge Spoils for Use as a River Training Berm**

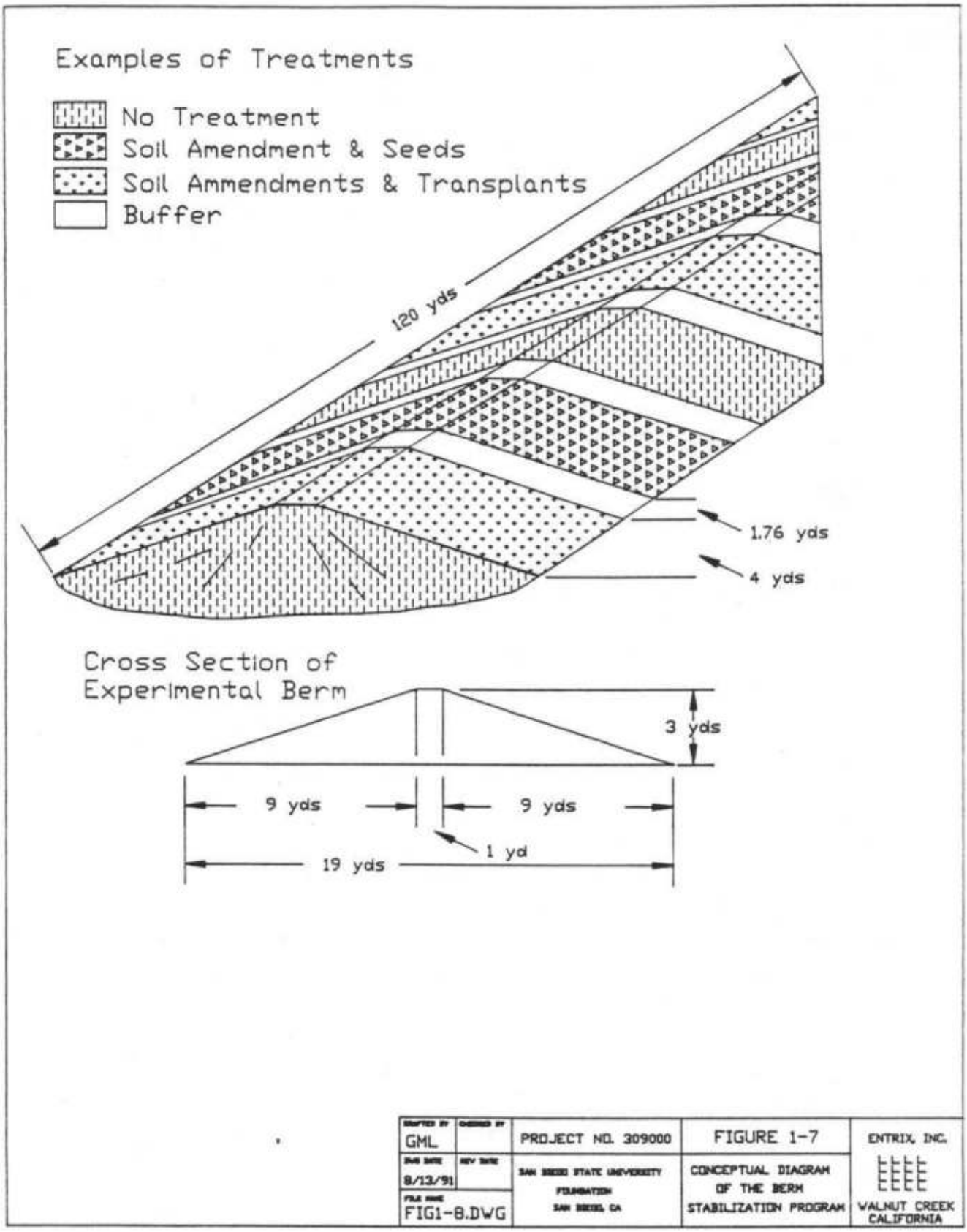
**Rationale.** Hydrologists have recommended the construction of a river training berm to protect the restoration site from future sedimentation from major Tijuana River flood events. Material dredged from the restoration modules are proposed for construction of this berm. To be effective, such a berm should become vegetated rapidly, develop high vegetative cover, support native plant species, and resist erosion. Since at least some of the substrate will be saline, it is unclear what native upland species will grow on the berm or what modifications to the substrate will improve vegetation establishment. Before developing a final design for the river training berm, we need to determine the ability of spoils to be vegetated, with emphasis on the types of sediments that will be most difficult to vegetate. Saline substrates would pose the greatest challenge for stabilization by terrestrial plants.

**Proposed Set-up.** The experimental berm will be located on a disturbed site in the southern arm of the estuary. The two potential locations are an area of the PERL facility and the area south of Monument Road, across from the abandoned model airplane facility. Neither of these sites are located on wetlands or lands that would be subject to the Corps jurisdiction pursuant to its authority under Section 404 of the Clean Water Act.

The proposed berm will have the following dimensions: 120 yards long, three yards high, one yard wide at the top and nineteen yards wide at the base, with 3:1 slopes on both sides (Figure 1-7). The cross-sectional area would be thirty square yards, and the total volume would be 3,600 cubic yards. Construction of the experimental berm would thus require only a small fraction of the total sediments to be excavated in the Model Project. The footprint would be just under 0.5 acres.

The experimental berm should be constructed mostly (71.40 yards long section) from saline soil, with some (14.28 yards long section) made of topsoil at one end of the berm. In between the saline and topsoil sections, there should be a short (14.28 yards long) section that has a saline core and a one-yard thick topsoil cap over both slopes and the top of the berm (Figure 1-7). The saline substrate will pose the greater challenge for vegetation, and most of the experimental work will concern improving the substrate for plant growth. The middle segment would yield information on whether or not a topsoil cap would accelerate vegetation growth.

Figure 1-7. Conceptual Diagram of the Berm Stabilization Experiment



Several treatments will be tested on the berm. Each treatment will comprise a four-yard long segment of the berm, extending over two sides and the top. A 1.76-yard buffer will allow foot traffic in between treatment strips. Ideally, the topsoil and capped treatments would be interspersed among the saline treatments. However, constraints of construction preclude this. Replicates for the topsoil and capped treatments will be "pseudoreplicates" that will help determine variability in stabilization ability, rather than the best experimental design for comparison with other treatments. Because we anticipate the least difficulty working with topsoil, the main comparison needed is between the topsoil, topsoil cap, and saline substrate, with soil amendments.

Suitable species for planting trials would include: *Isocoma venetus, Baccharis sarathroides, Lycium californicum, Distichlis spicata, Artemisia california, Eriogonum fasciculatum.* Each species chosen should be planted in all treatments with plants or seeds. Five treatments, each with three replicates, on saline substrate would encompass a 73-yard long section of the berm (fifteen treatment sections, each with an adjacent 1.76-yard buffer). Replicate four-yard sections of the saline portion of the berm to be assigned to the following treatments:

- no planting and no soil amendments,
- planting with selected seed and no soil amendments,
- planting with potted plants and no soil amendments,
- planting with selected seed plus soil amendments (nitrogen-rich organic matter), and
- planting with potted plants plus soil amendments (nitrogen-rich organic matter).

In the capped strips, potted plants should be planted plus soil amendments. Three replicates of this treatment will help determine variability in stabilization ability. In the non-saline portion of the berm, replicate areas with and without transplants will be set up. three replicates of this treatment will help determine variability in stabilization ability.

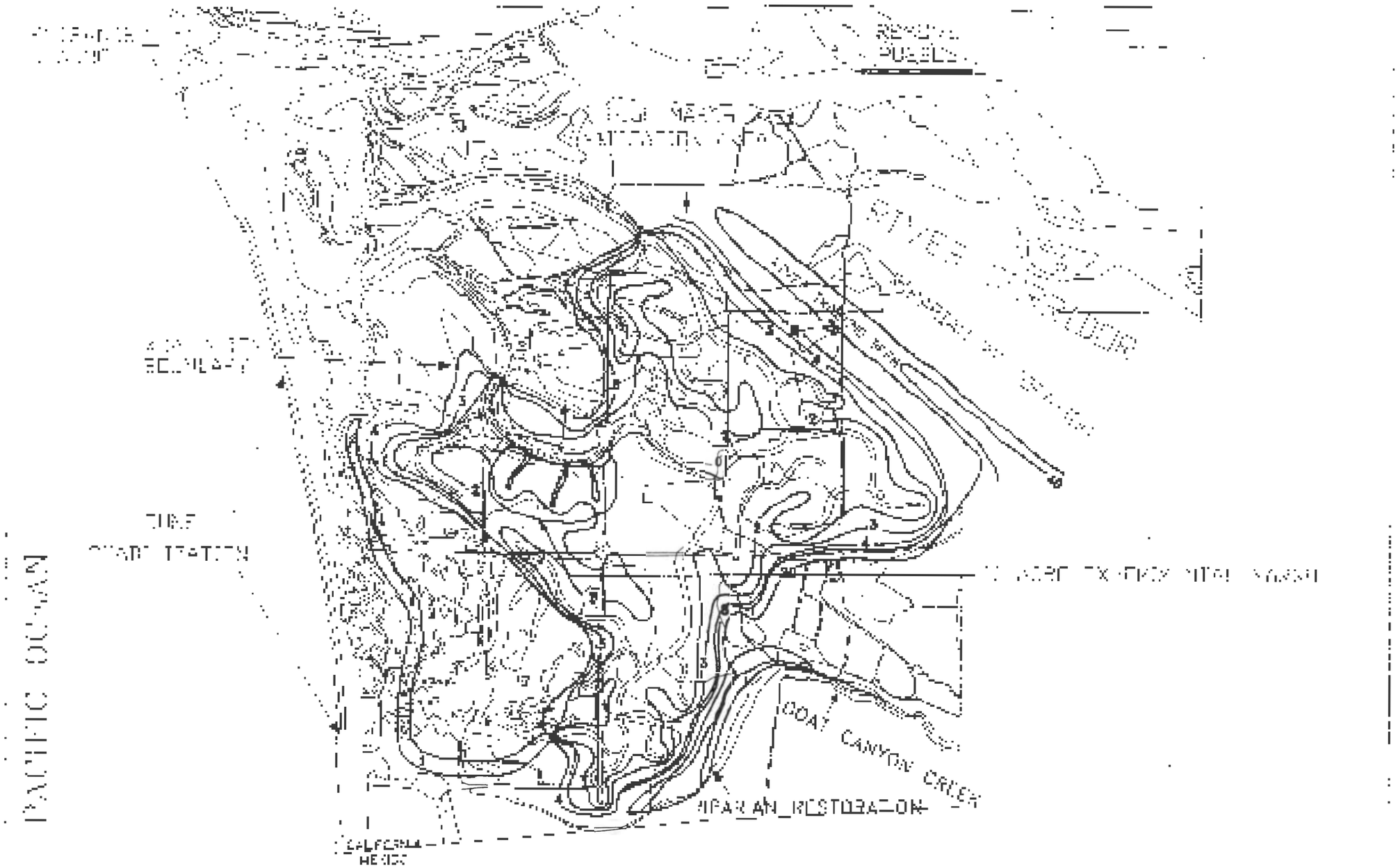
In addition, other smaller scale experiments may be implemented. These experiments should be set up in the topsoil substrate, which is most suitable for plant growth, to test the ability to establish sensitive plant species, such as barrel cactus. These could be done on the terminal face of the berm at the topsoil end. Monitoring would focus on the following:

- soil erosion rates (after major rainfall and annually),
- soil salinities (April and September) using profiles with depth to determine leaching and deposition zones,
- seedling establishment of seeded species (June),
- cover of exotic weeds (September), and
- survival of transplanted plants (six-month intervals).

**Data Analyses and Reporting.** At one, two and five years, results will be compared statistically to test for differences between treatments. A report will be prepared, that will include recommendations for construction of and vegetation establishment on the larger river training berm.

#### 1.2.4.4 495-Acre Restoration Project

The 495-acre Restoration Project, located in the south arm, consists of: (1) the restoration of 495 acres of tidal marsh; (2) construction of a river training structure; (3) stabilization of sand dunes along the barrier beach south of the tidal inlet; and (4) restoration of willow-dominated riparian habitat between the east side of the river training structure and the Tijuana River channel and at the mouth of Goat Canyon (Figure 1-8). Another feature of the project will be the removal of concrete rubble dumped along the north edge of the river channel within the Reserve (Figure 1-8). Finally, several sediment basins would be constructed in Goat Canyon to help reduce the movement of sediments into the restored marsh (Appendix E).




TIJUANA ESTUARY TIDAL RESTORATION PROGRAM

| | | | |
|---|---|---|---|
| NO. | BY | PROJECT NO. 302000 | FIGURE 1-6 |
| | | TIJUANA ESTUARY | 415 ACRE |
| | | TIDAL RESTORATION | RESTORATION |
| | | SAN DIEGO, CA | PROJECT |

ESRI, INC.
Goat Canyon
Enhancement

Appendix A through F present results of detailed geomorphic and hydrologic studies that were used to develop the preferred alternative. Design and implementation of the restoration project likely will change as new information is gained, which is a major component of the adaptive management approach being proposed for this program.

This project will be implemented as a series of modules. This will facilitate the learning process because early modules will generate information about how well procedures work, what problems develop, and what unforeseen benefits might be capitalized upon. This information will be used in the design of subsequent modules. The initial modules will benefit from the information gained by implementation of the Model Project, especially construction and monitoring the 20-acre experimental marsh and connector channel.

A major factor in the present and ongoing deterioration of the Tijuana Estuary is the accelerated rate of sedimentation in the estuary. The river training structure was designed to protect the restored tidal marsh, thus reducing the risk of closure of the mouth and loss of tidal flushing by protecting against the loss of tidal volume due to sedimentation. This approach was chosen because it would provide the restored tidal marsh with necessary protection from future flood-borne sedimentation while at the same time minimizing the impacts and cost associated with disposal of excavated material.

As with the design of the tidal marsh restoration, design of the river training structure will benefit from an experimental pilot program. Suitability of the dredged or excavated material to support native upland vegetation will be tested as part of the Model Project as will other possible beneficial uses for the dredged or excavated materials generated during construction of the tidal marshes.

**Tidal Marsh Restoration.** Restoration of the tidal marsh will involve the excavation of a series of tidal channels, lowering of the tidal marsh plain, and construction of a river training berm. The channel depths will range from -2.0 NGVD in the deepest part of the channel to 0.0 feet NGVD at the banks. The marsh plain will slope gradually from the channel edges up to an elevation of 4.0 feet NGVD. There will be a higher plain between 4.0 feet and 8.0 feet NGVD as replacement for the high marsh disturbed or lost as a result of implementation of the project. The volume of material removed for the total tidal marsh enhancement project will be approximately six million cubic yards of material.

Three main channels will be constructed to provide tidal circulation in the restoration area. Smaller tidal channels will be constructed off the three main channels to facilitate circulation and drainage of the interior portions of the restoration area (Figure 1-8). The size of the tidal channels will be based on hydraulic geometry relationships determined in earlier studies (Appendix D) and may be modified based on information obtained from the Model Project.

The mean diurnal tidal prism in the estuary after implementation of the project will be approximately 845 acre-feet, which will be smaller than the 1852 tidal volume estimated to have been 1,550 acre-feet. It is expected that the mean diurnal prism of 845 acre-feet will be sufficient to maintain an open entrance channel. The restored tidal volume represents a compromise between the volume necessary to keep the mouth open and the anticipated impacts that would occur in creating the new tidal volume.

A specific site development and planting plan will be developed as an initial step in the planning for a particular module or series of modules and the basic monitoring plan modified, as necessary, to document development of the constructed modules. Biological, hydrological, chemical, and physical data will be collected as part of the monitoring program.

**River Training Structure Alternative.** To protect the excavated tidal restoration site from major flood episodes, the river channel has to be prevented from migrating into the south arm of the estuary, as occurred in the 19th century. This can be accomplished by constructing a river training berm or levee to deflect sediment-laden flood discharges to the central part of the estuary and away from the restoration area in the south arm. As a result, flood flows and sediment would discharge directly to the ocean. The central part of the estuary is a constantly changing area and forms the active river delta that is subject to deposition and scour during floods. Provided there is sufficient tidal prism in the estuary, tidal channels will always be scoured through the active central area protecting it from sedimentation. During infrequent periods of high flood flows, turbid water would be carried into the south arm by the flood tide, even with a levee or berm in place. Sediments would be deposited on the mudflats and marsh plain eventually building up elevations to equilibrium levels similar to those in the north arm (approximately mean higher high water). However, a river training structure would protect the restored marsh in the south arm from the rapid and catastrophic sedimentation associated with the largest floods.

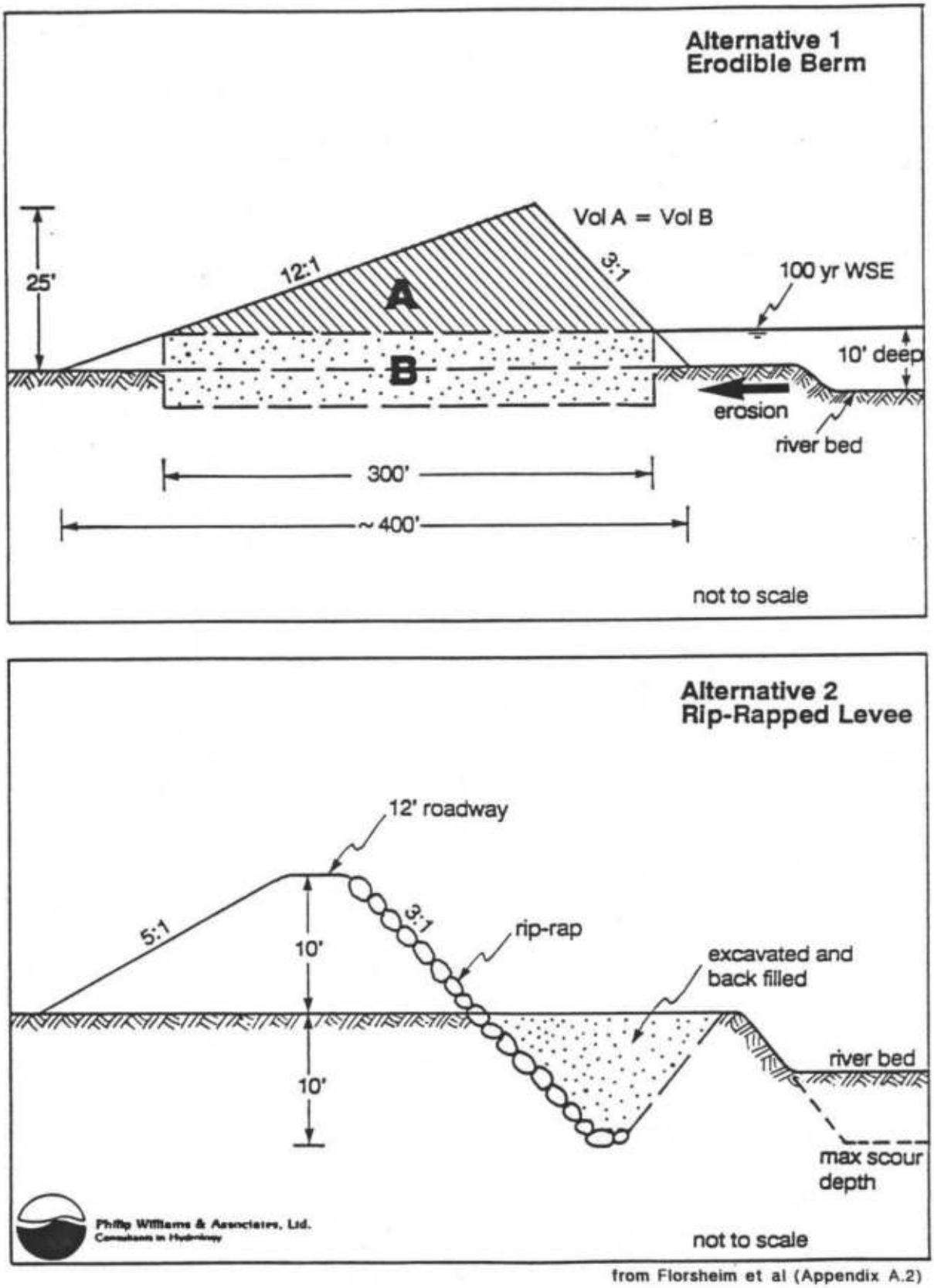
The location and orientation of the river training structure is determined by the need to provide as much restorable area in the estuary while not constricting the existing active river channel. This means placing the structure as far east as possible and at an oblique angle to the river valley to maintain at least a 2,600 feet wide area for the active river channel.

There are two alternatives for this structure: an erodible berm, or a rip-rapped levee (Figure 1-9). The berm would be unmaintained and allowed to erode on the eastern side. The berm is sized to accommodate 100 years of average erosion rates with a reasonable safety factor built in. In developing the design of the berm, an average annual erosion rate of 3 feet per year was used. This means that under natural conditions, approximately 300 feet of the outer face of the berm would erode over a 100 year time period at the flood water surface elevation, assuming that the river channel did not switch during that time period.

The analysis suggests that the berm should be at least 300 feet wide at the flood water surface elevation. Allowing for about a 3 feet increase in water surface elevation during the 100 year flood due to backwater effects caused by the berm, the typical flood elevation will be about 5 feet above the ground surface. To provide a safety factor of about 2.0 against erosion through the berm, an equivalent volume of material should be placed above the flood elevation as would be eroded away by natural channel migration (Appendix F). Assuming an eroded depth of approximately 10 feet and erosion width of 300 feet, the berm volume above the flood level should be approximately 3,000 cubic feet per foot of length. The conceptual cross-section of the berm is presented in Figure 1-9 (top).

Both slopes of the berm will be vegetated with native upland species. One of the purposes of the experimental berm is to identify appropriate techniques for vegetating dredged materials with native upland plant species.

The berm alternative would be approximately 25 feet above the existing land surface and would extend from the bluffs along the southeastern edge of the Reserve northwest to the southern edge of the central portion of the estuary (Figure 1-8). The footprint of the berm would be approximately 400 feet wide and 5,000 feet long and cover approximately 46 acres. The slope along the Tijuana River side of the berm (east side) would be 3:1. Along the side of the berm adjacent to the marsh restoration area (west side), the slope




from Florsheim et al (Appendix A.2)

Figure 1-9. River Training Structure Alternatives.

would be more gradual, grading down to 12:1 at the northwestern end of the berm (Appendix E). The slope of the berm crest should be approximately parallel to the slope of the Tijuana River, which is 0.02 percent in the reach adjacent to the proposed location of the river training berm. It would take approximately one million cubic yards of material to construct the berm.

The river training structures will be constructed on sections beginning from the west and progressing to the east. The initial action will be to fill the upper end of the Mid-Valley Slough channel at the location where the berm or levee will cross the slough channel (Figure 1-1). The Mid-Valley Slough is at the most likely location to which the Tijuana River would migrate during a sediment-laden flood flow.

The rip-rapped levee would be an erosion resistant structure that is high enough to prevent overtopping. Assuming a 100-year flood depth of five feet against the levee, the levee should be at least ten feet high to provide a measure of additional protection and for settlement (Appendix F).

The most likely cause of failure of levees of this type is undermining of the toe of the rip-rap when the river channel impinges directly against the levee. During peak flood flows, the river bed can scour considerably deeper than the normal channel bed elevation before and after the flood. At present, the channel bed is typically five feet lower than adjacent land elevations. Allowing for an additional five feet of scour means that the rip-rap would have to be placed at least ten feet below ground elevation (Figure 1-9 [bottom]).

The levee would have to be maintained and have a 12-feet wide access roadway on top. It would be approximately 10-feet high and rip-rapped on the eastern slope. The eastern side would have a slope of 3:1 and the western slope would be 5:1. The base of the levee would be approximately 100 feet wide. The footprint of the levee would be about 12 acres. It would be in the same location as the erodible berm. It would require approximately 190,400 cubic yards of material to construct the levee, not including the rip-rap material.

The western slope of the levee would be vegetated with native upland species. The eastern face of the levee will be vegetated to the extent possible. Initially, the rip-rap material may be covered with a dressing of soil to facilitate establishment of native upland vegetation.

Construction of the river training structure will necessitate re-routing of Monument Road. The current alignment of the road in the area of the river training berm or levee will need to be elevated to conform to the change in local topography that will be created by the berm or levee. The exact alignment of Monument Road will be determined after the specific design of the river training berm or levee has been completed.

In keeping with the adaptive management approach, the final design specifications for the berm or levee will be adjusted based on information gained from the monitoring of the Model Project and the first modules to be constructed. These assessments will be included in supplements to this program-level impact assessment.

**Sand Dune Restoration.** In addition to the tidal marsh enhancement activities, a program of dune restoration will be designed for the barrier beach south of the tidal inlet to Tijuana Estuary. This dune system has been progressively destabilized by disturbance from human trampling and horse traffic. Unless protected by fencing and vegetation, the sand will remain excessively mobile and able to move into nearby channels, either through the action of winds or storm washovers. Accumulation of dune sand in channels would decrease the tidal prism and increase the likelihood that the estuary mouth would close to tidal flushing.

The dune profile at Tijuana Estuary is low, due to past washovers, so that vegetation can grow to the water table (which is about one meter deep) more readily than in higher dune systems. However, disturbances continue to be a major impediment to plant growth. Pedestrian traffic is high, because of the proximity of the U.S.-Mexico border, and trampling is a major problem. The potential for natural plant recruitment is minimal in most years, because of the paucity of native plant seeds on the site and the abundance of aggressive exotic weeds (e.g., sea rocket, *Cakile maritima*). It is thus necessary to transplant native plants in order to reestablish the dune vegetation. Unfortunately, transplantation efforts are often hindered by low surface moisture and by occasional Santa Ana winds from the east, which can blast new transplants with sand as well as desiccate young plantings. An additional problem is herbivory by jackrabbits.

Because there are a number of problems with reestablishing a plant canopy that is dense enough to stabilize the sand dune, several measures will be undertaken to improve plant survival and growth. These will include substrate stabilization, irrigation, mulching and nutrient addition, and planting of native species. The following plan was developed

through extensive experience at this dune restoration site (B. Fink, PERL, personal communication). Prior to implementation of the dune restoration, a specific sand dune restoration plan will be developed for approval by the Management Authority and relevant agencies. Specific approval will be needed from the USFWS because of the use of dune areas for nesting by the endangered least tern. The plan will include a detailed site preparation plan, a planting plan, a schedule of implementation, a maintenance plan, a monitoring plan, and a specific management plan.

**Substrate Stabilization.** Sand fencing is the fastest way to stabilize the sand substrate. Although natural accretion is superior in some ways (more nutrient/organic matter incorporated in the dune), stabilization would not be attained with the current rate of pedestrian traffic. Sand fencing will need to be installed the entire length of the area that is to be stabilized. Fencing should be left in place for the duration of the project, both to slow sand movement and reduce trampling. Two rows of sand fencing at a slight oblique angle to the prevailing Northwest wind direction would probably work best. If the wrong angle is obtained, wind will carve out a tunnel directly under the fencing and sand will not accrete. The rows will be spaced 20 to 40 feet apart and connected to one another every 100 feet with perpendicular fencing. Seeding will occur between the two fences. Any plants/seeds must be protected from herbivores, so that as long as the fence is in place it should be used for protection as well as accreting sand. When the sand has reached the top of the fence, herbivores will be able to enter, but the vegetation will be mature and less palatable (at least better able to resprout following herbivory).

**Irrigation.** This is an absolute must in southern California where unpredictable winter rains and Santa Ana winds do not typically favor plant establishment. Care must be taken not to overwater as this leaches scarce nutrients through the soil horizon and makes plants more palatable to herbivores and "spoils" the plants so that they experience heavy mortality when the water is curtailed. A drip irrigation system is the preferred approach to irrigation. Irrigation will continue until the planted vegetation becomes established, which should occur within the first three years. The drip irrigation system will be operated during the late spring and summer months. During a year with low rainfall, drip irrigation may begin earlier in the spring.

**Mulching/Nutrients.** During 1990-91 at Border Field State Beach, an experiment was set up where nursery stock was mulched with wrack retrieved from the wrack line. Although no significant differences in growth are apparent as of February, 1991, survival

was enhanced. Sand has accreted around the wrack; some control plots experienced net sand loss leaving the plant roots exposed. In addition, wrack seems to keep the plants cooler, aid in establishment of the dune microflora and may provide nutrients in subsequent years. Wrack is a natural part of the system and should be implemented in future revegetation work.

**Planting.** Nursery stock should be planted at approximately 40 plants/acre and seed (if broadcasted) at a rate of 50 lbs/acre for species such as *Abronia maritima* with large papery seeds and 0.5 lb/acre for species such as *Camissonia cheiranthifolia* with very small seeds. Broadcasted seeds should be raked into the substrate at different depths or preferably buried in piles of wrack place on the sand substrate (this keeps them in place). Exotic vegetation observed in the restored areas will be periodically (monthly) removed by hand during the first three years or longer, depending upon the agreed upon maintenance schedule developing as part of the Sand Dune Restoration Plan.

**Riparian Restoration.** A minimum of 100 acres of willow-dominated riparian habitat will be restored in the area between the east side of the river training berm or levee and the active channel of the Tijuana River and fifteen acres near the mouth of Goat Canyon (Figure 1-8). The area east of the berm that will be restored to riparian habitat is currently being used for production of grass sod. Willow-dominated riparian habitat has decreased in the Reserve as the river channel has become more restricted by filling in the flood plain. Currently, willow-dominated riparian habitat is restricted to the main channel of the Tijuana River and some of the historic channels. A major goal in the design and implementation of the riparian restoration will be the creation of suitable least Bell's vireo habitat. The restoration proposal is in conflict with the current agricultural uses of the property.

The areas to be restored east of the river berm or levee will be excavated, if necessary, to an elevation close (within one foot) to the present elevation of the Tijuana River channel. The excavation will proceed in such a way that direct impacts to the existing riparian habitat will be minimal. Initial plantings will include several species of willows, cottonwood, and possibly sycamores. The need for additional planting will be determined from the results of the monitoring program. Additional restoration efforts will include removal of exotic vegetation from existing willow-dominated riparian habitat and replanting with willow or other appropriate native riparian species.

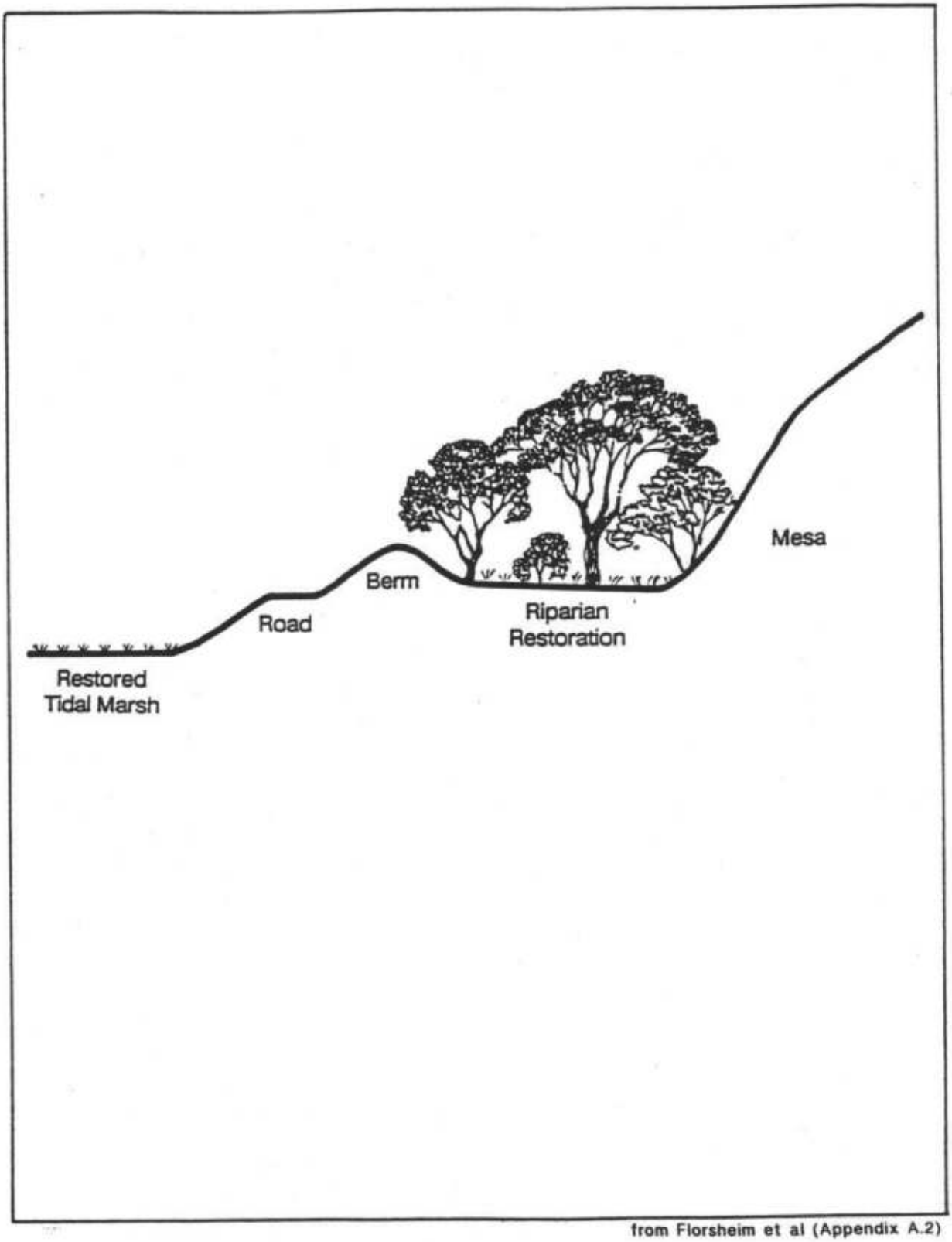
Construction will occur only during the months of October through February to avoid disturbing least Bell's vireo habitat during nesting season.

The riparian restoration site at the mouth of Goat Canyon will provide a sediment control function as well as creating new riparian habitat. A major source of sediments in the south arm is Goat Canyon and, to a lesser extent, other smaller side canyons (Appendix D). Expansion of alluvial fans at the mouth of the side canyons onto the southern part of the Reserve has contributed to the loss of about 30 acres of intertidal areas since 1852. In many places the vertical growth of the alluvial fan at the mouth of Goat Canyon has exceeded three feet and over a half a foot in the disturbed high marsh in the southern part of Border Field State Park. This accumulation of sediments has contributed to the disturbance and loss of salt marsh in the south arm.

Proactive measures are needed to reduce the movement of sediments from these side canyons onto the marsh surface, especially after construction of the intertidal marsh habitat. To control the movement of sediments out of Goat Canyon, Monument Road may be re-aligned toward the mouth of the canyon and raised to act as a berm (Figure 1-10). The relocated and elevated Monument Road would effectively trap sediments originating in Goat Canyon behind the road and prevent the sediments from reaching the restored marsh surface.

The roadway also will direct runoff along its southern boundary. Riparian vegetation will be planted at the mouth of Goat Canyon and along the southern boundary of the road. The vegetation will help stabilize the sediments behind the road in addition to adding to the inventory of riparian habitat in the estuary.

Prior to implementation of riparian restoration, a specific plan will be developed and approved by the Management Authority and relevant regulatory agencies. Because of the recorded presence of the endangered least Bell's vireo in the Tijuana River in the area of the proposed riparian restoration east of the berm, the restoration plan will be developed in close coordination with the U.S. Fish and Wildlife Service – Enhancement Office. This plan will include a detailed site preparation plan, a planting plan, a schedule of implementation, a maintenance plan, a monitoring plan, and a specific management plan.




from Florsheim et al (Appendix A.2)

Figure 1-10. Conceptual Cross Section of Goat Canyon Riparian Area.

### 1.2.4.3 Disposal of Excavated/Dredged Materials

Four disposal options have been identified to deal with the excavated or dredged material generated by construction of the 495-acre Restoration Project, including: (1) beach nourishment; (2) ocean dumping; (3) onsite disposal; and (4) offsite disposal. The preferred option would be to use the sediments to construct the river training berm of levee and to dispose the remainder in a nearby abandoned gravel pit. However, the quality of the sediments will need to be determined before the disposal option can be defined. A description of each alternative is presented below along with a discussion of the regulatory review that may be necessary before implementing the various alternatives.

**Beach Nourishment.** The feasibility of using dredging spoils for beach nourishment was evaluated early in the planning process. Benefits of beach nourishment include increased beach width that could add shoreline protection and additional recreational areas. Artificial placement of sand in the littoral zone would have the effect of increasing along shore sand transport.

The Corps of Engineers has regulatory responsibility for all dredged material disposal activities which occur in the waters of the United States under: (1) Section 10 of the Rivers and Harbors Act; (2) Section 404 of the Clean Water Act; and (3) Section 103 of the Marine Protection, Research, and Sanctuaries Act. Both Sections 404 and 103 require that materials discharged into waters of the U.S. shall not cause significant degradation of water quality and be compatible with the disposal site. Therefore, dredged material must be sampled and tested prior to discharge or disposal. Sampling may also be required at the disposal site.

The San Diego Regional Water Quality Control Board (SDRWQCB) would require sediment chemistry tests to identify constituents such as heavy metals or pesticides and other organics. Dredged materials must be tested with respect to Title 22 regulations, Section 66699, Tables b and c of the California Code of Regulations under Environmental Health. A Section 401 certification (Clean Water Act) would be required from SDRWQCB.

A three-tiered method of testing is required by the Corps of Engineers in order to obtain a Section 404 and Section 10 permit. Testing in each tier is contingent on the belief that

the potential for unacceptable adverse effects exists. The first tier consists of an initial evaluation to establish the presence of contaminants, evaluation of grain size compatibility, and chemical similarity of the dredged material to the substrate at the disposal site. If the material is determined to be size-compatible and chemically similar, no additional testing is necessary. However, if there is a reason to believe contaminants are present, the second tier is conducted.

The second tier consists of a bulk sediment inventory (with emphasis placed on PCBs, PAHs, pesticides, and other substances of ecologic concern) and an elutriate analysis. If high concentrations of contaminants are observed in the dredged material, a third tier is required which evaluates bioaccumulation in suspended and solid phase. Because of past sewage discharges into the Tijuana Estuary, it is possible that excavated sediment would not be appropriate for beach nourishment because of accumulation of contaminants.

A sediment size analysis was conducted in the areas to be excavated for the 495-acre Restoration Project. The median particle size of sediment was determined to be 0.072 mm (very fine sand). Size compatibility can be determined by comparing the particle size of material to be dredged to the size present at the proposed dumping location. Median particle sizes measured at Silver Strand Beach near the mouth of the Tijuana River range from 0.11 to 0.36 mm at the end of summer and 0.13 to 0.29 mm at the end of winter sample set (U.S. Army Corps of Engineers, 1985). This preliminary analysis suggests that sediment excavated from the Tijuana Estuary is too fine to be considered for beach nourishment on Silver Strand Beach.

One possibility would be to sieve the sediment and separate the fine from the coarser material. This would allow the coarser portion of the excavated material to be disposed of on the beach and the finer portion to be disposed of in one of the other options. Sieving the excavated material would add approximately $1.50 per cubic yard to excavation and transportation costs already associated with beach nourishment.

**Ocean Dumping.** Ocean dumping must occur in a designated site. At present, the designated site for the San Diego area is LA-5. There are several procedures that need to be followed in order to dispose of sediment excavated in the Tijuana Estuary. The Corps is the permitting agency, and the EPA reviews permits issued by the Corps. The permits required are the Ocean Dumping Permit under Section 103 of the Marine Protection

Research and Sanctuary Act, 1972, and a permit under Section 10 of the Rivers and Harbors Act of 1899.

Several tests are required in order to determine the suitability of the material for ocean disposal before permits are given. Information concerning historical land use and impacts on the Tijuana Estuary would have to be presented to the EPA and the Corps to determine which tests need to be performed. In the Tijuana Estuary, issues of particular concern will be sewage discharge and stormwater drainage. The EPA provides a basic list of detection limits for chemical constituents that must be tested in order to determine suitability. Other tests include size compatibility, water content, bioassay on suspended and solid phases, and bioaccumulation analysis. If the EPA requirements are met, the California Coastal Commission would require a consistency review. This analysis would be assessed against the goals of the coastal management program.

**Onsite Disposal.** Onsite disposal in the river training structure would minimize handling of sediment and costs associated with transportation, though only a small portion of the material generated by the project could be accommodated in the structure. The placement of excavated sediment for construction of a berm or levee as part of the 495-acre Restoration Project would need approval by several agencies to guarantee that the structure is consistent with the habitat resources program and serves to implement the project as a whole. These agencies include the Corps of Engineers, State Coastal Conservancy, U.S. Fish and Wildlife Service, Department of Parks & Recreation, Department of Fish and Game, California Coastal Commission, National Marine Fisheries Service, City of San Diego, San Diego Regional Water Quality Control Board, and San Diego County. Onsite disposal in a river training structure would require a Section 404 (Clean Water Act) permit issued by the Corps and a Section 401 certification (Clean Water Act) issued by the Regional Water Quality Control Board.

Dredged material may be altered in the dredging processes. Density increases because individual sediment grains loosen and separate. The bulking factor is approximately ten percent, and material placed on the river training structure must be compacted in order to reduce the bulking effect. Compaction will also increase stability.

**Offsite Disposal.** There are various possibilities identified for offsite disposal near the Tijuana Estuary: (1) suitable material can be sold; (2) disposal in existing gravel and sand pits near Goat Canyon; and (3) transporting the material to a landfill.

Excavated material of suitable size and composition could be sold if a buyer were located. The option of disposing excavated material in existing sand and gravel pits depends on acquisition of previously mined property. Excavated material also could be transported to offsite landfills. San Diego County Solid Waste Division administers the Otay Landfill near Chula Vista Road. This landfill accepts dry material as long as it is not contaminated with sewage or other hazardous materials. Costs of this disposal option are approximately $23.38 per cubic yard, plus a $30 administrative fee for each truck load (assume 16.5 cubic yards per load, or $0.55 per cubic yard). Costs of transportation from the Tijuana Estuary to the Otay Landfill, approximately ten miles away, would be approximately $10.10 per cubic yard. The cost to dump in a landfill can be expected to be approximately $34.00 per cubic yard, in addition to the costs associated with onsite excavation work. This alternative is considered economically infeasible at present.

#### 1.2.4.4 Other Projects

Early in the planning of the Tijuana Estuary Tidal Restoration Program, two small projects were identified and implemented based on recommendations developed by Philip Williams & Associates (PWA) in conjunction with PERL. These projects included: (1) the initial widening of Oneonta Slough; and (2) the development of 24 experimental replica tidal marsh systems (mesocosms). These projects are consistent with the objectives of the management plan and the proposed tidal restoration program.

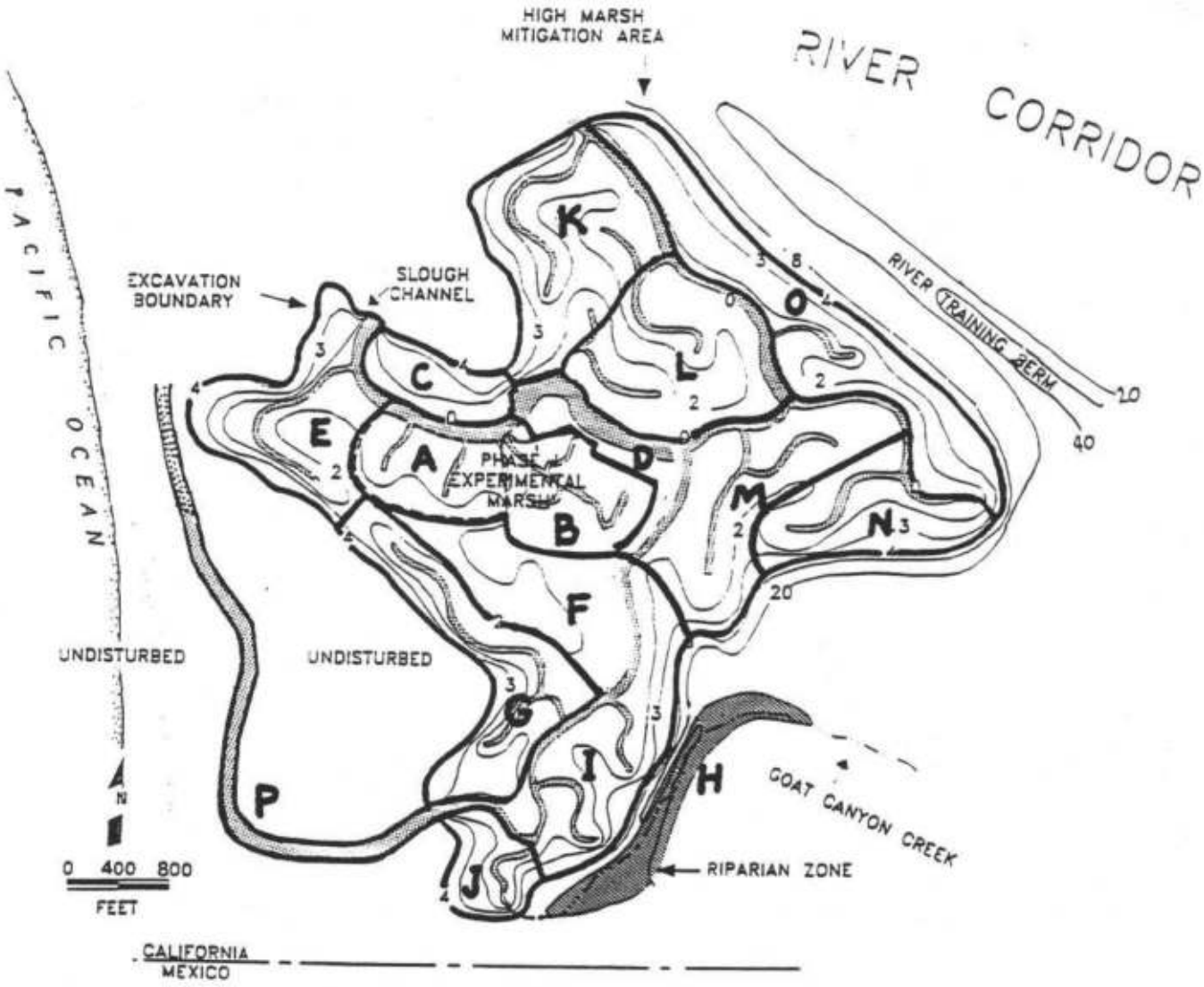
Dredging of a portion of Oneonta Slough occurred in 1986 to restore tidal action after the slough was partially filled with sand from storm-related dune overwash. This project was carried out by the U.S. Fish and Wildlife Service under an emergency authorization to keep Oneonta Slough tidally active. The project addressed a critical situation and provided an opportunity to apply an adaptive management approach. Channel dredging was undertaken carefully in increments and a monitoring program set up to follow the reaction of the channel system. If the channel system was not stabilizing over time and adequate tidal prism not restored, then additional dredging would have occurred. The area was re-surveyed in 1989, and the results showed that channels had become deeper and slightly wider and had become more stable (Appendix E). The adaptive management approach to this dredging project is estimated to have eliminated the need for as much as 40 per cent of the initially-anticipated dredging required to restore the slough.

The 24 experimental tidal mesocosms were excavated in 1990 at the northern end of the tidal lagoon by PERL. These were designed to refine knowledge of the effects of freshwater inflows and tidal regimes on the establishment and persistence of salt marsh (especially to add information on *Salicornia virginica* and the associated benthic algal and invertebrate community). The knowledge gained from these mesocosms will be used in the detailed design of the 20-acre experimental marsh. Research to be carried out in the tidal mesocosms is the first stage of the experimental work of this program. The mesocosms will be available for follow-on experimentation once the initial questions have been answered. Hence, they will provide many opportunities to research methods of improving wetland restoration.

### 1.2.5 IMPLEMENTATION PROCEDURES

Implementation of the 495-Acre Restoration Project will follow an adaptive management approach to habitat restoration. This means that the project will be implemented in a sequential, modular format, with information gained during the construction and monitoring of each module being used to refine techniques for subsequent modules. After a minimum of one year of assessment of the completed Model Project and upon approval by the Management Authority and permitting agencies, subsequent project modules may be implemented. Each project increment will be assessed according to the monitoring protocol described in Section 3.5.2.3. The project will include a series of at least 14 modules of varying size and complexity (Figure 1-11). The size of a given module may vary slightly according to available funding; however, the habitat type for the modules will remain consistent with this plan (Table 1-1). The timing of any one module will be influenced by: (1) location of sensitive habitat; (2) hydrologic connections of the tidal channels; (3) heavy equipment access to the excavation site, the river training structure or Monument Road, if offsite disposal is required; (4) property acquisition. This approach will require an infrastructure that will be rigid enough to provide the project stability and consistency, yet flexible enough to handle the different sources of funding that may be available.

The primary parties involved in the implementation of the Tidal Restoration Program may be described in general terms as the Project Proponent, the Project Office, the Decision Making Authority, and the Technical Advisors.




from Florsheim et al (Appendix A.2)

Figure 1-11 Conceptual Layout of Modules

**Table 1-1. Approximate Acreage for Each Module.**

| Module | Salt Marsh Habitat Acres | Channel Habitat Acres | Total Acres |
|---|---|---|---|
| Experimental Marsh (A) | 19.82 | 4.63 | 24.45 |
| Module B | 16.04 | 1.80 | 17.84 |
| Module C | 12.45 | 0.00 | 12.45 |
| Module D | 6.59 | 5.64 | 12.23 |
| Module E | 29.18 | 3.70 | 32.88 |
| Module F | 26.19 | 0.00 | 26.19 |
| Module G | 29.45 | 2.99 | 32.44 |
| Module H[a] | 0.00 | 0.00 | 0.00 |
| Module I | 30.54 | 8.30 | 38.84 |
| Module J | 10.77 | 0.64 | 11.41 |
| Module K | 37.24 | 4.85 | 42.10 |
| Module L | 32.78 | 5.91 | 38.70 |
| Module M | 32.26 | 8.78 | 41.04 |
| Module N | 21.58 | 2.79 | 24.37 |
| Module O | 45.09 | 0.81 | 45.90 |
| Module P | 0.00 | 15.00 | 15.00 |
| Totals | 349.98 | 65.84 | 415.82 |

[a] Goat Canyon restoration site -- 15 acres of willow-dominated riparian habitat will be restored.

The Project Proponent (Proponent) will be the source of funding for the implementation of a given module or set of modules. These parties may include federal or state resource agencies, private sources of mitigation moneys, local governments or private community and environmental organizations.

The Project Office (Office) will be the primary source of contact for parties interested in implementing portions of the Project. This position should be set up under an umbrella organization so that ancillary office administration needs are already in place. The Office is the primary contact source for the Proponent. The Project Office will accept proposals, provide public information regarding the Tidal Restoration Program, advise potential proponents regarding the availability of modules and the applicability of their needs to the project, advise proponents on the preparation of proposals, assist in tailoring individual modular designs, determine bidding procedures and contract awards, and update the Decision Making Authority regarding the progress of plans. The Office will also assist in the presentation of proposals to the Decision Making Authority and will help interpret feedback for the Proponent.

The Decision Making Authority (DMA) will have final approval over the implementation of all projects, modifications to all projects, module selection and ordering. The logical choice for this Authority is the Tijuana River National Estuarine Research Reserve Management Authority (TRNERRMA) or a committee from that group. The DMA would obtain technical advice from qualified hydrologists and wetland ecologists that have experience in the Tijuana Estuary ecosystem and management advice from the member agencies of the TRNERRMA. In presentation, it should be emphasized that the DMA is not a quasi-permitting authority; instead, it merely provides direction for the Tidal Restoration Project that is consistent with the EIR/S and the Tijuana Estuary Management Plan. Any actions in the Tijuana Slough National Wildlife Refuge will require a special use permit from the USFWS. All final implementation decisions must be approved by the respective landowning agencies.

Technical Advisors will include qualified hydrologists, wetland ecologists that have experience in the Tijuana Estuary ecosystem and other experts, as needed. The designated wetland ecologists will provide input to the DMA regarding the biological impact and importance of the phasing of specific modules. This task will include monitoring each module for contractual compliance and ecosystem response. This information will be used to reevaluate management and planning decisions, and to adjust

the restoration plans accordingly. The wetland ecologists also will provide suggestions for minor changes in channel and marsh design and construction in order to facilitate experimentation. Hydrologic advisors will provide hydrologic expertise regarding the ordering of modules, physical impacts of modifications to the modules, flow pattern analysis and salinity effects of module sequencing.

**Implementation of Modules**

Each module of the Project will be implemented in six steps, some of which are interactive and will require repeat interaction between parties. A general sequence of implementation follows (Figure 1-12).

(1) A Proponent will have a project that has received preliminary approval by the state and federal resource agencies. This project will have clearly defined restoration (or mitigation) goals that have been approved by the agencies. These goals will have to be compatible with the goals of the Tidal Restoration Plan. This plan will be submitted to the Project Office, along with a proposal to fund the implementation of a sufficient number of modules to meet the goals of its plan. The funding proposal will include provisions to provide needed studies to implement the established number of modules, maintain the modules during development of the modules, and monitor the development of the tidal marsh system. The Proponent also will be expected to fund development of the necessary environmental documents to comply with NEPA and CEQA and application for the necessary permits.

(2) The proposal is evaluated by the landowners and TRNERRMA (Decision Making Authority) and either approved, denied, or modified. If the modules to be developed occur on federal lands, the USFWS will have final approval of the proposal.

(3) After the Decision Making Authority has approved the proposal, the proposal will be returned to the Project Office. The Project Office will forward the approved proposal to the Proponent for the development of the implementation plan. Once the Project Office is satisfied that the

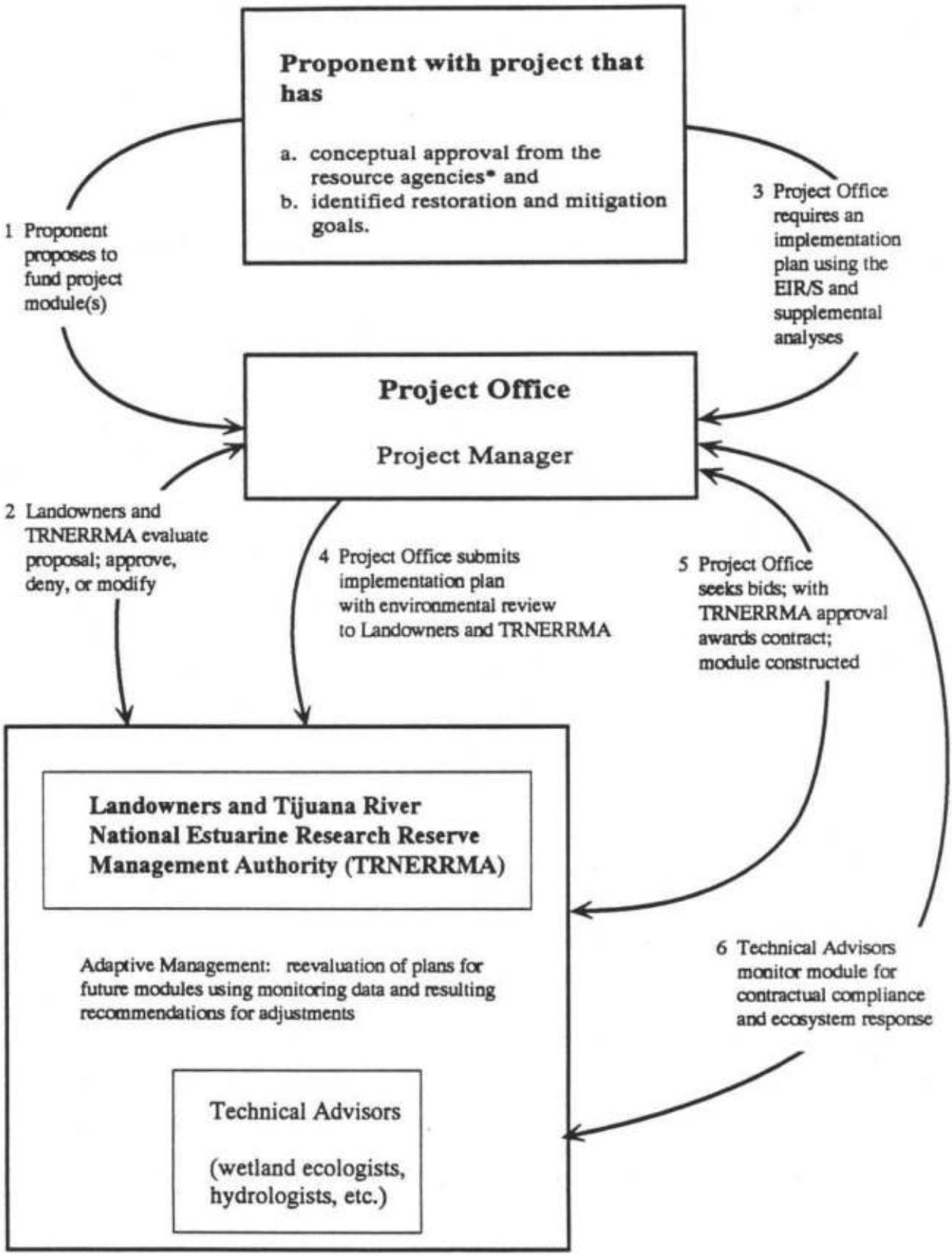



Figure 1-12. Implementation Procedures. Lines indicate interactions.

*Federal resource agencies include USFWS, NMFS, EPA, and COE;
State resource agencies include California DFG and Coastal Commission

implementation plan meets the expectation of the Decision Making Authority, the proposal and implementation plan will be forwarded to the Decision Making Authority.

(4) The Decision Making Authority will review the proposal and implementation plan and suggestion modifications or approve the package.

(5) The proposal and approved implementation plan will be returned to the Project Office. The Project Office will develop a bid package, advertise for qualified bidders, review proposals to implement the plan, coordinate proposal review with the Decision Making Authority, and award a contract to the approved bidder. The Project Office will then oversee implementation of the approved plan.

(6) Once construction is completed, the restored area will be monitored for contractual compliance and ecosystem response by the appropriate Technical Advisor. The monitoring program will be a necessary funded element of any project implementation plan. The standard for success of establishment will be "functional success," and monitoring will be comprehensive as laid out in this document. The rationale and detail of this monitoring program goes beyond the satisfaction of permit or mitigation requirements. As part of a modular restoration project, the monitoring program is an essential feedback mechanism that will give the entire project continuity and overall sensibility.

## 1.3 PERMITTING REQUIREMENTS

The establishment of the Reserve brought together federal, state, local government and privately-owned lands under a coordinated and cooperative management framework for long-term research, education and interpretation. The Management Authority facilitates the coordination of policies and on-site operations. Both the State Coastal Conservancy and the U.S. Fish and Wildlife Service are members of the Management Authority.

The management plan developed for the area has a specific management goal of restoring to natural conditions parts of the Reserve that have been disturbed, relying on the results of scientific research and an understanding of the entire estuarine system and its watershed (James Dobbin Associates, Incorporated, 1986). The State Coastal Conservancy, under the management plan, assumed the responsibility for providing technical advice and funding assistance, as available, for restoration activities within the Reserve.

In 1987, the State Coastal Conservancy funded a report by Philip Williams & Associates that defined the hydrologic basis for a restoration program for the Reserve (Appendix D). In March 1988, the State Coastal Conservancy awarded a grant to the San Diego State University Foundation to prepare an EIR/EIS and to develop a monitoring protocol for a proposed three-phased restoration program for the Reserve. This Environmental Impact Report/Statement will be used in acquiring the several permits needed at various levels of government.

The initial task for this EIR/EIS was to conduct a thorough environmental assessment in the project area (the Reserve). This environmental assessment identified sensitive habitat areas on the Reserve that should be avoided by the project. The task was then to integrate the hydrologic goals of the project with these biological constraints so as to work with the resource and minimize disturbance to existing habitat values. After several iterations, the existing preferred alternative was developed.

Federal permits will include Sections 10 of the Rivers and Harbors Act and Section 404 of the Clean Waters Act the U.S. Army Corps of Engineers. The Environmental Protection Agency has oversight of the issuance of the Section 404 permit. The National Marine Fisheries Service and the U.S. Fish and Wildlife Service (USFWS) generally provide comments to the Corps on the issuance of these permits. Any activities within the boundaries of the Tijuana Slough National Wildlife Refuge will require a special use permit issued by the USFWS. In addition, the USFWS will be required to conduct a consultation pursuant to Section 7 of the Endangered Species Act should there be any potential adverse impacts to any federally-listed endangered species. The Federal/State

permits and approvals required by the tidal restoration and wetland enhancement project include the following:

- NEPA EIS Record of Decision by the U.S. Fish and Wildlife Service.
- Special Use Permit from the U.S. Fish and Wildlife Service.
- No jeopardy finding by U.S. Fish and Wildlife Service pursuant to its authority under Section 7 of the Federal Endangered Species Act.
- Section 10 (Rivers and Harbors Act) and Section 404 (Clean Water Act) permits from the U.S. Army Corps of Engineers.
- CEQA EIR certification from the State Coastal Conservancy. Approval of the environmental documentation and selection of a preferred alternative for Phase I and the subsequent phases.
- Coastal Development Permit from the California Coastal Commission. A development/construction activities need to be evaluated to insure consistency with the California Coastal Act.
- Public Trust Doctrine Approval from the State Lands Commission. To insure that the project is consistent with any state public trust rights.
- Stream Bed Alteration Agreement from the California Department of Fish and Game. A 1601 agreement to alter the bed of the river and estuary.
- Section 401 Certification from the Regional Water Quality Control Board. A permit to discharge dredged materials into waters of the state.
- Special Use Permits from the California Department of Parks and Recreation. For permits to construct project and associated recreational opportunities.

In addition, formal consultation with the California Department of Fish and Game will be required under the California Endangered Species Act.

Required City and County permits include:

- Building and Grading permits from the City and County of San Diego and City of Imperial Beach.

Design considerations for the proposed alternatives also were based on expressed concerns of the reviewing agencies and the public during the scoping process. These included the desires to:

- Maintain existing habitat values.
- Not impact endangered species populations or their habitats. In addition, take care to minimize impacts to locally rare or sensitive species.
- Mitigate project impacts to fish and wildlife resources.
- Improve access and recreational opportunities while preventing intrusion into the wetlands.
- Maintain the option for the siting for sewage treatment facilities.
- Prevent the creation of mosquito breeding areas.

## 1.5 PUBLIC CONCERNS

The joint Draft Environmental Impact Report and Draft Environmental Impact Statement (DEIR/EIS) has been prepared in compliance with the California Environmental Quality Act (CEQA), the State Office of Planning and Research (OPR) CEQA Guidelines, and the National Environmental Policy Act (NEPA). A notice of intent to prepare an EIS appeared in the Federal Register on November 25, 1988 (53FR 47768). A Notice of Preparation (NOP) of the DEIR/EIS was circulated for review and comment pursuant to Section 15082 of the CEQA Guidelines. A public hearing was held at the City Hall Community Center in Imperial Beach on December 1, 1989. A copy of the public notices and comments received are presented in Appendix H.

The scope of the DEIR/EIS was determined through: (1) early consultation with the regulatory agencies, including the U.S. Army Corps of Engineers, the State Department of Parks and Recreation, the California Coastal Commission, the National Marine Fisheries Service, the City and County of San Diego, and the Regional Water Quality Control Board; (2) review of the agency comments upon the NOP; (3) consultation with the regulatory agencies during the preparation of the DEIR/EIS; and (4) review of the project in relation to Appendix I of the CEQA Guidelines: Environmental Checklist Form (see Appendix I for copy of Initial Study). A number of organizations and people were consulted during the scoping and preparation of the DEIR/EIS (Appendix J). This scoping process resulted in the identification of a number of environmental issues or concerns in connection with the Tijuana Estuary Tidal Restoration Program that were used as a basis for the analyses of the project and its projected impacts presented in this EIR/EIS.

## 1.6 RELATION TO PREVIOUS DOCUMENTS

The following documents provide the foundation for many of the concepts, plans and public policies that led to the Project described in this EIR/EIS.

- Allied Geotechnical Engineers, Inc. 1986. Soil Investigation and Geologic Reconnaissance for International Water Alternative 1D Project. Prepared for Luke-Dudek Civil Engineers. 22 pp. + figures.

- Butler/Roach Group, Inc. 1987. Draft Environmental Impact Report/Environmental Information Document for the Proposed Southbay land outfall, Phase 1. (EDQ No. 87-0638, SCH No. 87072216). Prepared for the City of San Diego, Water Utilities Department, San Diego.

- California Department of Parks and Recreation. 1974. Border Field State Park Resource Management Plan and General Development Plan (preliminary). January 1974. 31 pp.

- California Department of Parks and Recreation. Undated. Mosquito Management in Salt Marsh Ecosystems. A Department of Parks and

Recreation final statement of intent for coastal lagoon management in District 6. 17 pp.

- California Department of Parks and Recreation and California Department of Fish and Game. 1972. A review of Lands Uses: Tijuana River Valley. Requested by Assembly Concurrent Resolution 65, December 1972. 13 pp. and append.

- City of San Diego. 1988. Water Utilities Department. Final Environmental Impact Report/Environmental Information Document for the Southbay Land Outfall Phase 1, prepared by the Butler Roach Group. January 1988. 17 pp.

- International Boundary and Water Commission. United States and Mexico. 1976. Tijuana River flood control project. San Diego County, California, final Environmental Impact Statement. May 1976. 59 pp. and append.

- James Dobbin Associates Incorporated. 1986. Tijuana River National Estuarine Sanctuary Management Plan. Prepared for the State of California Coastal Commission, U.S. Department of Commerce National Oceanic and Atmospheric Administration Sanctuary Programs Division and the Tijuana River National Estuarine Sanctuary Management Authority. 183 pp.

- Lowry and Associates. 1983. City of San Diego Facilities Plan, proposed Joint International Wastewater Treatment, Reclamation and Disposal Project, San Diego - Tijuana. Vols I and II.

- Moffat and Nichol, Engineers. 1987. Silver Strand littoral cell preliminary sediment budget report, Ref. No. CCSTWS 87-3. Coast of California Storm and Tidal Waves Study. Prepared for the U.S. Army Corps of Engineers, Los Angeles District, Coastal Resources Branch, December 1987. 157 pp.

- Nordby, C.S. 1987. Response of channel organisms to estuarine closure and substrate disturbance. In: Proceedings of the Society of Wetland Scientists; Eighth Annual Meeting, May 26-29, 1987, Seattle, Washington. pp. 318-321.

- Pacific Estuarine Research Laboratory. 1990. A manual for assessing restored and natural coastal wetlands. California Sea Grant Report No. T-CSGCP-021. La Jolla, California. 105 pp.

- Park, R.A., M.S. Trehan, P.W. Mausel and R.C. Howe. 1988. The effects of sea level rise on U.S. coastal wetlands. Holcomb Research Institute Report No. 142, Holcomb Research Institute, Butler University, Indianapolis, Indiana. 60 pp.

- Swanson, M.L. 1988. Tijuana River Estuary: the effect of the Oneonta Slough dredge project on tidal circulation entrance channel closure conditions. A report prepared for the California State Coastal Conservancy by Philip Williams & Associates, June 30, 1988. 14 pp. and append.

- U.S. Department of Commerce (National Oceanic and Atmospheric Administration, Office of Coastal Zone Management) and California Coastal Commission. 1981. Proposed estuarine sanctuary grant award to the State of California for a Tijuana River National Estuarine Sanctuary, final Environmental Impact Statement. August 1981. 205 pp.

- White, W.S. and R.C. Wunderlich. Undated. Fish and wildlife resources of Tijuana Estuary, California. U.S. Fish and Wildlife Service, Department of Interior. 74 pp.

- Zedler, J.B. 1977. Salt marsh community structure in the Tijuana Estuary, California. Est. Coast. Mar. Sci. 5:39-54.

- Zedler, J.B. 1982. The ecology of southern California coastal salt marshes: a community profile. U.S. Fish and Wildlife Service, Biological Services Program, FWS/OBS-81/54. 110 pp.

- Zedler, J.B. and C.S. Nordby. 1986. The ecology of the Tijuana Estuary, California: an estuarine profile. U.S. Fish and Wildlife Service, Biological Report 85(7.5). 104 pp.


In addition several reports were prepared especially for this project. These reports, which are presented as technical appendices, include the following:


Affinis. 1991. Cultural Resources Inventory for the Tijuana Estuary Enhancement Model Project, Tijuana River Valley, San Diego, California. Prepared for ENTRIX, Inc. (Appendix M)

DiGiorgio, C.L. 1989. Invertebrates of the Tijuana Estuary. Report prepared for Pacific Estuarine Research Laboratory for the Tijuana Estuary Tidal Marsh Enhancement Plan. (Appendix K.2)

Espinoza, R. 1989. Herpetofauna. Report prepared for Pacific Estuarine Research Laboratory for the Tijuana Estuary Tidal Marsh Enhancement Plan. (Appendix K.4)

Florsheim, J., P.B. Williams, L. Fishbain, and P. Goodwin. 1991. Hydrologic and Geomorphic Analysis of the Tijuana Estuary: Technical Appendix. Report prepared for the San Diego State University Foundation with funding from the San Diego State University Foundation and the California Coastal Conservancy. 60 pp. (Appendix E)

Kus, B.E. and P. Ashfield. 1989. Bird Use of the Tijuana River Estuary. Report prepared for Pacific Estuarine Research Laboratory for the Tijuana Estuary Tidal Marsh Enhancement Plan. (Appendix K.1)

Taylor, E.W. and J. Tiszler. 1989. The Mammals of the Tijuana Estuary. Report prepared for Pacific Estuarine Research Laboratory for the Tijuana Estuary Tidal Marsh Enhancement Plan. (Appendix K.5)

Williams, K.S., M. Busnardo, D.W. Gibson, K.M. Johnson, and S.A. Snover. 1989. Terrestrial Arthropods of Tijuana Estuary. Report prepared for Pacific Estuarine Research Laboratory for the Tijuana Estuary Tidal Marsh Enhancement Plan. (Appendix K.3)

Williams, P.B. and M.L. Swanson. 1987. Tijuana Estuary enhancement: hydrologic analysis. Prepared for the San Diego State University Foundation with funding from the California State Coastal Conservancy, June 12, 1987. 50 pp. (Appendix D)

Winfield, T.P. 1991. Identification and Delineation of Waters of the United States in the Tijuana River National Estuarine Research Reserve. Prepared for San Diego State University, Pacific Estuarine Research Laboratory. (Appendix L)

# 2.0
# ALTERNATIVES

In 1986, the Tijuana River Estuary Management Plan was developed to provide a framework for future enhancement of the Tijuana Estuary and to address the physical changes that were adversely affecting the estuary. The management plan and subsequent hydrological and biological analyses have confirmed the progressive deterioration of tidal flushing of the estuary, especially in recent years. This deterioration has resulted in extended periods when there was no tidal flushing resulting in the loss of valuable wildlife habitat and the lowering of water quality. As a result of the concerns over the possible long-term loss of habitat values due to the continued deterioration of tidal flushing, Philip Williams & Associates, Ltd was retained to develop a hydrologic solution that would reduce the deterioration of tidal flushing and be sensitive to preservation and enhancement of the present values of the estuary.

Two major constraints were identified early in the planning process that were used to judge the acceptability of potential restoration alternatives: (1) land ownership; and (2) projected impacts on existing biological resources, especially special status species. One of the earliest ideas was construction of a channel and embayment system on the site of the U.S. Navy Outlying Landing Field. This idea was eliminated because the land is owned by the U.S. Navy. However, considering the recent trend to decommission government facilities, this idea may need to be reconsidered in the future.

Another option that was presented and dismissed included dredging the hardpan at Oneonta Slough. Under this approach, tidal flushing in the north arm would be maintained by creating a connector channel through the upland/coastal sage scrub between the southern tidal pond and the main river channel. This option was eliminated from further consideration because of the value of the potentially impacted coastal sage scrub habitat to the California gnatcatcher and to maintain biodiversity in the estuary.

Another option considered early in the planning process was a "central estuary" restoration with a larger channel and embayment upriver. This option would have created a large embayment east of the mouth. The option was dismissed because the hydrology and geomorphology of the estuary are too dynamic. Therefore, lasting

benefits from such a project design would not be assured. Moreover, this project design probably would have impacted habitat for the endangered least Bell's vireo.

The north arm of the estuary was not considered for extensive restoration activities because it already performs critical functions as endangered species habitat. It was felt that only if future studies identified beneficial enhancement opportunities that would not have damaging impacts should additional restoration work be undertaken in the north arm.

These early deliberations resulted in the development of four conceptual alternatives. These included the: (1) no project alternative; (2) restoration of wetlands in the central estuary; (3) restoration of 250 acres in the south arm; and (4) restoration of 500 acres in the south arm (Appendix D). The following section discusses the various alternatives that were considered in developing the present project design (see Appendix D, E, and F).

## 2.1 NO PROJECT ALTERNATIVE

In the last 100 years there has been a dramatic change in the physical structure of the estuary. The area of intertidal wetlands has been reduced by about 60 percent and the tidal prism in the estuary has been reduced by about 80 percent. In 1852 the tidal prism was about 1,550 acre-feet and currently it is about 290 acre-feet. The initial hydrologic studies identified several conditions affecting the tidal flushing of the estuary (Appendix D).

The reduction in tidal prism has significantly reduced the tidal scouring of the entrance channel, causing it to become unstable and more susceptible to closure. Historically, the tidal inlet remained open during all conditions, including storm periods when there tends to be large-scale movements of sediment. When the entrance channel closes, tidal flows are eliminated and the hydrologic systems changes dramatically. Reduced circulation can result in a deterioration of water quality, including changes in salinity and increases in algal blooms, and public nuisance problems such as odor and mosquitos. Water levels can experience long-term fluctuations depending on river inflow, rainfall, and evaporation.

The reduction in tidal prism has been caused by:

- widespread sedimentation during episodic flooding of the Tijuana River,
- gradual or incremental sedimentation on intertidal mudflats and conversion to intertidal marsh plain,
- sedimentation from tributary drainages due to watershed disturbance,
- migration of the barrier beach inland due to the effects of sea level rise, destruction of dune vegetation, and overwash during periods of severe wave action, and
- filling and road construction.

If the enhancement plan is not implemented, it is possible that a substantial portion of the existing tidal prism will be lost due to the forces listed above. As a result, the entrance channel will be primarily closed resulting in the loss of existing habitat values of the estuary.

The north arm of the estuary currently contributes approximately 50 percent of the total tidal prism of the estuary by flows through Oneonta Slough. Assuming that the barrier beach continues to migrate inland at the rate observed in the last decade (2.24 feet/year), it will be impossible to maintain tidal flow in Oneonta Slough in about 20 years (Appendix D). The loss of tidal circulation in the north arm would probably result in the permanent closure of the entrance channel because of the loss of a large portion of the present tidal prism. Without tidal circulation and with no avenue for river flows to reach the north arm, the north arm likely would turn into a system of stagnant hypersaline channels and dry hypersaline soils. This situation occurred in 1984 and resulted in the elimination of the major habitat for the endangered light-footed clapper rail.

The central and south arms of the estuary would be influenced by wastewater flows, as well as flood flows, from the Tijuana River basin. With closure of the entrance channel, ponded water would become brackish. The entrance channel would be open for short periods of time when flood flows in the Tijuana River are able to scour an opening

through the barrier beach. However, depending on the magnitude of the flood flows, the mouth would open only briefly and close when the flood flows abated.

The presence of brackish water in the south and central arm would change the nature of the vegetation from salt marsh to brackish marsh. The loss of pickleweed would be especially significant since this area supports a large population of the state endangered Belding's Savannah sparrow. Extended periods of high water also would adversely affect the sensitive species that currently occur throughout the estuary, including the federally-endangered salt marsh bird's beak, the light-footed clapper rail and its habitat (cordgrass), and the other species unable to escape or survive the high water.

The no project alternative was found to be inconsistent with the goal of maintaining the existing values of the estuary. Therefore the no project alternative was found to be unacceptable by the management authority responsible for management of the Reserve.

## 2.2 RESTORATION OF WETLANDS IN CENTRAL ESTUARY

This alternative was investigated because it would minimize disturbance of remnant wetlands in the south arm. The south arm supports a number of special status species, including the Belding's Savannah sparrow, and several species of insects. Under this alternative, approximately four million cubic yards of substrate would have been excavated to create approximately 300 acres of wetlands. This would have required the construction of a river training berm 8,000-feet long extending upstream to Hollister Street, at the north end of the Tijuana River Valley, near Nestor. This levee would have been required to prevent flood flows from discharging directly into the restored wetland and filling it with sediments.

This alternative was eliminated for the following reasons (Appendix D):

(1) This alternative would require proportionately a greater amount of excavation per unit area than the two alternatives for the south arm.

(2) The area restored would be limited in size.

(3) The training levee would tend to deflect flood flows to the south arm, increasing deposition of sediments in the wetland areas in the south arm.

(4) The training levee would be extremely long and would not be tied into upland bluffs at its upstream end. As a result, it would be susceptible to failure during an extremely large flood.

(5) The restoration site would overlap areas that are potentially restorable to high-value riparian habitat.

(6) This alternative would require the purchase of considerable areas of private land outside the present boundaries of the Reserve.

## 2.3 RESTORATION OF 250 ACRES IN THE SOUTH ARM

Under this alternative, approximately 250 acres of intertidal marsh and high marsh would have been restored in the south arm of the estuary. Tidal flow would have been enhanced by deepening the existing south slough channel up to the tidal inlet to a depth of -3 feet NGVD. Approximately two million cubic yards of material would have been excavated for the tidal marsh and high marsh restoration and an additional tenth of a million cubic yards dredged to deepen the tidal channel.

This alternative would meet many of the enhancement plan objectives described above and would not involve the purchase of private land. However, this alternative by itself had several major drawbacks:

(1) It did not provide sufficient tidal prism to ensure long-term maintenance of tidal flushing.

(2) It did not maximize the area of restorable wetlands.

(3) It was susceptible to a greater percentage of future loss of wetland due to the eastward migration of the barrier beach.

## 2.4 RESTORATION OF 500 ACRES IN THE SOUTH ARM

This alternative was the recommended enhancement alternative developed early in the planning process. It included the phased excavation of two large areas in the south arm and a limited area in the north arm, to create sufficient tidal prism to maintain an open entrance channel. Excavation of these areas would have been done so as to maximize acreage for the restoration of mudflat and salt marsh habitat.

To protect the restored areas in the south arm from sedimentation from the Tijuana River during large floods, two large training berms would be constructed during each phase of the project to deflect the main course of the river to the central part of the estuary. The levees also would have served as the preferred disposal location for sediments excavated during construction of the new wetlands and mudflats.

This alternative would have duplicated in the south arm the hydrologic functioning of a wetland of similar size to that existing in the north arm. The training berms would have provided protection of the newly created wetlands from excessive river sedimentation in the same way that the raised bluffs at the U.S. Navy Outlying Landing Field have protected the north arm. The new tidal wetlands would have been largely isolated from the river channel except where the main channel joined the central estuary near the mouth. The configuration of this alternative would have been similar to the 1852 configuration.

This alternative would have been constructed in three phases. The first phase would have involved deepening and widening of Oneonta Slough to a depth of -3 feet NGVD, restoration of the barrier beach dunes and dune vegetation, and the deepening of the Old River Channel and construction of a 10-acre experimental tidal marsh and berm. A total of about a quarter of a million cubic yards of material would been excavated.

The second phase of this alternative would have been similar to the 250-acre restoration alternative described above. The third phase would have resulted in the restoration of an additional 200 acres of tidal marsh in the south arm east of the tidal marsh restored in the second phase. Excavation of the 200 acres would have produced approximately one and a half million cubic yards of materials. This alternative would have increased the tidal prism to approximately 1,650 acre-feet and restored the tidal prism to approximately that existing in 1852.

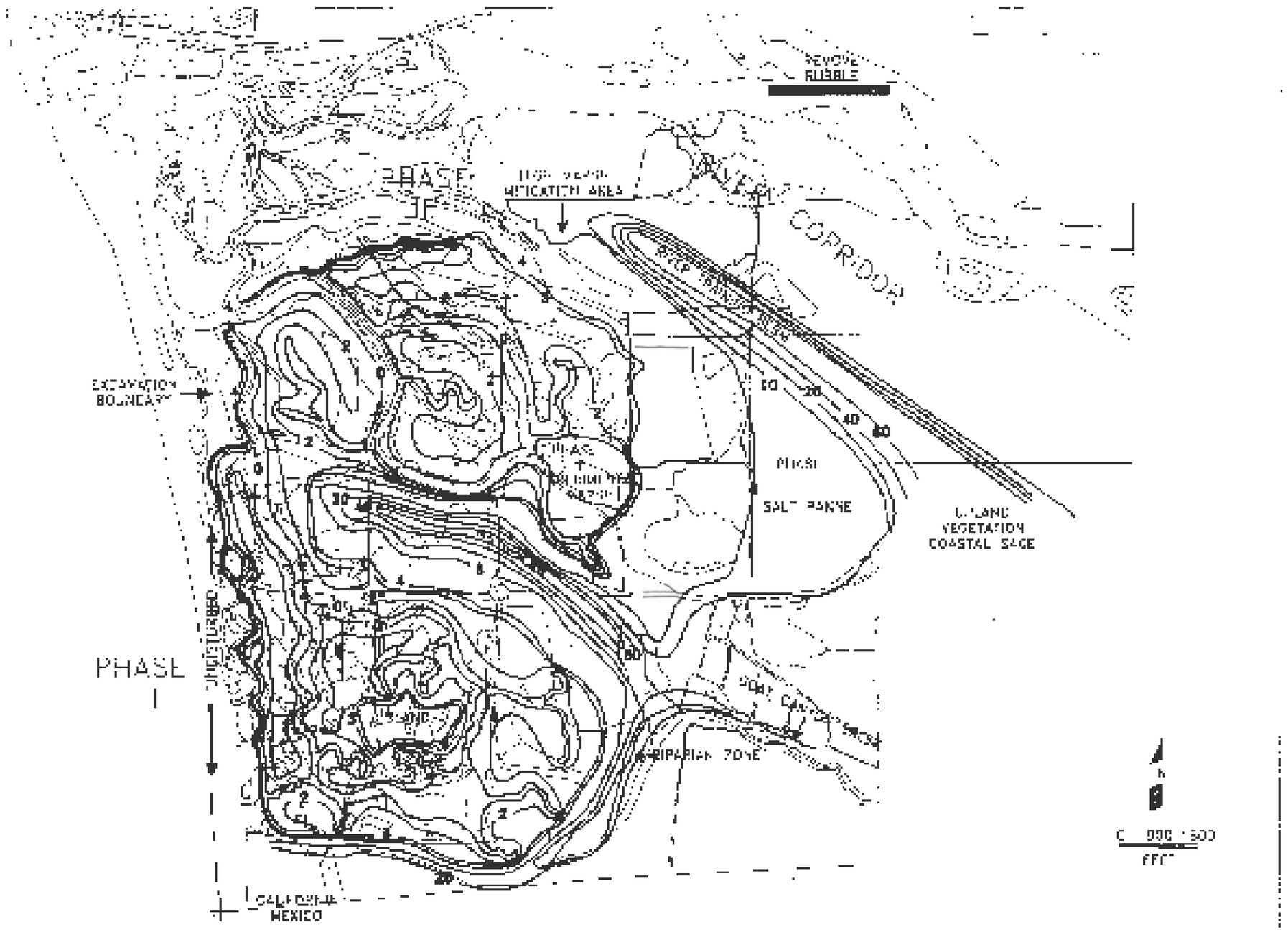
Construction of the latter two phases would have impacted most of the marsh habitat in the south and resulted in the loss of marsh habitat equal to the footprint of the two river training berms. This would have resulted in unacceptable impacts to the sensitive resources in the south arm. Because of its impacts, the project likely would not have received permits necessary for construction.

## 2.5 MINIMUM DREDGING

The Minimum Dredging alternative was a modification of the 500-acre Alternative (Appendix D). The purpose of the Minimum Dredging alternative was to restore the 1852 tidal prism in the Tijuana Estuary with minimum dredging. The Minimum Dredging alternative would restore 560 acres of marsh in the south in three phases (Figure 2-1). Phase I would have created a 20-acre experimental marsh and also included widening of Oneonta Slough and construction of the connector channel. Phase II would have restored 270 acres of tidal marsh, and Phase III would have restored an additional 290 acres of tidal marsh. Phase I is identical to the Model Project in the preferred alternative and was described in detail in Section 1.2.4. This alternative was the project assessed when the EIR/EIS was initiated in 1988.

To protect the restored tidal marsh, a river training berm would have been constructed in conjunction with implementation of Phase II and Phase III (Appendix E). The river training berms would have had to be long enough to deflect the Tijuana River away from the restoration areas. An inner river training berm would have been created using material excavated or otherwise removed from the Phase II restoration area. The inner berm would have protected the Phase II restoration area from flood and sedimentation from the Tijuana River. In Phase III, the outer river training berm would have been constructed to protect the Phase III restoration area from floods and sedimentation.

This alternative was later modified to increase the area of wetlands to be restored. The Phase III river training berm was moved toward the east to create a larger area in the excavation area. Phase III was expanded to create 325 acres of tidal wetlands rather than the 290 acres in the original plan for this alternative. The western boundary of the excavation was moved toward the east away from the dune to avoid impacting the back side of the dune, which supports several sensitive species.


REMOVE RUBBLE
PHASE II
EXCAVATION BOUNDARY
PHASE I
DISTURBED
MEXICO
SALT MARSH
UPLAND VEGETATION COASTAL SAGE
RIPARIAN ZONE
COPRIDOR

Our investigations revealed significant adverse impacts associated with the Minimum Dredging plan and another plan was formulated, now the preferred plan, which integrated the hydrological rationale of the Minimum Dredging alternative with concern for preserving the existing biological resources of the Preserve. The Phase II river training berm would have covered the location of one of the two alternative sites for the 20-acre tidal wetland marsh enhancement site. The values developed in this experimental marsh would have been lost. The Phase III river training berm may have affected the Tijuana River floodway and constrained flow in its present course on the north side of the floodplain. This could have lead to a long-term increase in the erosion rate on the bluff adjacent to the Naval Air Station. Also, preliminary analyses indicated that the Phase III river training berm could have increased base flood levels immediately upstream of the berm in excess of one foot. This would have required a revision to the existing FEMA map for the Tijuana River.

However, the biggest constraint of this alternative was that it would have intruded too much on existing wildlife resources in the south arm. In order to have constructed this alternative, virtually all of the salt marsh and salt panne resources in the south arm would have had to be sacrificed. In light of the considerable habitat for Belding's Savannah sparrow in the south arm, this cost was considered too high relative to the benefits that would have resulted.

## 2.6 ALTERNATIVES TO A RIVER TRAINING STRUCTURE

A river-training berm or levee is proposed to protect the restored wetlands in the south arm of the estuary from the extensive sedimentation known to be characteristic of large flood events on the Tijuana River. The geologic substrate of the Tijuana River watershed is highly erodible and produces large sediment loads during extreme storm events. This natural phenomenon has resulted in extensive sediment deposits in the river bed throughout the river's course. Large-scale floods scour the riverbed adding additional stored sediment to the flow. Consequently, extremely large quantities of sediment reach the estuary during the largest floods. A restored marsh in the south arm of the estuary would be highly vulnerable to sudden and catastrophic sedimentation from a single large-scale flood event.

Alternatives to constructing a river-training structure were analyzed including both structural and non-structural measures. These include: (1) use of upstream gravel pits and sediment detention basins to trap flood-borne sediments upstream of the estuary; (2) extensive revegetation of the flood plain upstream of the estuary to create a riparian woodland to trap flood-borne sediments upstream of the restored marsh, and (3) erosion control measures in the watershed.

While existing gravel pits located approximately three miles upstream of the restoration area could be managed for capture and recovery of coarser sands and gravels transported as bed load by a flood, they would not be very effective in capturing the finer sands and silts that comprise at least 75 percent of transported sediment. In addition, because of the distance from the project area, river flows would have scoured bed load from the channel downstream to replace material deposited in the gravel pits. As a result, it would be unlikely that there would be any significant differences in sediment concentrations in the river flow at the estuary. New sediment retention basins constructed downstream closer to the restored marsh also could not be effective in preventing sedimentation from the fine sands and silts. Additionally, construction of sediment retention basins in the lower valley would likely result in unacceptable impacts to existing riparian resources, including habitat for the endangered least Bell's vireo.

Riparian vegetation over an extensive floodplain does capture sediment during floods and can help build up floodplain elevations. However, because of the relatively small area of the Tijuana River floodplain and the extremely high sediment loads characteristic of the river in flood, only a small fraction of the total flood-borne sediment could be captured in a revegetated riparian woodland. A large-scale revegetation program from the estuary upstream to the Mexican border would not prevent a substantial sediment load from reaching the estuary.

Other characteristics of the river's flood hydrology affect the potential for sedimentation of the restored marsh. While high flood flows overtop the banks of the active river channel and spread across the floodplain throughout the valley, it is at the lower end of the estuary where flow velocities drop significantly as the floodwaters spread out over the more extensive floodplain provided by the north and south arms. Here, because of the reduced velocities, low vegetation is effective in trapping sediments. This sediment deposition has resulted in the extensive loss of tidal prism and estuarine habitats. Establishing an extensive riparian woodland on the floodplain upstream would not alter

this characteristic of Tijuana River flood hydrology nor would it alter the dynamic and mobile nature of the river channel at its mouth.

Another approach to sediment control involves actions which address sediment at its source through erosion control measures. Erosion from human land use causes significant increases to the sediment load of the river, already burdened by the sediment contribution from the watershed's highly erosive substrate. A watershed-wide program of erosion control has been shown to be effective at reducing coarse heavy sediments in stream flow as well as the fine sediments which typically escape sediment-detection structures. Effective erosion control at the watershed scale requires regulation of land development projects and general adherence to principles of soil conservation. The significance of this issue has been recognized by the land-owning agencies in the Tijuana River Valley. Of particular concern is the sediment contribution to the estuary and floodplain from the Border Highlands immediately to the south of the valley.

However, two-thirds of the Tijuana River watershed lies in Mexico and is not subject to United States regulatory influence. While new initiatives and stricter adherence to existing policy and regulation on United States lands may produce localized benefits in reduced sediment input from tributary drainages, much of the sediment input which could be addressed through nonstructural measures lies within Mexico. No significant reduction in Tijuana River sediment loads are expected through Mexican land use controls. A river training structure is proposed as a feature of the tidal restoration project because of the probability of sedimentation and the loss of created habitats in a large flood event. Alternative measures to achieve the same objective were judged to be ineffective at providing the project necessary protection.

# 3.0
# ENVIRONMENTAL SETTING, IMPACTS AND MITIGATION MEASURES

This section presents a description of the environmental setting of the Reserve, an assessment of impacts of the Model Project and the larger 495-acre Restoration Project, and a discussion of proposed mitigation to offset unavoidable project-related impacts for each project component. Review by the project team and resource agencies has identified a number of areas of concern related to the anticipated impacts of the project:

- Geology, Topography and Soils
- Surface and Groundwater Hydrology
- Water Quality
- Air Quality
- Biological Resources
- Cultural Resources
- Land Use
- Transportation and Circulation
- Utilities
- Human Health
- Aesthetics
- Recreation

The design of all components of the Model Project has been completed and its impacts are well understood. Although many of the impacts that will result from the 495-acre Restoration Project can be anticipated and assessed, there are still uncertainties associated with the certain aspects of the project. Most significant of these, perhaps, relates to disposal of dredge spoils; extensive testing will be required to determine suitability of excavation material for various uses. Important experiments undertaken with the Model Project will assess the usefulness of this material in constructing the river training structure. The adaptive management design approach and the programmatic approach to impact assessment, with its commitment to supplemental reports, provides a mechanism to document the actual impacts of the project during early stages. These evaluations will result in refined assessments of the environmental impact of later components of the project and allow for adjustments to the design of the project, where necessary. Given the scale of the project and the status of current knowledge in the field of wetland restoration, this approach was deemed necessary. The areas where adaptive management evaluations will be used to refine project design to the benefit of the Reserve are identified in the following discussions.

The assessment of impacts presented in this section for the 495-acre Restoration Project is for full buildout of the project. However, as currently planned the project will be implemented in a modular fashion, as described in Section 1.2.5. As a result there will be periodic impacts related to the construction of each module or set of modules. NEPA and CEQA supplements will be tailored to the actual project components proposed at a particular time and will build on information developed in this document.

## 3.1 GEOLOGY, TOPOGRAPHY AND SOILS

### 3.1.1 ENVIRONMENTAL SETTING

#### 3.1.1.1 Geology and Topography

The lower Tijuana River Valley, its estuary and surrounding uplands are sculptured by its geologic past and current conditions. This area is underlain by coastal plain sediments of Pliocene (seven million years ago) to Quaternary age (2 million years ago) (San Diego Association of Geologists, 1982; USGS, 1911). The Pliocene San Diego Formation

consists of consolidated conglomeritic sandstones of varying thickness that outcrop along the south side of the valley and in the uplands to the east. Dense formational sands and gravels of pliocene San Diego Formation are found at the southeastern end of the river valley.

Overlying the San Diego Formation are distinctive reddish-brown sandstones, siltstones and conglomerates of the Pleistocene Linda Vista Formation. This unconsolidated Holocene (10,000 years ago) alluvium is generally over 100 feet thick. Pre-Quaternary bedrock, exposed in the mountains to the east, consist of igneous and metamorphic rocks of the Peninsular Range batholith and the pre-batholithic Santiago Peaks Volcanics.

The structural shape of the river valley is controlled by the faults of the Quaternary age (Kennedy and Tan, 1975). The east side of the project area is bounded by the San Ysidro fault, juxtaposing Tertiary and Quaternary-aged rock along the southwest side toward the floor of the river valley. The south side of the valley is bounded by a complex, discontinuous group of faults. Approximately 25 well exposed or inferred faults traverse the Border Highlands, which are located along the southern boundary of the Reserve adjacent to Mexico. Three prominent faults on Spooner's Mesa together constitute the northern part of the Los Buenos Fault, which extends south into Mexico. Significant separation on the order of 35 meters, juxtaposes rocks of the San Diego (early Pleistocene) and Linda Vista (late Pleistocene) formations. Landslides, the product of oversteepening slopes, groundwater saturation and surface water erosion, have occurred in several locations along the valley walls in the Border Highlands primarily in the San Diego Formation.

#### 3.1.1.2 Soils

Tidal flats, alluvial sandy loams and sands account for the majority of soils in the lower Tijuana River Valley. Nearest the influence of the tide, the fertility of the basin as a whole is lowest. Non-arable tidal flats extend beyond the upper limit of the slough system and provide the substrate for mudflat and marshland habitat.

The recent deposits, both horizontal and vertical, tend to have few characteristics such as clay translocation or clay film formation. Further from the active channels or deeper within a given soil profile, there is a greater likelihood for the occurrence of true soil

horizon formation. Intertidal soils are of such recent origin that their morphology reflects depositional factors almost entirely. At slightly higher elevations, climatic and biogenic factors have had longer time to work resulting in the existence of true soil horizons.

Soils of many estuarine environments often exist over a sandy substratum, but they always have a substantial clay or silt and organic fraction. There are four soil types in the project study area: (1) Chino silt loam; (2) Tujunga sand; (3) Visalia sandy loam; and (4) tidal flats (USDA Soil Survey, San Diego Area, California, 1973). A brief description of each soil type is provided below.

**Chino silt loam.** This soil comprises much of the eastern half of the project site. This soil is one of several of the Chino Series, which generally consists of moderately well drained fine sandy loams derived mainly from granitic alluvium. The Chino silt loam is a slightly saline, finer textured member of the series. A small area of this soil is cultivated within the project site; the soil is considered to be highly suitable for cultivation and is assigned a capability unit of IIs-6. The erodibility of this soil is moderate.

**Tujunga sand.** This soil is found immediately adjacent to the Tijuana River, in the extreme northeast portion of the project site. The soils of the Tujunga Series are generally very deep, excessively drained sands derived from granitic alluvium. The Tujunga sand is low in fertility and not highly suitable for cultivation. As such, the capability unit is IVs-4. The erodibility of the soil is low owing to its high sand content.

**Visalia sandy loam.** This soil comprises a small area in the extreme southeast of the project area, in the vicinity of the proposed berm. The soils of the Visalia Series are generally moderately well drained, very deep sandy loams derived from granite. The Visalia sandy loam is highly suitable for cultivation, and is assigned a capability unit of I-1. The erodibility of the soil is low owing to its high sand content.

**Tidal Flat soils.** These clay to sand soils comprise much of the western half of the project site. Generally these are categorized by the USDA Soil Survey as soils that are periodically covered by water and are essentially barren. The Soil Survey indicates that the tidal flat soils are used for wildlife habitat and have a low potential for cultivation. The soil capability unit is VIIIw-6. These soils are generally highly erodible owing to their relatively high content of clay.

### 3.1.1.3 Soil and Sediment Quality

The quality of the material to be excavated will need to be determined prior to implementation of the project. Appendix G presents the study plan for assessing the quality of materials to be excavated during implementation of the Model Project. This plan was developed in coordination with the San Diego Regional Water Quality Control Board (SDRWQCB) and is acceptable to the USFWS.

The presence of heavy metals in the sediments in the Tijuana River Valley has been studied by Gersberg et al. (1988) and Kramer (1989). Gersberg et al. (1988) measured heavy metals in sediments, biota, and water of the Tijuana River and estuary and Kramer analyzed heavy metals in fish, water, and sediments in the Tijuana Estuary. Gersberg et al. (1988) found the sediments of the estuary to contain 0.7 to 1.7 parts per million (ppm) cadmium, 13 to 18 ppm chromium, 12 to 14 ppm nickel and 29 to 59 ppb lead. Kramer sampled the Old River Channel near the Pacific Estuarine Research Laboratory (PERL) facilities in the south end of the estuary and found the following concentrations of selected heavy metals in the sediments; (1) 1.5 ppm cadmium; (2) 17.92 ppm copper; (3) 19.03 ppm chromium; (4) 12.32 ppm nickel; (5) 13.07 ppm lead; and (6) 73.15 ppm zinc. These values provide an indication of possible sediment quality of the sediments that will be excavated from the Old River Channel during implementation of the Model Project.

## 3.1.2 IMPACTS AND MITIGATION

### 3.1.2.1 Impacts of Model Project

**Site Geology and Topography.** The Model Project will not have any short-term or long-term impacts on site geology. Dredging and excavation of material will affect the local topography. Oneonta Slough widening will result in the conversion of approximately 2.6 acres of intertidal salt marsh and high marsh habitat into tidal channel habitat. This lowered topography will be evident during periods of low tide but it does not represent a new topographic element in the area.

Construction of the connector channel and ditch will affect the local topography over approximately 2.6 acres. The present surface of the area will be excavated down to about -2 feet NGVD. The area where the channel and ditch will be constructed does not contain channels or ditches, so the construction of the channel and ditch will introduce a new topographic feature in the area.

Excavation of the 20-acre experimental marsh will substantially lower the surface elevation by four feet or more and introduce channels into an area currently devoid of tidal channels. The result will be most evident at low tides when the tidal channels are exposed. This represents a substantial local change in the surface topography of the marsh. However, the resulting topography will be similar to the topography of the intertidal areas in the north arm and to historic conditions in the Reserve.

Construction of the experimental berm in the south arm will provide local topographic relief in the relatively flat south arm but surrounding vegetation will screen much, if not all, of the berm at the PERL site. The berm would be more obvious if constructed at the alternate location. The benefits of constructing and performing the experimental trials will offset the impact of the berm on the local topography. It will allow researchers to address the applicability of using excavated materials to construct the larger berm that is part of the 495-acre Restoration Project and will put into practice the adaptive management approach to identify the most appropriate method to prepare the sediments and revegetate the berm.

**Soils.** Sediment quality and texture analyses will be presented in a permit application coordinated by the Corps and SDRWQCB. If contaminants are found, supplemental environmental documentation will be required to assess disposal option. The sediment analysis study has been approved by the SDRWQCB and will be performed prior to submittal of permits for the Model Project Appendix G.

### 3.1.2.2. Impacts of 495-Acre Restoration Project

**Site Geology and Topography.** The project will not have any short-term impacts on site geology. The dredging and excavation of material and stockpiling of materials will result in an impact to topography. Dredging will lower the present surface of the marsh area by up to four feet or more; it will extend the tidal channels into the southern part of the

estuary where tidal channels are not currently present. The result will be a substantial change in the surface topography of the southern part of the estuary.

Any stockpiling of dredged or excavated materials will result in a short-term change in surface topography by creating relief in an otherwise flat terrain. The height of the possible stockpiled material will depend on the amount of material dredged or excavated during implementation of any one sequential module.

The project will not have any long-term impacts on site geology. Dredging and excavation will result in long-term impacts to the topography of the project site. Under final buildout, 60 acres will be less than zero feet NGVD, 414 acres less than four feet NGVD and 547 acres less than eight feet NGVD. This represents substantial long-term change in the topography of the site as a result of dredging and excavation.

Deposition of the dredged or excavated materials for the construction of the river training structures will create relief in the estuary that does not now exist. The affected land is primarily agricultural land and relatively flat. The erodible berm will be approximately 25-feet high from the ground surface and would cover approximately 46 acres, and would result in a perceptible change in local topography. The levee will be approximately ten feet high, would cover approximately 12 acres, and would result in a perceptible change in local topography, albeit less than the berm. The berm will resemble a northwesterly extension from the southern bluffs.

**Soils.** The short-term and long-term impacts to soils resulting from implementation of the project, especially sediment quality impacts, will be discussed in subsequent environmental documents as each module is developed. Sediment quality studies will be performed to identify the quality of the materials to be removed and of the new surface material. Sediment texture information will be collected at the same time. These data will assist in addressing issues on sediment quality, disposal options for the dredged and excavated material, and the texture of the surface sediments that will be exposed after dredging and excavation.

#### 3.1.2.3 Mitigation

**Model Project.** No significant adverse impacts have been identified for the Model Project and no mitigation measures proposed.

**495-Acre Restoration Project.** The 495-acre Restoration Project will result in a substantial change in the local topography in the southern arm resulting from construction of the berm or levee. Although this impact may be significant at the local level, construction of the river training berm or levee is necessary since net long-term gains in wetland acreage can only be achieved by converting transition and upland areas to wetland and protecting the restoration area with the river training berm or levee. The significant impact to local topography will be balanced and offset by the benefits gained by the project. The net gains of the project will have a significant beneficial impact at the regional level. As a result, no mitigation measures have been proposed to mitigate for the changes in the topography. The berm is designed at a scale to withstand anticipated floods and protect the newly created marsh and tidal prism. A smaller scale berm or levee involving less change to the current topography would provide diminished protection from sedimentation associated with flood events and may require some maintenance. A higher berm would increase the topographic relief and is not necessary either to protect the marsh from floods.

## 3.2 SURFACE AND GROUNDWATER HYDROLOGY

### 3.2.1 ENVIRONMENTAL SETTING

#### 3.2.1.1 Surface Water

The Tijuana River is formed by the confluence of Cottonwood Creek and Rio de las Palmas in southeast Tijuana and flows in a northwesterly direction for 11 miles until discharging into the Pacific Ocean south of Imperial Beach, California. Runoff from the upper 988 square miles is controlled by the Rodriguez Dam on the Rio de las Palmas. Built in 1936, the dam is located 5.6 miles above the confluence with Cottonwood Creek. The reservoir has a capacity at the top of the spillway gates of 111,070 acre-feet. Two dams are located on Cottonwood Creek within the United States portion of the drainage

area. Morena dam was built in 1910, with a drainage area of 114 square miles. The reservoir has a capacity of 50,210 acre-feet and provides raw water storage for the City of San Diego. Barrett Dam, built in 1921, is located 8.5 miles downstream from Morena Dam. Barrett Reservoir also provides 44,760 acre-feet of raw water storage for the City of San Diego. The drainage area between the dams is 133 square miles.

Construction of the dams in the watershed of the river system resulted in reduced volumes of surface water flowing to the valley. Runoff from about 78 percent of the drainage area is controlled by these three dams, with a resulting modification of flow patterns in the Tijuana River. The effects of these reservoirs on streamflow are undetermined, because all three were installed before the streams were gaged. It is estimated, however, that the dams have diverted about 50 percent of the streamflow and have reduced the sediment supply to the lower river valley by about 30 percent.

It is also likely that dry-season flows are lower and that flood flows are delayed by the presence of these reservoirs. Maximum river flows now tend to occur in winter months and early spring (January through May), the period of the year during which flooding would be most likely. On the average, the Tijuana River has its peak flow in March. Similarly, low flows are most likely to occur during summer and fall months (June through December).

Immediately prior to entering the United States, the Tijuana River flows through a lined flood channel in Mexico, designed to carry a flow of 13,500 cubic feet per second (cfs). The international flood control project includes an energy dissipator in the United States to reduce backwater flooding into Mexico and to control downstream damage in the United States. Downstream from the energy dissipator, a low flow channel with a design capacity of 1,000 cubic feet per second (cfs) extends to a point just below Dairy Mart Road. The dissipator and low flow channel were designed to deliver water into the existing channel at velocities which could occur under natural conditions.

Until recently, the lower Tijuana River was an ephemeral stream. In the last several years, the river has experienced perennial flow due to the introduction of sewage flows from the City of Tijuana. Estimated average flows are ten million gallons per day (MGD). Within the next five years, the flows are projected to increase four fold or to 40 MGD.

The historic development of the Tijuana Estuary is instructive for understanding the present and possible future hydrology of the estuary. The recent geomorphic evolution of the Tijuana Estuary began at the close of the last ice age about 12,000 years ago. Sea level rose rapidly drowning the lower Tijuana River Valley and transforming it into a coastal lagoon. Between about 5,000 and 12,000 years ago, the rate of sea level rise was approximately five feet per century. About 5,000 years ago, the rate of sea level rise slowed to about 0.6 feet per century which is similar to the present rate. With this lower rate of sea level rise, the Tijuana River delta began to advance into the lagoon filling it and converting it to a gently sloping floodplain.

At the same time that rising sea levels invaded the valley, it is likely that barrier beach spits, separated by a tidal entrance channel, formed across the lagoon mouth. The Tijuana River delta continued its westward expansion until most of the central part of the lagoon was filled leaving two isolated areas to the north and south and three remnant river channels. the remnant north arm developed into large areas of intertidal mudflat and salt marsh fed by a large slough channel, Oneonta Slough. According to the 1852 map of the area the estuary contained a large embayment. By 1904, the bay had become smaller. In 1904, there were two river courses, one entering the center of the estuary and one toward its southern end. The latter no longer connects with the river.

Since 1852, over 60 percent of the original intertidal wetlands have been filled or otherwise modified and removed from tidal influence. During the seven major flood events between 1852 and 1986, the Tijuana River delta advanced into the central part of the estuary and filled over 200 acres of former intertidal wetland. This occurred as the river channel migrated across the entire width of the alluvial valley. Landward movement of the barrier beach into the north arm and the southern estuary filled or removed about 100 acres of additional salt marsh and slough channel habitats. In the north arm, 50 acres of lower intertidal mudflat were converted to higher elevations by the expansion of higher intertidal marsh plain consisting of pickleweed. Growth of the Goat Canyon alluvial fan and other minor side-canyon alluvial fans filled roughly 30 acres of intertidal area in the southern arm of the estuary. Combined with grading, cultivation and road construction, over 250 acres have been removed from tidal circulation in the south arm.

The historical landward movement of the barrier beach was another major factor in reducing the tidal prism of the estuary. Sand washed over the barrier beach has filled

slough channels and constricted tidal flows. Between 1852 and 1986, the seaward edge of the barrier beach retreated landward over 300 feet on average of both the north and south segments. The landward edge has retreated about 400 feet on the average in the same period because of washout and flattening of the barrier beach dunes.

Beach retreat and sea level rise are expected to continue. The projected long-term inland migration rate is approximately 2.5 feet per year (Appendix D). Reduced sand delivery to the beach and the projected increase in sea level rise could increase the rate of beach migration. It is estimated that dams constructed in the watershed have reduced sand delivery to the beach by about 30 percent. Additionally, sea level rise is now expected again to escalate. Projections in the rate of sea level rise for the next century are between three and seven feet (Park et al. 1988). These factors could accelerate inland migration to about eight feet per year.

The Tijuana Estuary is a wetland-dominated estuary. There is no major embayment, but rather a system of tidal sloughs and salt marshes. The estuary can be characterized as a mature salt marsh system. Four main tidal channels extend inland from a common tidal inlet. Oneonta Slough runs northward, parallel to the coast into the isolated north arm Marsh. The other three main slough channels extend eastward and are incised within the Tijuana River floodplain. These channels have been termed the Tijuana River Slough, the Mid-Valley Slough, and the Old River Slough. Another slough, the South Slough, extends south into the south arm but is essentially cut off from tidal flows. Salt marshes occur along the margins of slough channels and in broad intertidal plains typically from one to approximately eleven feet above the National Geodetic Vertical Datum (NGVD) or Mean Sea Level 1929 (MSL). Intertidal salt marsh occurs to about 3.5 feet NGVD.

The estuary slough channels contact the Pacific Ocean through a tidal inlet that breaches the barrier beach. This barrier beach extends from the coastal bluff at the international border to the low headlands at Imperial Beach and serves as a buffer between the estuary and the waves of the Pacific Ocean. The ocean floor off the beach is shallow, sloping gently to the 100 foot contour about four miles offshore.

Water levels in the estuary fluctuate with the tidal cycle. The estuary is normally flushed by mixed semi-diurnal tides twice daily. The volume of the tidal prisms may vary from 100 to 300-acre feet. The potential tidal prism is now estimated to be only about 290-acre feet. These fluctuations can result in the flooding of as many as 1,100 acres of the

estuary and salt marshes during yearly high tides. This tidal regime maintains a shallow mouth at the entrance of the estuary at approximately 100 feet in width at mean high water. Tidal data collected during spring tide conditions in August 1986 demonstrate that the shallow entrance channel depth cuts off the lower half of the ocean tidal cycle inside the estuary. Within most of the estuary, the low tide does not drop below an elevation of 0.0 feet MSL. Tidal hydrodynamic modeling, which predicts ebb flow velocities through the entrance channel, indicates only about two-thirds of the present channel needs to be obstructed to cause it to become unstable and close.

Tidal circulation in the estuary is limited by the shallow depth of the entrance channel and low hydraulic efficiency of tributary slough channels. Consequently, the "effective tidal prism," the volume of seawater which actually discharges through the entrance channel during the ebb flow, is considerably less than the "potential tidal prism," the volume calculated from measurements of topography. Because the scouring force of the tidal currents has been significantly lessened, the mouth of the estuary is now susceptible to closure, and slough channels are less efficient hydraulically. Inside the estuary, the tidal range decreases and the time lag between tide peaks increases as the distance from the entrance channel increases.

#### 3.2.1.2 Groundwater

Groundwater in the Tijuana River Valley occurs mainly in alluvial deposits laid down by the Tijuana River. The groundwater aquifer is unconfined with a storage capacity of about 900 million cubic feet (Department of Water Resources, 1967). The aquifer rests on bedrock surface and consists of from 50 to 90 feet of sand and silt overlying 10 to 35 feet of interbedded layers of gravels and sand (Department of Water Resources, 1967; United States Geologic Survey, 1919).

Groundwater flows from east toward the mouth of the river. In 1983, the groundwater table had a westward slope of 15 percent (Boyle Engineering, 1987a). The groundwater levels are dependent on recharge from the Tijuana River. Groundwater elevations vary naturally from year-to-year, depending on streamflow and accumulated rainfall, and between wet and dry seasons.

Human modification, principally groundwater pumping and flow diversion for water supply, have decreased groundwater recharge historically, resulting in lowered groundwater elevations. Groundwater pumping in the Tijuana River Valley for agriculture occurred in the late 19th Century after a sustained period of drought limited surface water supply. In the early 1900s numerous wells were established in the Tijuana River Valley and by the 1950s and 1960s groundwater pumping had greatly exceeded recharge. The groundwater table was lowered to a point that the hydraulic gradient reversed, resulting seawater intrusion. By 1967, the intrusion of seawater had affected most of the wells in the Tijuana River Valley up to the border with Mexico and total dissolved solids in the groundwater exceeded 1,000 ppm (Department of Water Resources, 1967).

As groundwater elevations decreased, recharge from flows in the lower Tijuana River was reduced by upstream water diversions and dams. Between 1936 and 1976, average streamflow was about 50 percent below expected natural flow and in some years, the entire runoff flow from the watershed was trapped by dams in Mexico. In 1978 groundwater levels began to recover as a result of above average rainfall and the introduction of wastewater spills from the City of Tijuana, in Mexico. As a result, the interface between saline and fresh groundwater has expanded even farther in recent years as a result of reduced pumping and sewage inflow.

Recently, Engineering Science (1987) found that groundwater in the river valley occurs near the ground surface. In the fall of 1986, groundwater levels ranged from four to 15.5 feet below the ground surface from the barrier beach east approximately to Dairy Mart Road. These measurements described a relatively level groundwater source with elevations ranging from +1 foot MSL at the dune to approximately +23 feet MSL near Dairy Mart Road.

### 3.2.2 IMPACTS AND MITIGATION

#### 3.2.2.1 Impacts of Model Project

**Surface Water.** Widening of Oneonta Slough and construction of the connector channel will have a beneficial effect on surface water hydrology. Widening of Oneonta Slough

will facilitate the ability of Oneonta Slough to accommodate the eastward migration of the barrier beaches. Since Oneonta Slough accounts for approximately 50 percent of the total prism in the estuary, any restriction on tidal flow in Oneonta Slough would have a significant adverse effect on the overall tidal prism in the estuary. Loss of tidal flow in the estuary could lead to a significant loss of sensitive resources that are found in the estuary as was documented by Zedler and Nordby (1986).

The connector channel also will have a beneficial effect on tidal circulation in the tidal lagoons in the northeastern corner of the Reserve by facilitating tidal flushing. Increased tidal flushing will benefit the local water quality in the tidal ponds which in turn could benefit the biological resources that utilize the tidal lagoons.

The 20-acre experimental marsh will increase tidal circulation in the immediate area of the marsh. Increased tidal circulation is necessary in order to establish the experimental plots in the 20-acre marsh that will be used to generate information that will be used to guide the development of the larger 495-acre Restoration Project. Additionally, the small increase in tidal prism will contribute to the overall goal of the Tidal Restoration Program of increasing the tidal prism in the estuary.

The experimental berm will not impact the surface water hydrology in the Reserve.

**Groundwater.** The Model Project will not have a measurable impact on groundwater hydrology in the Reserve.

#### 3.2.2.2 Impacts of 495-Acre Restoration Project

**Surface Water.** The 495-acre Restoration Project will result in a significant beneficial change in the surface water hydrology. In fact, one of the major objectives is to change the hydrology by increasing the tidal prism. Sequential development of the modules will result in incremental changes in surface hydrology. The size of these incremental changes will depend on the size of the individual modules. The short-term impacts will not result in significant adverse impacts. In fact, when taken in combination of other expected changes, the changes in surface water hydrology will be beneficial.

At full buildout, the tidal prism will be 845 acre-feet, compared to the present tidal prism of 290 acre-feet. Most of the increase in the tidal prism will occur in the southern arm of the estuary, an area that is lacking regular tidal flushing at the present time. The new tidal prism is designed to maintain continual tidal flushing which is objective of the project. The impact will be significant and beneficial.

The proposed river training structure may result in an increase in surface water elevations upstream during large floods. An increase in flood surface water elevations would constitute a significant adverse impact.

**Groundwater.** The incremental increase in the tidal prism is not expected to measurably affect groundwater. Increase in the tidal prism could increase the influence of tidal water on groundwater. The result could be an increase in the groundwater levels in the south arm. If the planned sewer projects are completed and are successful at intercepting sewage flow from Mexico, the possible increased infiltration of tidal water into the groundwater system could replace some of the recharge resulting from the present day sewage flow. The effects of the changes in the surface water levels due to the changing tide also may be evident in the groundwater.

#### 3.2.2.3 Mitigation

**Model Project.** No significant adverse impacts have been identified for the Model Project and no mitigation measures proposed.

**495-Acre Restoration Project.** Impacts of the 495-acre Restoration Project to surface water hydrology will be significant but beneficial. Therefore, there are no mitigation measures being proposed for surface water hydrology impacts. Impacts to groundwater will not be significant and mitigation will not be necessary.

A Federal Emergency Management Agency (FEMA) surface water elevation assessment must be undertaken to establish the impact of the proposed river training structure on the backwater flood hydrology of the river. Should significant affects be anticipated as a result of the structure, then design changes must be made to reduce the impact to levels acceptable to FEMA and local flood management agencies.

## 3.3 WATER QUALITY

### 3.3.1 ENVIRONMENTAL SETTING

#### 3.3.1.1 Surface Water

For over 50 years, the river has received raw sewage flows from the City of Tijuana. However, these water problems, due largely to the deterioration and inadequacy of the city of Tijuana's sewage collection and conveyance systems and extremely rapid population growth, have increased in severity in recent years. Only about half of the households in Tijuana are connected to city sewers (Weisman, 1984). The population of the City in 1985 was estimated to be one million, and by the year 2000 the population is expected to exceed two million. Today, the river is receiving between ten and twelve million gallons daily of untreated sewage (Seamans, 1988).

The raw wastewater in the Tijuana River estuary contains both heavy metals and toxic organics, since Mexican industry practices little or no pretreatment before discharge; In April 1983, Conway and Salgado (1983) ran tow samples of sewage from the Tijuana Pump Station. Total suspended solids were 624 mg/L and total coliforms were too numerous to count. Samples were also collected and analyzed from the Tijuana River from a sampling point at Dairy Mart Road bridge. Total suspended solids were less (36 mg/L) than in the sewer, but total coliforms were again too numerous to count. The river water at this point was somewhat better in quality than the wastewater, but still showed the influence of the surface discharge.

Conway et al. (1985) sampled the Tijuana River water from a series of stations in 1983 and 1984. The stations included one on the Alamar, one on Las Palmas and three on the Tijuana River. Biochemical oxygen demand ranged from 2.4 to 11.6 mg/L; total suspended solids from 5 to 82 mg/L; nitrate-nitrogen from 0.8 to 2.7 mg/L; hardness from 211 to 530 mg/L; conductivity from 1100 to 3000 mhos/cm and chromium from 0.01 to 0.06 mg/L. Total coliform was too numerous to count. A general trend observed in this study was that the quality of water decreased as one moved downstream towards the ocean. This was especially true for hardness, conductivity and total coliforms.

Thirteen sampling stations were monitored for water quality in the Tijuana River drainage in 1985 and 1986 (Conway et. al, 1987). In that study, the trend seen for the sampling results in the Tijuana River was a reduction in Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS) and Settleable Solids (Set S) as you proceed downstream towards the ocean. The average BOD (40 mg/L) and COD (128 mg/L) within Mexico are much higher than would be expected for a river, but are about one-fifth that of wastewater. While this indicates either dilution or cleansing is occurring the influence of surface runoff of wastewater is still evident.

The effects of tidal flow and sewage flow down the Tijuana River on the quality of water in the Tijuana Estuary was part of a recent study by Zedler et al. (1990). The purpose of their study was to expand their understanding of the Tijuana Estuary by expanding their view of the ecosystem and its linkages with the urban landscape. The authors tested three hypotheses in their study in order to increase their understanding of the linkages between the estuary and its urban landscape. The subject areas addressed by the three hypotheses were: (1) water quality; (2) salt marsh vegetation; and (3) channel fauna. Stations were established through the estuary in order to characterize seasonal and spatial patterns of the water quality parameters investigated. Salinity was the main parameter used by the authors as an indicator of linkages between the estuary and its urbanized watershed.

In general, this study found that the sewage flows and urban runoff produced a patchy and seasonally variable pattern of salinity in the estuarine waters. The lowest salinities were found upstream in the Tijuana River near the source of sewage inflow (Mexico), intermediate salinities in impoundments where tidal influence is minimal, and highest salinity in tidal creeks farthest from street drains and river channels. The highest water quality (low nutrients, low sediment turbidity, high dissolved oxygen) and lowest algal abundance were found where tidal influence was greatest.

The water in the Tijuana River was found to be measurably diluted all year long. Without the perennial flow of sewage from Mexico down the Tijuana River, salinity levels in the lower part of the river (near the mouth) would be similar to seawater (34 to 35 parts per thousand [ppt]) through the dry season (approximately April through October. However, the influence of the sewage flow down the river is evident in the salinity measurements. Over the 15 months of data collection, the salinity at the western-most station in the Tijuana River channel averaged 27 ppt. At the eastern-most station located at the Hollister Street Bridge, salinity ranged from one to six ppt and averaged

two ppt. This result indicates that the seawater influence in the Tijuana River extends at least as far east as the Hollister Street Bridge, which is 0.5 miles east of the eastern boundary of the Reserve.

The Old River channel, which extends from the mouth to the southeast, was historically a major river channel. Currently, the channel is buffered from tidal flows and river inflows due to sedimentation at both the eastern and western end of the channel, although some tidal water flows into the channel during spring tides. At the western end of the channel near the mouth, salinities in the channel averaged 30 ppt in the 15-month study period, indicating some influence from the saline water of the lower Tijuana River (Zedler et al., 1990). At the inland station to the southeast, the channel was consistently brackish with an average salinity of 20 ppt. The authors speculate that for the water at the inland station to become hyposaline in summer would require the introduction of sewage or agricultural water into the channel, possible through the groundwater. This conclusion is supported by soil salinity samples taken from the vegetation monitoring station near the channel. The salinity of the soils was lower at the 30-cm depth than at the surface; whereas at soil sampling stations elsewhere in the estuary, the soil salinity was similar or higher at depth compared to the surface.

Oneonta Slough is the main tidal channel of the estuary and accounts for approximately 50 percent of the total tidal prism of the estuary (Appendix D). Zedler et al. (1990) found the waters of Oneonta Slough to be measurably diluted for most of the year. They recorded salinity values above seawater only in two months and the average salinity for each of the four stations was 31 ppt. The latter authors concluded that the major source of water diluting the salinity of the marine waters entering Oneonta Slough was the sewage flows coming from Mexico and that this flow of sewage water was resulting in a ten percent reduction in the salinities in Oneonta Slough.

The study of Zedler et al. (1990) also assessed the nutrient content of water entering the estuary and reported on results of samples taken between November, 1989 and April, 1990. At the western-most station in the Tijuana River the range of values for ammonium was 8.5 to 13.8 mgN/L and for nitrate the range was 0.1 to 1.0 mgN/L. Phosphate concentrations ranged from 3.1 to 5.5 mgP/L. The authors cite data on the values found in secondary treated wastewater for ammonium (1 to 25 mgN/L), nitrate (0.7 to 19 mgN/L), and phosphate (6 to 12 mgP/L) and conclude, based on the lower values observed in the Tijuana River, that the raw sewage flowing from Mexico is

measurably treated by the riparian and marsh habitats along the river. The water flows slowly down the Tijuana River, which supports extensive growths of willows, bulrushes, cattails and other herbaceous marsh species.

Mean dissolved oxygen of the bottom waters in the Tijuana Estuary ranged from 3.3 to 8.1 parts per million (ppm) (Zedler et al., 1990). At the four stations in Oneonta Slough, mean dissolved oxygen was fairly constant, ranging from 6.4 to 6.7 ppm. At the four stations further upstream near the sewage ponds, mean dissolved oxygen was more variable, ranging from 5.9 to 7.3 ppm. At the Tijuana River stations, the mean dissolved oxygen values ranged from 5.9 to 7.0 ppm. In Old River, mean values ranged from 3.3 to 7.2 ppm. In general, the dissolved oxygen values were lower in the spring and summer months and highest in the winter (Zedler et al., 1990).

Mean bottom water temperatures (°C) also were variable in the Reserve (Zedler et al., 1990). In Oneonta Slough, the mean bottom temperatures was relatively constant, ranging from 18.3 to 19.0°C. At the stations near the sewage lagoons, mean bottom temperatures were higher, ranging from 18.7 to 21.5°C. In the Tijuana River, mean bottom temperatures ranged from 19.0 to 20.5°C. In the Old River Channel, mean bottom water temperatures ranged from 16.9 to 18.9°C (Zedler et al., 1990).

#### 3.3.1.2 Groundwater

Data on the quality of the groundwater in the Reserve is limited. The U.S. Geological Survey has sampled water from wells in the Tijuana River Valley and found the quality of the water to be poor through the valley. Total dissolved solid concentrations were typically between 1,000 and 1,500 mg/L with an observed peak value of 3,600 mg/L. These values reflect the influence of salt water on the groundwater in the lower Tijuana River Valley. Recent groundwater assessments have been undertaken in association with International Boundary and Water Commission projects in the Tijuana Valley. An extensive monitoring program has been initiated which will provide updated information on the groundwater quality in the valley and provide a baseline for future assessments.

## 3.3.2 IMPACTS AND MITIGATION

### 3.3.2.1 Impacts of Model Project

**Surface Water.** The Model Project will have a limited local beneficial effect on the surface water quality in the estuary. Widening of Oneonta Slough, when combined with the increased tidal prism of the larger 495-acre Restoration Project, will have a long-term beneficial effect on the surface water quality of the estuary due to the greater volume of tidal waters to dilute the sewage waters flowing into the Reserve from Mexico. The connector channel will be beneficial to the surface water quality in the tidal lagoons by improving the tidal flushing in these lagoons. The ditch constructed to carry street runoff into the connector channel will contribute to improved quality of runoff water reaching the tidal waters in the north arm of the estuary. The experimental berm will not have an impact on surface waters in the estuary.

The increased tidal flushing resulting from the Model Project by saline estuarine water will not affect the salinity of the active river channel. Tidal waters will be brought to the Model Project area by dredging the Old River Slough, which joins the active river channel near the tidal inlet. The tidal capacity of the active river channel will not be affected by excavation of Old River Slough and therefore, increases in salinity in the active river channel is not expected.

During construction of each of the components of the Model Project, there will be some release of sediments into the tidal waters that will result in short-term construction-related impacts to surface water quality (increased turbidity). Dilution of the suspended sediments will keep the area of this impact to a minimum. Appropriate construction measures will be implemented to control the release of sediments into the surface water.

**Groundwater.** The Model Project will not have a measurable impact on the quality of the groundwater in the Reserve. There may be some movement of saline water into the groundwater associated with the experimental berm, but this occurrence would be restricted to a relatively small area. However, the data indicate that groundwater in the Reserve area already has a high salt content. Therefore, the additional saline water reaching the groundwater probably will not result in further degradation of the groundwater quality beyond its current levels.

### 3.3.2.2 Impacts of 495-Acre Restoration Project

**Surface Water.** Increases in the tidal prism will result in a greater volume of tidal waters to dilute the sewage flowing into the estuary. This will improve the local water quality and is considered a beneficial impact. The project will not affect the volume or quality of the sewage above the mixing area in the estuary.

The San Diego Regional Water Quality Control Board has defined a number of beneficial uses for the surface waters in the Reserve. The surface water beneficial uses of coastal waters, defined as waters subject to tidal action, include the following:

- water contact recreation
- non-water contact recreation
- ocean commercial/sport fishing
- preservation of threatened and endangered species
- marine habitat
- shellfish harvesting

The deteriorated water quality in the estuary and recent episodes of reduced tidal flushing currently limit water contact recreation and non-contact recreation. The water quality also limits the quality of habitats for shellfish and sport fishes in the estuary. The Reserve itself prohibits fishing in the estuary; however, poor water quality lowers the beneficial value of the estuary to fish.

The project is expected to enhance the beneficial uses of the estuary. It will not adversely impact any of the beneficial uses. For example, the project is designed to increase the tidal prism of the estuary. In doing this, the project will improve tidal flushing and decrease the likelihood that tidal flushing will be reduced or eliminated in the future. Studies of the estuary during recent episodes of closure of the mouth have documented that full tidal flushing of the estuary is necessary for the maintenance of populations of the endangered, threatened, or otherwise sensitive species that inhabit the

estuary. In addition, this project will improve habitat for resident and transient fish species, some of which support sport fisheries elsewhere.

The increase in tidal prism resulting from this project coupled with the elimination of Tijuana River sewage flows by the planned sewer treatment facilities should result in positive impacts on the surface water quality in the Tijuana River and the estuary. However, a region-wide salinity model is needed to document possible changes in surface water salinity levels before and after elimination of sewage flows in the river and tidal restoration. Salinity effects have been documented in the Tijuana River east of the eastern boundary of the Reserve. With the elimination of the continuous surface water flow in the Tijuana River, salinity may extend farther eastward. The increase in the salinity of the surface waters could affect the riparian vegetation in eastern areas of the Reserve and further upstream. This would be considered a significant adverse impact because the riparian habitat is used by the endangered least Bell's vireo.

**Groundwater**. The groundwater in the project area and adjacent areas is slightly saline, ranging from one to five parts per thousand. The project will have short-term impacts on groundwater quality during construction, including localized increases in salinity at sites of dredge spoil deposition during staging processes and longer-term impacts from leaching of the river training structure. This impact could be beneficial because it will help reverse surface soil salinity dilution that occurred during sedimentation and disturbance events in the past. Higher soil salinities reduce exotic species invasions that have occurred in areas of sewage inflow (Zedler et al., 1990).

After the complete build out, the salinity levels in the groundwater will be higher at the project site and may increase slightly adjacent to the project. The extent of the effects will depend on impacts of another project in the Tijuana River Valley, namely the elimination of sewage flows in the Tijuana River by construction of an international sewage treatment plant. The impact of the salinity increase at the project site will be beneficial because it will inhibit brackish or weedy vegetation from invading the newly formed salt marsh. The impacts of salinity increases adjacent to the project are more difficult to estimate. Assessments of impacts to groundwater are further complicated by the several gravel extraction and agricultural facilities which pump significant amounts of groundwater from wells upstream. The future of these groundwater uses will be a significant factor in assessing impacts on groundwater as the project is built out.

### 3.3.2.3 Mitigation

**Model Project.** No significant adverse impacts have been identified for the Model Project and no mitigation measures proposed.

**495-Acre Restoration Project.** There are no mitigation measures proposed for the 495-acre Restoration Project since the impacts to surface water and groundwater are not considered significant. However there could be a significant cumulative effect to surface water quality once surface flow of sewage in the Tijuana River is eliminated. The potential extent and magnitude of salinity intrusion further up the active river channel as well as in the groundwater system must be modelled to determine if the resulting salinity intrusion has a potential to result in significant impacts. Supplements to this program-level document will assess the effects of proposed actions on salinity levels in the estuary and upstream.

The San Diego Regional Water Quality Control Board has established beneficial uses for groundwater in its jurisdiction. However, these beneficial uses do not apply to groundwater west of Hollister Street, where the Reserve is located. It is unlikely that the project will impact the groundwater east of the boundary of the Reserve. However, within the eastern portion of the Reserve, there may be a cumulative impact caused by reduced groundwater recharge currently provided by renegade sewage flow. An assessment of this potential impact must be coordinated with the EPA, International Boundary and Water Commission and U.S. Fish and Wildlife Service during the supplemental environmental review process.

## 3.4 AIR QUALITY

### 3.4.1 ENVIRONMENTAL SETTING

The coastal San Diego County climate has moderate air temperatures and low rainfall. The air temperatures along the coast are moderated by low clouds through much of the year. Annual rainfall in the coastal region of San Diego occurs primarily between November and March. Monthly average rainfall and temperature are presented in Table 3-1.

**Table 3-1. Monthly Average Temperature and Precipitation for San Diego Coastal Region as Measured at the San Diego Airport**

| Month | Temperature (°F) | Precipitation (In.) |
|---|---|---|
| Oct. | 71.5 | 0.33 |
| Nov. | 61.8 | 1.10 |
| Dec. | 57.4 | 1.36 |
| Jan. | 56.8 | 2.11 |
| Feb. | 58.4 | 1.43 |
| March | 59.0 | 1.60 |
| April | 61.2 | 0.78 |
| May | 63.4 | 0.24 |
| June | 66.3 | 0.06 |
| July | 70.3 | 0.01 |
| Aug. | 72.2 | 0.11 |
| Sept. | 71.0 | 0.19 |
| Total | 63.8 | 9.32 |

Ambient air quality standards have been established by the federal and state governments (Table 3-2). The federal standards represent levels that are not to be exceeded more than once a year or a level not to be exceeded for annual standards. California standards are values that are not to be equaled or exceeded, except for standards established for carbon monoxide (CO), one-hour average sulfur dioxide ($SO_2$), nitrogen dioxide, ($NO_2$), and particulate matter less than a equal to ten micrometers in diameter (pm 10).

Regions in the San Diego Air Pollution Control District (APCD) are either nonattainment, attainment, or unclassified for achieving national ambient Air Quality Standards (NAAQS). The western portion of the air basin is designated nonattainment for achieving federal ozone, carbon monoxide, and particulate matter standards. The APCD is classified as attainment for federal sulfur dioxide standards and unclassified for nitrogen dioxide.

## 3.4.2 IMPACTS AND MITIGATION

### 3.4.2.1 Impacts of Model Project

Project construction will cause temporary air quality impacts. A detailed project description including the construction schedule, equipment to be used, and anticipated duration of use will be identified in an application for an "authority to construct" permit from the APCD. Appropriate mitigation measures will be identified to reduce impacts to levels acceptable to the APCD.

### 3.4.2.2 Impacts of 495-Acre Restoration Project

Project construction will cause temporary air quality impacts. A detailed project description including the construction schedule, equipment to be used, and anticipated duration of use will be identified in an application for an "authority to construct" permit from the APCD. Appropriate mitigation measures will be identified to reduce impacts to levels acceptable to the APCD.

## Table 3-2. Federal and State Ambient Air Quality Standards

| Pollutant | Averaging Time | California Standards | | Federal Standards | | | |
|---|---|---|---|---|---|---|---|
| | | | | Primary[a] | | Secondary[b] | |
| | | ppm | μ g/m$^3$ | ppm | μ g/m$^3$ | ppm | μ g/m$^3$ |
| Ozone[c] | 1 hour | 0.10 | 200 | 0.12 | 240 | 0.12 | 240 |
| Carbon monoxide | 8 hours | 9 | 10,000 | 9 | 10,000 | 9 | 10,000 |
| | 1 hour | 20 | 23,000 | 35 | 40,000 | 35 | 40,000 |
| Nitrogen dioxide | Annual | | | 0.05 | 100 | 0.05 | 100 |
| | 1 hour | 0.25 | 470 | | | | |
| Sulfur dioxide | Annual | | | 0.03 | 80 | | |
| | 24 hours | 0.05 | 131 | 0.14 | 365 | | |
| | 3 hours | | | | | 0.05 | 1,300 |
| | 1 hour | 0.25 | 655 | | | | |
| Total suspended particulate matter[d] | Annual | | | | 75 | | 60 |
| | 24 hours | | | | 260 | | 150 |
| PM10 | Annual | | 30 | | 50 | | 50 |
| | 24 hours | | 50 | | 150 | | 150 |
| Lead | Calendar quarter | | | | 1.5 | | 1.5 |
| | 30-day average | | 1.5 | | | | |
| Sulfate | 24 hours | | 25 | | | | |
| Visibility-reducing particles (California) | Insufficient amounts to reduce the prevailing visibility to less than 20 miles when relative humidity is less than 70 percent | | | | | | |

[a] Designed to protect human health

[b] Designed to protect public welfare (i.e., to prevent damage to vegetation, property, and visibility)

[c] California standard is for oxidant measured as ozone.

[d] California standards for TSP were replaced by PM10 standards in late 1984. Federal TSP standards were replaced by PM10 standards in July 1987.

Source: California Air Resources Board (CARB).

#### 3.4.2.3 Mitigation

**Model Project.** Mitigation measures will be developed in coordination with the Air Resources Control Board to offset any significant impacts to air quality resulting from the project.

**495-Acre Restoration Project.** Mitigation measures will be developed in coordination with the Air Resources Control Board to offset any significant impacts to air quality resulting from the project.

## 3.5 BIOLOGICAL RESOURCES

### 3.5.1 ENVIRONMENTAL SETTING

This section presents the central area of research undertaken in preparing this draft EIR/EIS. Discussions concern the vegetation that characterize the various habitats found in the Reserve and the wildlife that utilize these habitats. Special status species, which are species that are either listed as threatened or endangered by the state or federal government or are candidate or proposed species for listing, are discussed separately. Material is presented in five sections concerning: (1) vegetation, (2) wildlife, (3) special status species, (4) Tijuana Estuary's resources in relation to the regional resource base, and (5) federal jurisdictional wetlands. The section concludes with the discussion of impacts to biological resources associated with the Model Project and the 495-acre Restoration Project and proposed mitigation measures. A number of technical biological studies were completed as part of this assessment and are presented in Appendix K.

#### 3.5.1.1 Vegetation

The following discussion contains a description of the vegetation that characterizes the various habitats found in the Reserve (for the purpose of this analysis, the Reserve represents the project area). This description is based on studies completed by PERL scientists from San Diego State University as well as earlier works of Zedler and Nordby (1986) and Zedler (1982). The Tijuana Estuary is dominated by emergent marsh habitat.

There are no major embayments and the open water areas are generally associated with the tidal channels (Zedler and Nordby, 1986). The tidal channels are connected to the ocean by a narrow inlet that closes only occasionally. The emergent intertidal marsh habitat is primarily dominated by salt marsh vegetation, but there are substantial areas of other vegetation types, such as riparian and brackish marsh.

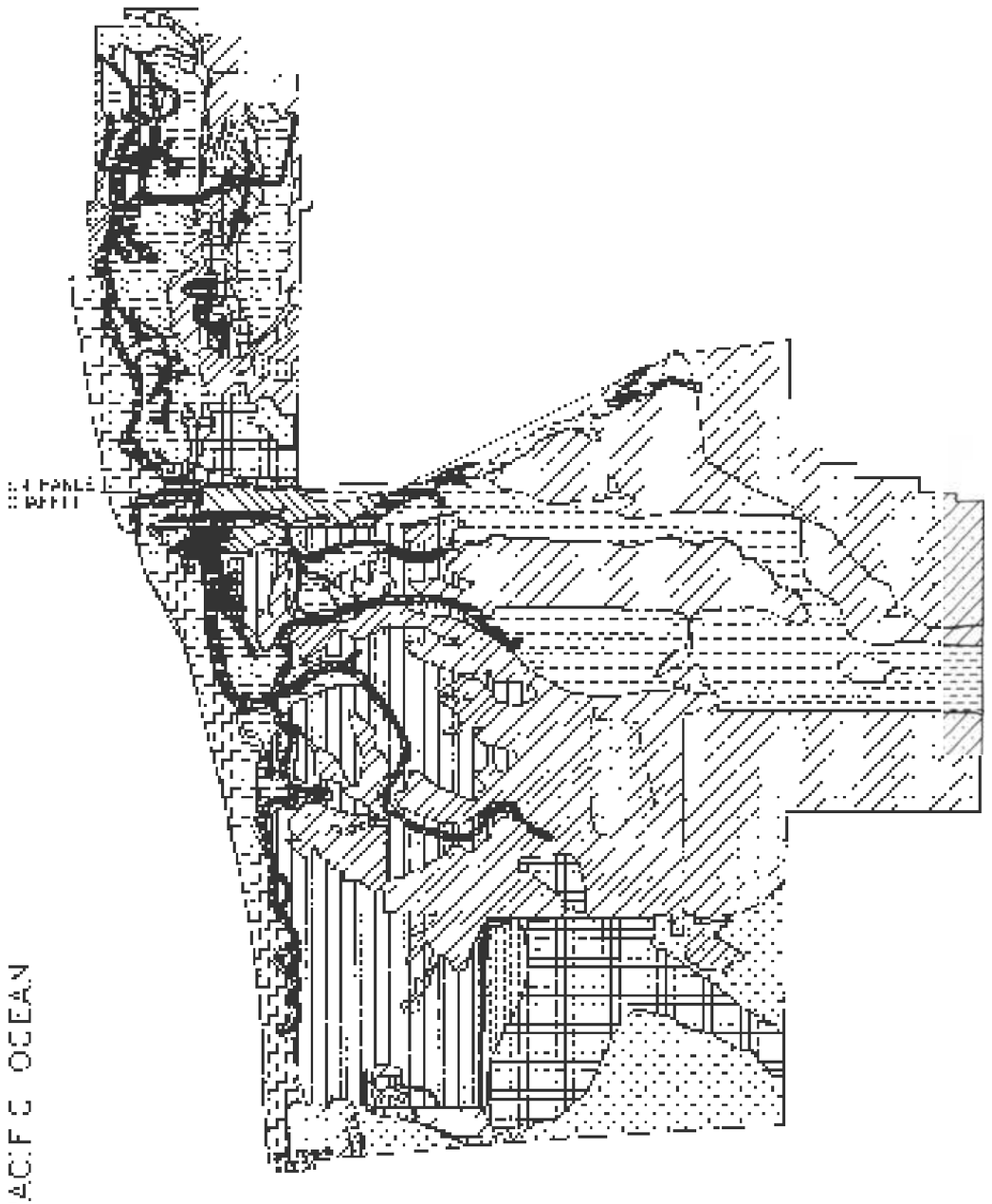
## Habitat Types and Vegetation

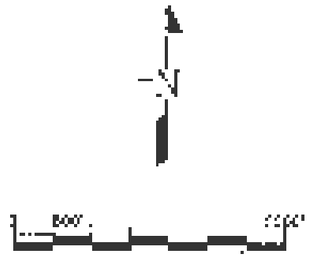
Ten different habitat types have been identified in the Reserve (Figure 3-1). Zedler and Nordby (1986) identified seven major habitat-types as occurring in the estuarine area of the Reserve: (1) tidal channels; (2) intertidal flats; (3) salt marsh; (4) salt panne; (5) brackish marsh; (6) coastal beaches and dunes; and (7) transition and mixed transition/disturbed. Field studies associated with the development of the tidal restoration program identified three other habitat types occurring in the southern and eastern portions of the Reserve: (8) riparian; (9) coastal sage scrub; and (10) disturbed and developed areas. The location and approximate acreage of each of these habitat types are presented in Figure 3-1, which was developed from 1986 aerial photographs.

The vegetative structure of habitats in the Tijuana Estuary has been well studied and the results of these studies are summarized in Zedler and Nordby (1986). This information has been supplemented by the environmental studies conducted for the Tijuana Estuary Tidal Marsh Restoration Program by the Pacific Estuarine Research Laboratory. The following discussion summarizes what is known about the vegetation and habitats and is taken from Zedler and Nordby (1986) and Zedler (1982) and the supplemental studies. The following discussion does not contain quantitative data, except in a few cases. These data are, however, incorporated by reference from the above listed documents.

### Tidal Channels and Mudflats

This category includes both the permanently submerged and intertidal portions of the tidal channels and tidal and non-tidal ponds. There are approximately 173 acres of permanently submerged habitat and 33 acres of intertidal mudflats in the estuary. Oneonta Slough is the main tidal channel in the northern arm of the estuary and three



| | Acreage |
|---|---|
| Coastal Dunes & Beaches | 124 |
| Tidal Channels and Brackish Ponds | 173 |
| Intertidal Mud Flats | 33 |
| Intertidal Salt Marsh | 176 |
| Salt Marsh/Salt Panne | 439 |
| Transition | 610 |
| Disturbed | 366 |
| Mixed Transitional/Disturbed | 181 |
| Brackish Marsh | 50 |
| Riparian | 248 |
| Coastal Sage | 151 |

relic river channels serve the central portion of the estuary. These areas are important habitat for plankton, macroalgae, invertebrates, fishes and birds.

Phytoplankton communities in the estuary have been little studied. Phytoplankton communities are composed of dinoflagellates (*Gymnodinium* spp), diatoms, filamentous blue-green algae (cyanophytes) and unidentified unicells or "monads" (Zedler and Nordby, 1986). Many of the phytoplankton species that occur in the estuary also occur in the nearby marine waters but in lower numbers. During phytoplankton blooms (March-June) in the estuary, cell counts in the estuary are higher than in the nearby marine waters by one to two orders of magnitude (Zedler and Nordby, 1986).

Algal blooms in the estuary are thought to be associated with reduced tidal flushing (Rudnicki, 1986; Fong, 1986; cited in Zedler and Nordby, 1986). As a result of the 1983 winter storms, tidal flushing in Oneonta Slough became sluggish and algal biomass increased in the tidal creeks and along the shores of the abandoned tidal pond area.

During 1984 when tidal flushing was temporarily absent, algal growth was high. In the following years, Rudnicki (1986) and Fong (1986) censused the algae monthly and found the highest biomass of macroalgae and phytoplankton in the small tidal creeks where current speeds were low. Species of algae occurring in the estuary include *Enteromorpha* sp. and *Ulva* sp. Eelgrass (*Zostera marina*) is absent in the estuary.

**Salt Marsh and Salt Pannes**

Approximately 615 acres of the estuary are characterized by salt marsh vegetation and includes tidal and nontidal areas. Seventeen of the twenty-two well-known native salt marsh plants are present in the Estuary. An additional 70 acres, located mostly in the southern arm of the estuary, is characterized as salt panne habitat. While the salt pannes themselves are mostly devoid of vegetation, glasswort (*Salicornia subterminalis*) patches are interspersed among them. Intertidal marsh covers approximately 176 acres and non-tidal salt marsh/salt panne an additional 439 acres.

The vegetational composition of the estuary is not a cohesive entity explained simply by zonation, but is a complex of individual species responding to environmental conditions and past disturbances. Plant distribution is correlated with a variety of factors including

salinity, tidal inundation, soil type and drainage and competition by other species. However, four species of plants tend to dominate the salt marsh. Approximate 40 acres are predominantly cordgrass (*Spartina foliosa*) or low saltmarsh, 272 acres are predominantly pickleweed (*Salicornia virginica*), approximately 165 acres are predominantly glasswort and 18 acres are predominantly saltgrass (*Distichlis spicata*).

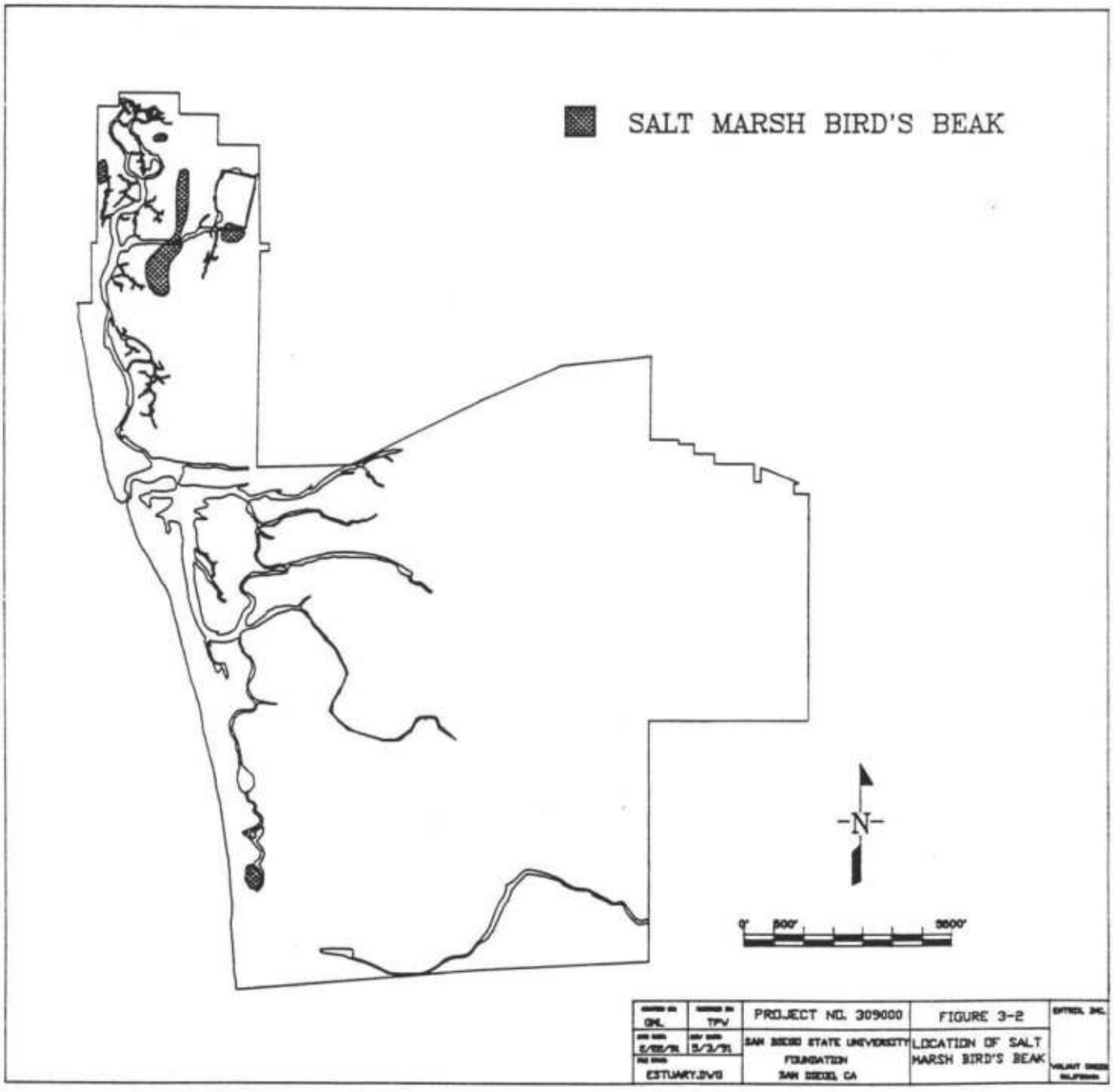
**Low Marsh.** The cordgrass community is typically located adjacent to the mudflats in the north arm of the estuary. Cordgrass is typically found mixed with pickleweed. Pickleweed, saltwort (*Batis maritima*) and jaumea (*Jaumea carnosa*) are present primarily inland of the tidal channels.

**Middle Marsh.** The middle marsh is dominated by pickleweed with jaumea, saltwort, arrowgrass (*Triglochin concinnum*) and marsh heather (*Frankenia grandifolia*) also being common. Shore grass (*Monanthochloe littoralis*), saltgrass, and sea blite (*Suaeda esteroa*) also may be present. Pickleweed areas are found in both the northern and southern arms of the estuary, however, the largest portion is in the southern arm.

**High Marsh.** The upper saltmarsh is characterized by either glasswort or saltgrass. Also commonly present are shore grass, sea lavender, and alkali weed; less commonly present are marsh heather, sea blite and Watson's saltbush. High marsh is present in both the north and south arms of the estuary, but is more prevalent in the south arm. The endangered salt marsh bird's beak (*Cordylanthus maritimus* spp. *maritimus*) occurs in the upper salt marsh, often in association with shore grass. The distribution of salt marsh bird's beak in the estuary is shown in Figure 3-2.

The upper salt marsh exhibits some topographic variation, especially in the southern arm. The deposition of sediment from runoff coming out of Goat Canyon has resulted in higher relief in the southern arm of the estuary and cut off the high marsh from tidal flushing. The increased elevation combined with the recent drought has resulted in the development of large areas with widely scattered high salt marsh vegetation with annual grass species, such as *Avena* sp. and *Bromus* sp., being common as well as other species, including a perennial bunchgrass (*Sporobolus airoides*), saltbush (*Atriplex semibaccata*), golden bush, and cholla (*Opuntia* spp.). Most of this modified high marsh-transitional habitat is located southeast of the river mouth in the southern arm of the estuary (Figure 3-1).

Figure 3-2. Location of Salt Marsh Bird's Beak.



**Salt Pannes.** The salt pannes change their appearance with the seasons. During the winter months, tidal and rain waters accumulate forming shallow water ponds. These ponds may become vegetated with wigeon grass (*Ruppia maritima*). The ponds are heavily used by migratory water-associated birds, particularly waterfowl. In the spring, the water on the pannes begin to evaporate and the barren flats become salt encrusted. At the end of the dry season, surface soil salinities can reach 200 parts per thousand. Salt panne habitat is most prevalent in the south arm.

### Brackish Marsh

Approximately 30 acres of brackish/freshwater marshes are scattered throughout the estuary. Brackish marsh occurs at the south end of the inland lagoon in an area fed by nearby runoff, at the abandoned gravel pits, and at the southern end of the estuary, where sewage spills from Mexico flow through Goat Canyon and provide an intermittent water source.

According to Zedler and Nordby (1986), this habitat forms in response to hydrologic and topographic modifications, which facilitate the accumulation of fresh water in the modified areas. The resulting vegetation is characteristic of freshwater marshes and includes cattails (*Typha domingensis*) and bulrush (*Scirpus californicus*). Wigeon grass may become abundant during the spring in standing water.

### Coastal Beaches and Dunes

The shoreline along the coast is a dynamic environment subject to a number of environmental factors including wind, wave action, salt spray, high temperatures, and moisture stress (Zedler and Nordby, 1986). The beach is that part of the strand above the mean high water line and continues to the foredunes. The dune system extends from the foredune to the wetlands. The major environmental differences between beach and dune are the amount of salt spray, level of soil salinity, and air and soil temperature microenvironments.

Vegetation is a stabilizing factor on dunes, and without vegetation the dunes become more susceptible to the erosional effects of wind and wave action. At one time the dunes

that form the western boundary of the Tijuana Estuary were vegetated. Housing construction on the dunes along the northern arm of the estuary and a variety of activities on the remaining dunes have eliminated most of the vegetation resulting in an unstable dune system. In the winter of 1983, the high waves associated with large Pacific storms washed over the dunes and transported sand into Oneonta Slough. This resulted in the closure of the mouth of the estuary in April, 1984.

Beach and dune systems are typically low in plant species richness and plant cover. Despite past and current disturbances at the Tijuana Estuary, several native plant species are still present, including sand verbena (*Abronia maritima*), dune ragweed (*Ambrosia chamissonis*) and dune primrose (*Camissonia cheiranthifolia*). The area of native vegetation has been expanded through recent beach/dune restoration efforts. Sea rocket (*Cakile maritima*), hottentot-fig (*Carpobrotus edulis*) and saltbush (*Atriplex semibaccata*) are exotics that have become widely established on the dunes due to disturbance. This mixture of natives and exotics comprises approximately 12 acres of vegetated dune habitat out of a total of approximately 124 acres of beach and dune habitats.

**Transition and Mixed Transition/Disturbed**

This zone of transition from wetland to upland comprises approximately 610 acres and contains a mixture of wetland and upland plants. Mixed Transition/Disturbed habitat accounts for about 181 acres and is intermediate in structure between Transition habitat and disturbed habitat discussed later. Wetland plants typically present include glasswort, saltgrass, marsh heather, and alkali weed. Upland species include a mix of exotic grasses (*Avena* sp. and *Bromus* sp.) as well as boxthorn (*Lycium californicum*), golden bush (*Haplopappus venetus*) and California sagebrush (*Artemisia californica*). While not typically subject to tidal inundation, water sources to support these wetland transition areas probably include rains, fog drip, salt spray and sub-irrigation and capillary action of tidal waters (Neuenschwander et al., 1979).

**Riparian**

The riparian habitat within the Reserve is approximately 248 acres in size. The riparian habitat is a mosaic of different species and is found in the eastern part of the reserve associated with the Tijuana River channel, the historic channels and the flood plain areas associated with the river. At the lower elevations several species of willows (*Salix* spp.) are common. Spike rush (*Juncus acutus*), pickleweed, salt grass, and other middle and upper salt marsh species are common in the understory. Mulefat (*Baccharis viminea*) and tamarisk also are common. Mulefat-dominated riparian is the dominant riparian habitat and stands along the higher flood plain adjacent to active and historic channels.

**Coastal Sage Scrub**

Coastal sage scrub occurs on the hillsides that form Spooner's Mesa and the Border Highlands south of Monument Road, in the Tijuana River floodplain and on the uplands adjacent to the northern arm of the estuary. There are approximately 151 acres of this habitat type within the Reserve.

Plants commonly present include California buckwheat (*Eriogonum fasciculatum*), California sagebrush, deerweed (*Lotus scoparius*), California encelia (*Encelia farinosa*) and others. Areas of the coastal sage scrub also contain a number of cholla cacti (*Opuntia* spp.).

**Disturbed and Developed Areas**

Approximately 366 acres of developed or disturbed areas are present in the Reserve. The developed areas include roadways, designated and undesignated trail systems, the model airplane runway and the Visitor's Center. Disturbed areas are typically those dominated by exotics. Most of the disturbed/developed areas are adjacent to the southern arms of the estuary.

The facilities at PERL are in this category but this area has value as a habitat. A number of experimental marsh units that were created at PERL, including fresh and brackish

marsh and mudflats, as well as riparian habitat revegetation areas consisting of young willow and cottonwood trees, provide wildlife and habitat value.

#### 3.5.1.2 Wildlife

The wildlife found in the northern and western parts of the Tijuana Estuary have been described in Zedler (1982) and Zedler and Nordby (1986). Additional information on the wildlife found in the estuary was developed by the scientists from PERL as part of this project. This information is contained in five technical reports that are incorporated by reference and presented in Appendix K:

(1) Bird Use of the Tijuana River Estuary. (Kus and Ashfield, 1989) [Appendix K.1]

(2) Invertebrates of the Tijuana River Estuary. (DiGiorgio, 1989) [Appendix K.2]

(3) Terrestrial Arthropods of Tijuana Estuary. (Williams et al., 1989) [Appendix K.3]

(4) Herpetofauna. (Espinoza, 1989) [Appendix K.4]

(5) The Mammals of the Tijuana Estuary. (Taylor and Tiszler, 1989) [Appendix K.5]

The estuary provides habitat for a number of special status species including the federally-endangered light-footed clapper rail, California least tern, California brown pelican, American peregrine falcon, and the state-endangered Belding's Savannah sparrow, as well as a number of other special status species. The special status species are discussed in Section 3.5.1.3

The diversity of habitats, open tidal connection, and size all contribute to the high value that the estuary has as a habitat. The following discussion summarizes what is known about the occurrence of wildlife in the estuary and is taken from Zedler and Nordby (1986), Zedler (1982), and the five technical reports listed above (see Appendix K),

except where noted. The following discussion does not include quantitative data, except in a few cases. These data are, however, incorporated by reference from the above listed documents.

**Birds**

The estuary is used by a large and diverse group of birds that exhibit temporal and spatial variation in their abundance, distribution, and activity. Waders, the most abundant of the bird groups in the estuary, were found by Kus and Ashfield (Appendix K.1) to use two major areas in the estuary. These included roosting areas along the barrier beach north of the mouth, and the large mudflats in the tidal pond area that are used for feeding. Small waders usually were observed roosting along the barrier beach north of the mouth while the large waders typically roosted along the margins of unvegetated tidal channels. The roosting areas along the barrier beach north of the mouth also served as an important refuge during high tides.

One important observation by Kus and Ashfield (Appendix K.1) was the low abundance of birds in the south area of the estuary. They speculated that relatively small areas of appropriate habitat, especially for foraging, may be a factor. Another factor may be that the food quality and/or availability may be lower in the south channel, which may be related to the lower water quality and restricted tidal flushing of this channel.

Other groups of birds did not display the same pattern of use as did the waders. Herons and egrets, and waterfowl occurred primarily in intertidal habitat throughout the estuary. Gulls, terns, pelicans, and cormorants also did not exhibit much of a movement pattern in response to the changing tides. The latter group of species, however, generally were confined to roosting sites on islands and nearby sites in the vicinity of the mouth, since this habitat does not occur elsewhere in the estuary.

**Tidal Channels and Mudflats.** The complexity of coastal estuarine systems results in avian use-patterns that are determined by many variables. Tidal influence is the major abiotic factor affecting shorebird distribution and behavior (Burger, 1984). Tidal factors influence the timing and location of foraging and roosting and dictate a daily fluctuation in shorebird numbers in specific areas. Seasonal variation in wetland use also occurs

when most shorebirds leave southern California wetlands in the Spring and head to the Arctic to breed.

The subtidal areas provide important foraging habitat for a number of birds, particularly the endangered California least tern (*Sterna antillarum browni*). While breeding, the least tern feeds exclusively on small fishes captured in shallow nearshore areas, estuary channels and river mouths. Fishes preferred by the least tern include the northern anchovy, topsmelt, and jacksmelt.

Foraging shorebirds can typically be seen along all the mudflats. Preferred foraging locations reportedly differ among species. The least sandpipers seem to prefer to forage on high mudflats while the western sandpipers appear to prefer foraging on the landward side of the tidewater edge at various tidal levels. Godwits and dunlins normally forage in shallow tidewater, which includes the edges of deeper tidal channels.

Typically, a greater number of individuals is found along the wider, broader mudflats. For example, approximately 85 percent of the foraging activity of the western sandpiper occurs in the intertidal mudflats and approximately 60 percent of the foraging activity of the marbled godwit occurs in the tidal channel or along the mudflats. Studies from other estuaries in southern California suggest that the most heavily utilized prey organisms are the annelids (Quammen, 1982).

Kus and Ashfield (Appendix K.1) consistently found fewer species of small waders, large waders and waterfowl along their southern transect that paralleled the Old River Slough channel than along the other transects. For example, the number of small waders using the Old River Slough channel was one-third to a half that using the other areas of the estuary.

The endangered light-footed clapper rail occurs in the low marsh and forages along the mudflats adjacent to the vegetated low marsh. The birds eat crabs (*Pachygrapsus crassipes, Hemigrapsus oregonensis* and *Uca crenulata*) and California horn shells (*Cerithidea californica*).

**Low Marsh.** The cordgrass habitat appears to be favored by the resident light-footed clapper rail, an endangered species. Cordgrass comprises its preferred nesting habitat (Jorgensen, 1975). They appear to spend more than 50 percent of their time in this

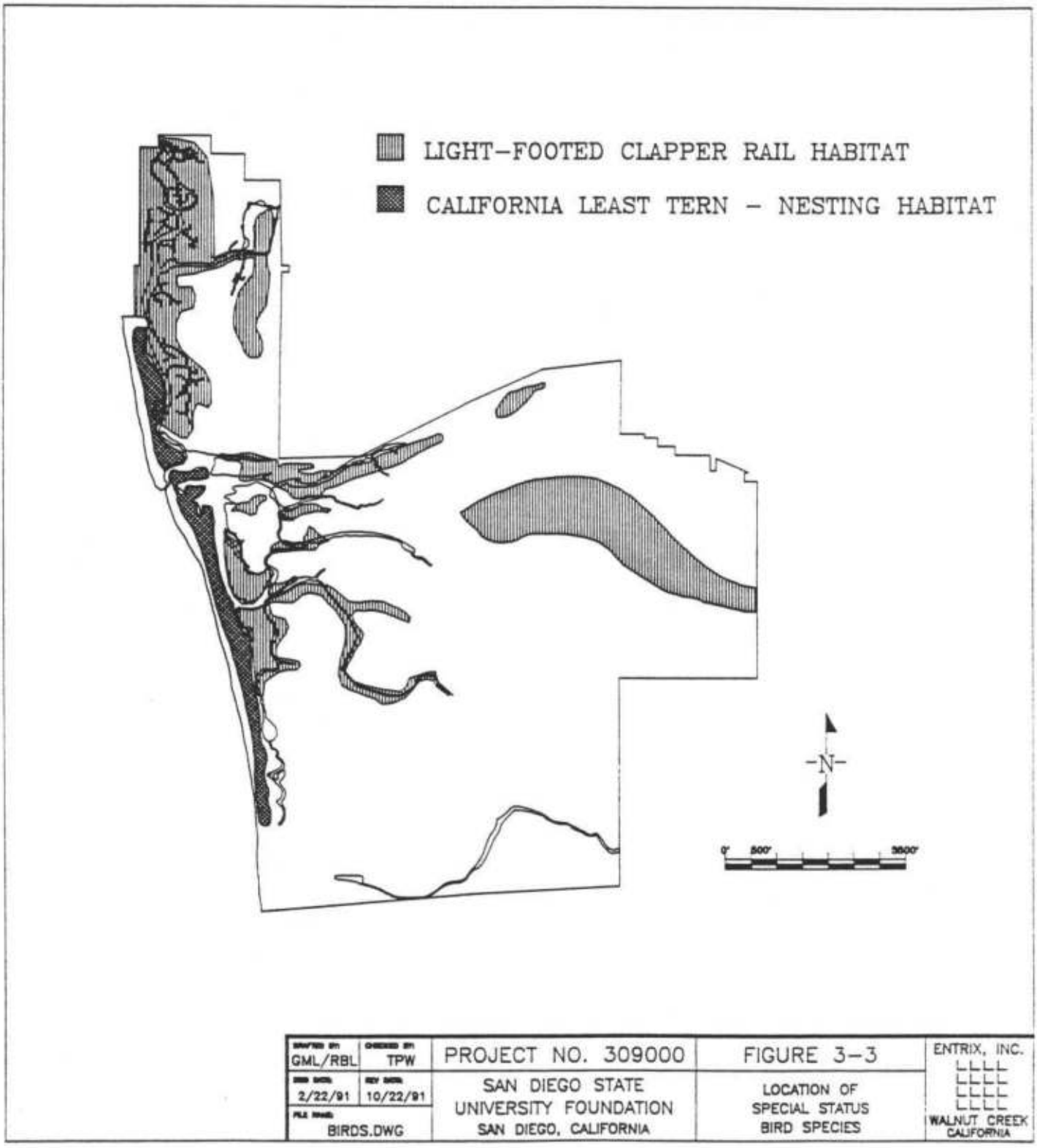
habitat. Nevertheless, rails regularly forage above this zone and in tidal channels during low tide. Upper marsh vegetation, stands of reeds and the upland fringe also serve as refugia during higher tides. The home ranges, however, appear to be small (Zembal et al., 1989). The distribution of the clapper rail habitat in the Reserve is shown in Figure 3-3.

The rail population in the estuary has fluctuated in recent years. This fluctuation has largely been attributed to the closure of the mouth of the estuary in 1984 and the resulting loss of cordgrass and mudflat foraging habitats. In 1988-89, the estimated number of breeding pairs in the estuary was 14. The results of the rail surveys in the Spring 1989 indicated that the total number of individuals was approximately 47. All the birds were located in the northern arm of the estuary. However, an additional lone male was heard upriver near the U.S. Navy airfield and one female was found as far east as wetlands adjacent to Interstate Route 5. The 1990 rail survey (March 29, 1990) found 16 to 17 pairs, mostly in the north arm. A highwater count taken on December 3, 1990 found 82 rails. The 1991 rail survey recorded 108 individuals, including 41 pairs.

**Middle Marsh.** This community is the preferred habitat for Belding's Savannah sparrow, a State of California endangered species. The status of this species in the Reserve has been surveyed for several years including a recent survey conducted in Spring 1989. The total number of singing males in the estuary was 299 with a possible high estimated to be 320. Between 135 and 144 singing males were observed in the northern arm of the estuary; between 15 and 27 males were located near the mouth of the estuary; approximately 60 males were observed in the south-central pickleweed flats and 89 males were located at the southern end of the estuary behind the dunes. While the birds were typically in dense stands of pickleweed, birds were also using a mixture of dense glasswort, marsh heather, and shore grass with only some pickleweed. The increased number of birds reported in Zembal et al. (1988) and Kus and Ashfield relative to earlier surveys was probably due to a more adequate and extensive survey of the Reserve as opposed to an increase in population of this bird. The location of Belding's Savannah sparrow habitat is shown in Figure 3-4.

**High Marsh.** The high marsh provides habitat for a number of birds that are frequently found associated with upland habitats. This includes the white-crowned sparrow, song sparrow, and western meadowlark. The latter two species will nest in the high marsh along with the killdeer and the Belding's Savannah sparrow. The northern harrier forages

Figure 3-3. Location of Clapper Rail Habitat and Least Tern Nesting Sites.

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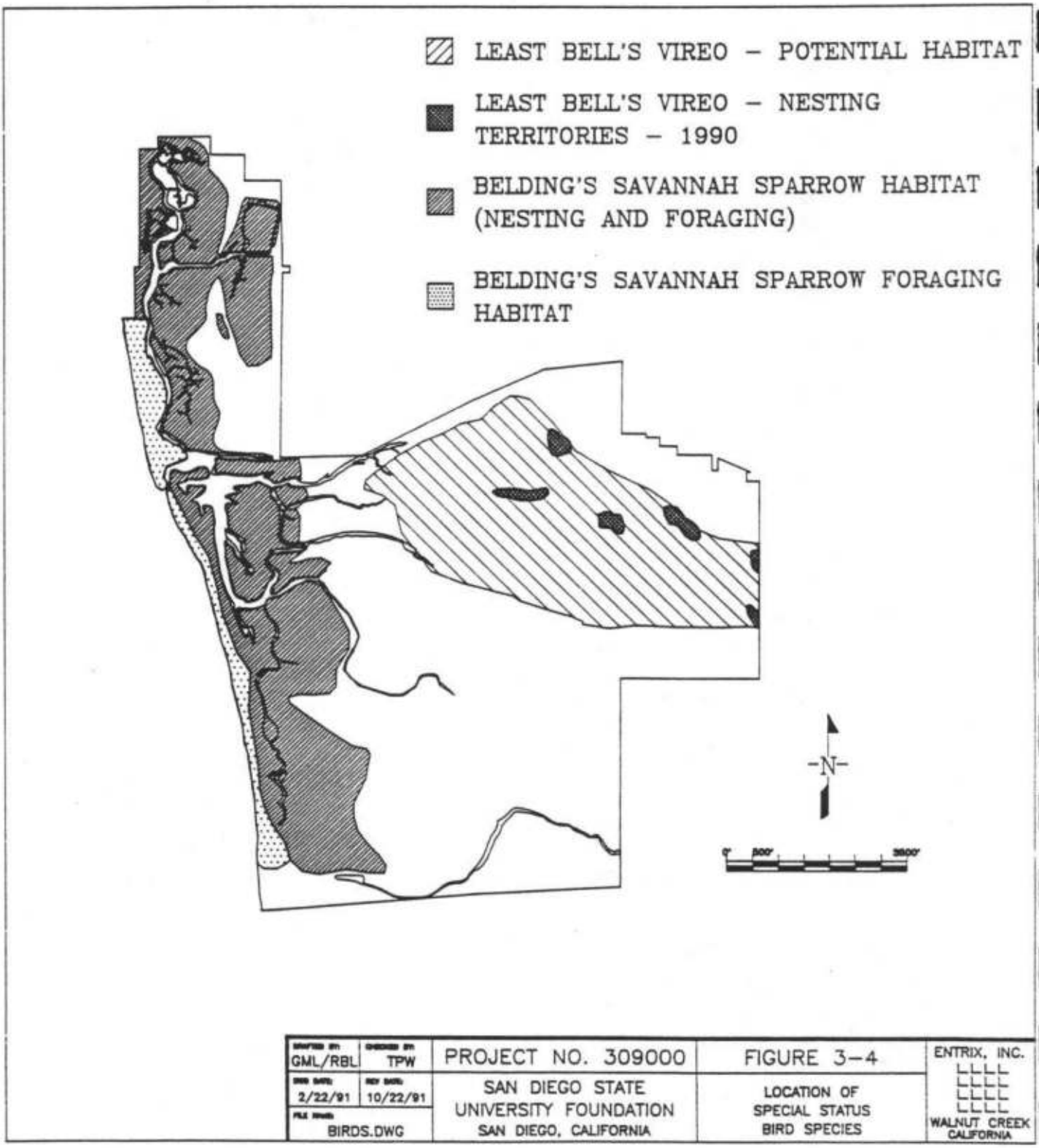
|---|---|---|---|---|
| GML/RBL | TPW | PROJECT NO. 309000 | FIGURE 3-3 | ENTRIX, INC. WALNUT CREEK CALIFORNIA |
| 2/22/91 | 10/22/91 | SAN DIEGO STATE UNIVERSITY FOUNDATION SAN DIEGO, CALIFORNIA | LOCATION OF SPECIAL STATUS BIRD SPECIES | |
| BIRDS.DWG | | | | |

Figure 3-4. Location of Belding's Savannah Sparrow and Least Bell's Vireo Habitat.



across the high marsh as does the American kestrel. Other species that will frequent the high marsh include the horned lark and loggerhead shrike.

**Salt Panne.** Many of the same species that forage in the high marsh will also forage in the salt panne habitat, including the Belding's Savannah sparrow. The California least tern and western snowy plover are known to nest in salt panne habitat. During the winter when these areas are flooded, shorebirds and waterfowl will frequent this habitat.

**Brackish Marsh.** The red-winged blackbird is the species that most characterizes this habitat. Recent observations in upper Newport Bay and San Elijo Lagoon document the use of this habitat by the endangered light-footed clapper rail at other locations. In the last two years, light-footed clapper rails have been observed or heard in brackish marsh areas at the Tijuana Estuary on several occasions (R. Ryno, personal communication). This habitat also receives heavy use by waterfowl, and is possibly preferred habitat for waterfowl in the estuary (R. Ryno, personal communication). Brackish marsh also provides habitat for a number of other birds including the sora rail, Virginia rail, black-crowned night heron, black-necked stilt, American avocet, and snowy egret. Belding's Savannah sparrows are year-round residents of pickleweed, saltgrass, and adjoining habitats to the brackish marshes around the quarry ponds.

**Coastal Beaches and Dunes.** The unvegetated dunes are an important habitat type. Both the north and south barrier beach is used for nesting by the California least tern (*Sterna antillarum browni*), a state and federal endangered species (Figure 3-3). This migratory species returns to the California coastline in late April to nest colonially and raise its young. Unfrequented sandy beaches with sparse vegetation cover close to estuaries and coastal embayments have traditionally served as nesting sites for the least tern. Nesting has been reported on the dunes both north and south of the mouth of the estuary since 1969 (E. Copper, personal communication). Creating small scrapes in the dunes, the female least tern typically lays two eggs that she then incubates for approximately 20 days.

The dunes also provide nesting habitat for the western snowy plover, a candidate endangered species. This species typically nests within the California least tern colony. Like the terns, the plover scrapes a nest and typically lays three eggs. The young and adults can be seen in the summer feeding along the water's edge on the sandy shoreline of the strand. Belding's savannah sparrow also forage along the coastal dunes (Figure 3-4).

The unvegetated dunes, especially the dune spit, provide habitat for many other species of birds. The spit at the mouth of the estuary serves as the major high-tide roost site for large and small shorebirds. This appears to be the preferred roosting area for the sandpipers and plovers, for the larger shorebirds also will roost in the wetlands.

**Transition Areas.** The birds found in the transition areas are those usually associated with upland habitats, including a number of species of migratory and resident songbirds. Several of the species found in the high marsh will also occur in the transition areas including the western meadowlark, horned lark, and American kestrel. The northern harrier and black-shouldered kite will also forage over this habitat as well as other raptors. Other expected visitors to the transition areas include the golden eagle, peregrine falcon, red-tailed hawk, red-shouldered hawk, and turkey vulture.

**Riparian Areas.** Least Bell's vireo (*Vireo pusillus bellii*), an endangered species, is dependent on high quality riparian habitat for nesting and foraging. This species has been reported nesting throughout most of the length of the Tijuana River Valley. Singing males have been reported in the Reserve; two in 1986 and one in 1987. In the most recent survey, three breeding pairs and four singing males were reported to occur in the Reserve (M. Kenney, personal communications). The presence of a singing male typically indicates a nest site. The westerly-most report of a singing male was in riparian habitat east of the Pacific Estuarine Research Laboratory in 1986 and 1989 (M. Kenney and P. Jorgenson, personal communication) and 1991 (M. Kenney, personal communications) [Figure 3-4]. Much of the riparian areas of the Reserve are considered to be suitable habitat for the least Bell's vireo (Chambers Group, Inc., 1991) [Figure 3-4].

Between the study site and the Mexican border there are approximately 214 additional acres of riparian wetlands. These wetlands are important to both migratory and resident passerines. Ponds associated with these areas provide habitats for waterfowl and shorebirds. The endangered peregrine falcon, the protected golden eagle and the sensitive black-shouldered kite also have been reported to use the riparian wetlands in the river valley.

**Coastal Sage Scrub.** Insects provide food for a number of insectivorous birds that also use this habitat. The California gnatcatcher (*Polioptila californica californica*), a federal proposed endangered species, and the cactus wren (*Campylorhynchus brunneicapillus*), a

federal candidate species, are found in Goat Canyon and on the hillsides of the mesas (E.Taylor and E. Copper, personal communication).

**Disturbed and Developed Areas.** These areas have little value as a habitat for marsh-dependent birds except during periods of flooding when these areas may provide refuge from the floods. However, these areas provide important foraging habitat for raptors. These areas may provide some foraging habitat for songbirds. There is probably little, if any, use of these areas for nesting except by killdeer, especially if the area is relatively devoid of vegetation.

When wet, the artificial ponds at PERL provide habitat for a number of shorebird and waterfowl species and nesting habitat for American avocets and black-necked stilts. The willows located throughout the facility also provide habitat for resident and migratory song birds and some nesting by these species may also occur.

**Fish**

The estuarine habitats are dominated by four or five species of fish that feed at low trophic levels: topsmelt (*Atherinops affinis*), arrow goby (*Clevelandia ios*), California killifish (*Fundulus parvipinnis*), longjaw mudsucker (*Gillichthys mirabilis*) and staghorn sculpin (*Leptocottus armatus*). Their position in the food chain makes the high productivity of wetlands available to higher-order consumers such as birds (e.g., herons, egrets, terns) and other fishes (e.g., California halibut).

Tidal creeks are important spawning and nursery grounds for topsmelt and Pacific staghorn sculpin. Comparing findings for tidal creek, main channel and nearshore areas demonstrates that tidal creeks provide a unique habitat for fish utilization (Nordby, 1982). Larval communities in tidal creeks were different from the main channel communities. One reason for this lack of similarity is the association of atherinids (e.g. topsmelt) with macroalgae mats which are absent in the nearshore environment. Main channels and nearshore larval communities were more similar to one another due to the high relative abundance of goby larvae in both habitats.

Recent surveys of the fish populations in the estuary have shown the following: (1) there has been a shift in species composition with arrow gobies becoming more dominant,

apparently due to their plasticity or early reproductive age; and (2) fish species richness was lowest near the sewage inflow (Tijuana River) (Nordby and Zedler, in 1991). Prior to inlet closure in 1984, the fishes of Tijuana Estuary were dominated by goby species (*Clevelandia ios, Ilypnus gilberti* and *Gillichthys mirabilis*), California killifish, topsmelt, striped mullet (*Mugil cephalus*) and Pacific staghorn sculpin. Commercial and recreational fishes important to the system included California halibut (*Paralichthys californicus*), surfperches, anchovies, plueronectids and seabass, although none of these was abundant. In all, 29 species of adult and juvenile fishes from 19 families were collected from the estuary prior to 1984.

The estuary month was closed April through December, 1984. During the eight months of closure, fish populations were subjected to a number of physiological stresses including increased salinity and temperature. Species diversity was drastically reduced and several dominant species became absent. Fishes collected during closure from seven sampling stations represented six species from three families. These collections were dominated by topsmelt (74 percent), followed by California killifish (22 percent) and longjaw mudsucker (4 percent). Two species, topsmelt and California killifish, were able to withstand the high salinities, although densities decreased and the median size of topsmelt decreased, indicating stunting due to stress. Flatfishes and staghorn sculpin were especially sensitive to estuary closure. California halibut, diamond turbot (*Hypsopsetta guttulata*) and staghorn sculpin, reported to be abundant in the estuary in 1976 and collected frequently in 1978 and 1979, became absent during the stressful closure conditions.

Between 1986 and 1988, three years after the reinstatement of tidal flushing, species diversity increased to 21 species representing 15 families, with arrow goby, topsmelt and California killifish the dominants. These three species represent 97 percent of the samples. California halibut, staghorn sculpin and diamond turbot were again present. Cheekspot goby, a pre-closure dominant, was rarely encountered, accounting for less than 1 percent of the gobiid species collected. Long jaw mudsuckers were not collected immediately following the opening but were encountered in low densities on two later sampling periods suggesting a lag response to increased salinity. Ichthyoplankton samples also contained far fewer larvae of this species than previously collected further suggesting salinity-induced stress.

**Benthic Invertebrates**

Invertebrate fauna of the estuary has undergone substantial change since the 1970s due to a series of catastrophic events that occurred in the mid 1980s. Details of these changes are discussed in Zedler and Nordby (1986) and summarized below. Observations presented in Zedler and Nordby (1986) about the current status of the invertebrate populations in the estuary is supplemented by the invertebrate study completed as part of the environmental studies for the Tijuana Estuary Tidal Restoration Program (Appendix K.2).

Hosmer (1977) studied the bivalve molluscs (pelecypods) in the estuary. He collected thirteen species and observed three additional species. For six of these species, he was able to correlate species distribution to sediment size. The most abundant species found was the purple clam (*Sanguinolaria nuttallii*). It was found in both the northern and southern arms throughout a wide range of sediment types from very coarse sand to fine sand. The littleneck clam (*Protothaca staminea*) was the second most abundant species and was found in both arms of the estuary in sediments ranging from very coarse sand to very fine sand with biomass tending to be greater in coarse sand. Bent-nose clams (*Macoma nasuta*) were present in small numbers in both the north and south arms in sediments ranging from coarse sand to very fine sand.

White sandclam (*M. secta*) and egg cockle (*Laevicardium substriatum*) were found in only the southern arm. The white sandclam was found only in medium to fine sand sediments. False mya (*Cryptomya californica*) was more common in the north arm than in the south and found in all sediment types, ranging from very coarse sand to very fine sand. Jackknife clams (*Tagelus californianus*) were found in the southern arm and in sediments characterized as medium sand to very fine sand; biomass increased as the sediment got finer. The distribution of the littleneck clam, however, was correlated to increasing tidal depths (Smith, 1974).

Homziak (1977) found the dominant crustacean in the estuary to be the ghost shrimp. The populations of two sympatric burrowing shrimp (crustaceans): *Callianassa gigas* , *C. californiensis* and a *Upogebia* sp. were studied by Homziak (1977). He found that the distribution of *C. californiensis* and the *Upogebia* sp. were related to sediment grain size, as with the bivalve molluscs.

All bivalves and several other species were apparently extirpated from the estuary in 1984 when the mouth was closed for eight months. Sampling during this period revealed only spionid worms and epibenthic gastropods (Nordby, 1987). Following reinstatement of tidal flushing in December 1984, bivalve species diversity increased rapidly to 19 species. Littleneck clams and California jackknife clams dominated, with false mya, bent-nose clams and egg cockle being the lesser dominants. The purple clam, which dominated samples before mouth closure, has not yet been recruited into the estuarine waters.

In 1986, most of the invertebrate populations were again severely impacted by sewage inflows. When high tides washed dune sand into the main channel of the estuary total mortality of bivalves and reduction of the densities of the other invertebrates was observed. A large section of Oneonta Slough was dredged in April 1987 to remove sediment and improve the tidal prism. Nordby and Zedler (1991) evaluated the benthic invertebrate communities in the north arm of the estuary from 1986 to 1989. Fifty-eight taxa of benthic invertebrates were collected during that period. The dominant bivalve species included jackknife clams, littleneck clams and bent-nose clams, while capitellids and spionids dominated the polychaete fraction. The decapod crustacean, a ghost shrimp (*Callianassa californiensis*), was also abundant.

Sampling of the benthos of the south arms was again conducted in the fall of 1988 for comparison with samples in the north arm (Appendix K.2). In the north arm, *Armandia brevis*, a deposit feeding polychaete found in sandy sediment, was the dominant polychaete at the station nearest the mouth. The north channel showed relatively low similarity between stations with respect to presence or absence of species. Polychaete dominance changed with each station; at the station furthest from the mouth, *Streblospio benedicti* dominated. This polychaete is typically found in muddy and/or enriched sediments (Pearson and Rosenberg, 1978).

The number of species and their densities were generally lower away from the mouth in the south channel. In the south channel there was less variability among stations. Capitellids, however, dominated at two of the three stations with polychaetes. These data tend to support the idea that the north channel is more variable and that the fauna respond to this spatial variability. The similarity between stations and species was relatively higher in the south channel, suggesting that this channel may be more homogeneous. The relatively high similarity between total number of species at the mouth of the north

and south channels also suggests that an ocean effect rather than a channel effect may be influencing the types of organisms found at the mouth.

Arthropod and other invertebrate species were also collected in the 1988 study of the benthic invertebrates of the estuary (Appendix K.2). Of note are differences in the bivalve populations in the channels. In the south channel, only eight bivalve species were present, most near the mouth. Individuals were generally greater than or equal to four mm in size. There were 13 bivalve species in the north arm. In comparing the benthic communities in the two channels, the north channel had more species, many of which could be considered opportunistic species. While these species may reflect the highly dynamic environment of the channel, they may also form the climax community.

The hydrologic differences between the two channels may also account for the observed differences in the numbers, and types of species. In the north channel, changes in sediment quality create a heterogeneous bottom over most of its length. In contrast, the southern channel has relatively poor tidal flushing and has a relatively homogeneous bottom for much of its length. Because of the poor tidal flushing, organic enrichment and anoxic conditions may be the dominating factor controlling community composition. Benthic communities in the south arm are less variable than in the north, for fewer species are able to tolerate these conditions.

**Insects and Other Arthropods**

Insects and other arthropods are important components of the ecosystem, including salt marshes, freshwater marshes and riparian forests. Arthropods provide valuable food for vertebrates, pollinate flowering plants, and serve as regulators of vegetation and animal populations, by balancing communities of beneficial and potentially detrimental species (Atkins, 1978; Daly et al., 1978). A number of the insects associated with coastal habitats are threatened with extinction because of the loss and disturbance of these habitats (Appendix K.3). For example, the globose dune beetle (*Coelus globosus*), the salt marsh wandering skipper butterfly (*Panoquino panoquinoides errans*), and Belkin's dune fly (*Brennania belkini*) have been proposed for listing as either threatened or endangered. Additionally, tiger beetles of the genus *Cicindela* also have been identified as being in danger of extinction due to increased human activities in the coastal areas of southern California (Nagano, 1982). The following discussion of the insects and other

arthropods in the Tijuana Estuary is summarized from Zedler and Nordby (1986) and Williams et al. (Appendix K.3).

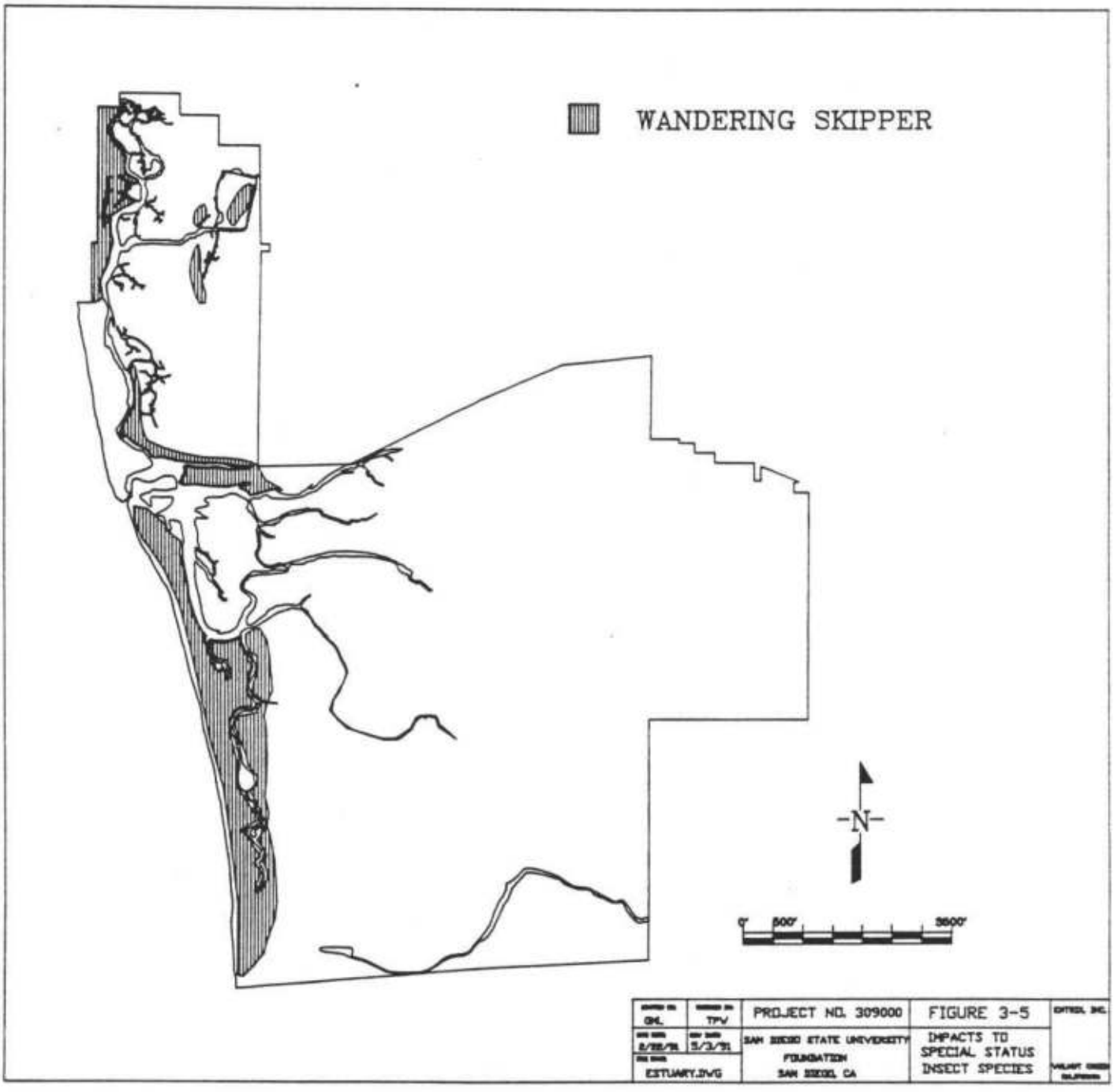
Insect populations of the *Spartina* community were surveyed as part of the studies for this project (Appendix K.3). Eleven orders of arthropods were collected from the *Spartina* wetlands. These include, in decreasing order of abundance, Diptera (flies), Hymenoptera (bees and wasps), Araneida (spiders), Homoptera (leafhoppers and planthoppers), Amphipods, Heteroptera (true bugs), Trichoptera (caddisflies), Dermaptera (earwigs), Orthoptera (grasshoppers and crickets) and Lepidoptera (butterflies and moths).

The pickleweed areas of the middle marsh provide habitat for 11 orders of arthropods. Diptera (flies) was the most common order, followed by Hymenoptera (bees and wasps), Araneida (spiders), Homoptera (leafhoppers and planthoppers) and Amphipods. Heteroptera (true bugs), Tricoptera (caddisflies), Dermaptera (earwigs), Orthoptera (grasshoppers and crickets), Coleoptera (beetles) and Lepidoptera (butterflies and moths) were uncommon. Diptera, Araneida, Homoptera, Heteroptera, Orthoptera and Lepidoptera are important food sources of many bird species and may serve as the prey based of the insectivorous Belding's Savannah sparrow.

The primary larval food plant of the salt marsh wandering skipper butterfly (*Panoquina panoquinoides errans*) (candidate species) is saltgrass (Emmel and Emmel, 1973; Howe, 1975), and in the insect study, larvae were found feeding on saltgrass only. Larvae and adults were found in all habitat types where saltgrass occurs. Larvae were found in such low densities that relative abundances could not be compared among habitat types. Adults were patchily distributed within all habitats (Figure 3-5), and approximately twice as many were found in northern north arm and south arm regions as were found in southern portion of the north arm.

The presence of a healthy insect community is important to many species in the salt marsh, perhaps most notably as pollination vectors for salt marsh bird's beak (*Cordylanthus maritimus* ssp. *maritimus*), an endangered species. This annual plant is pollinated by bees and flies. Pollination is required for successful seed set, with at least five potential bee and fly pollinators (Lincoln, 1984). For these insect species, salt flats and higher ground with mammal burrows were likely nesting sites.

Figure 3-5 Location of Salt Marsh Wandering Skipper Butterfly.



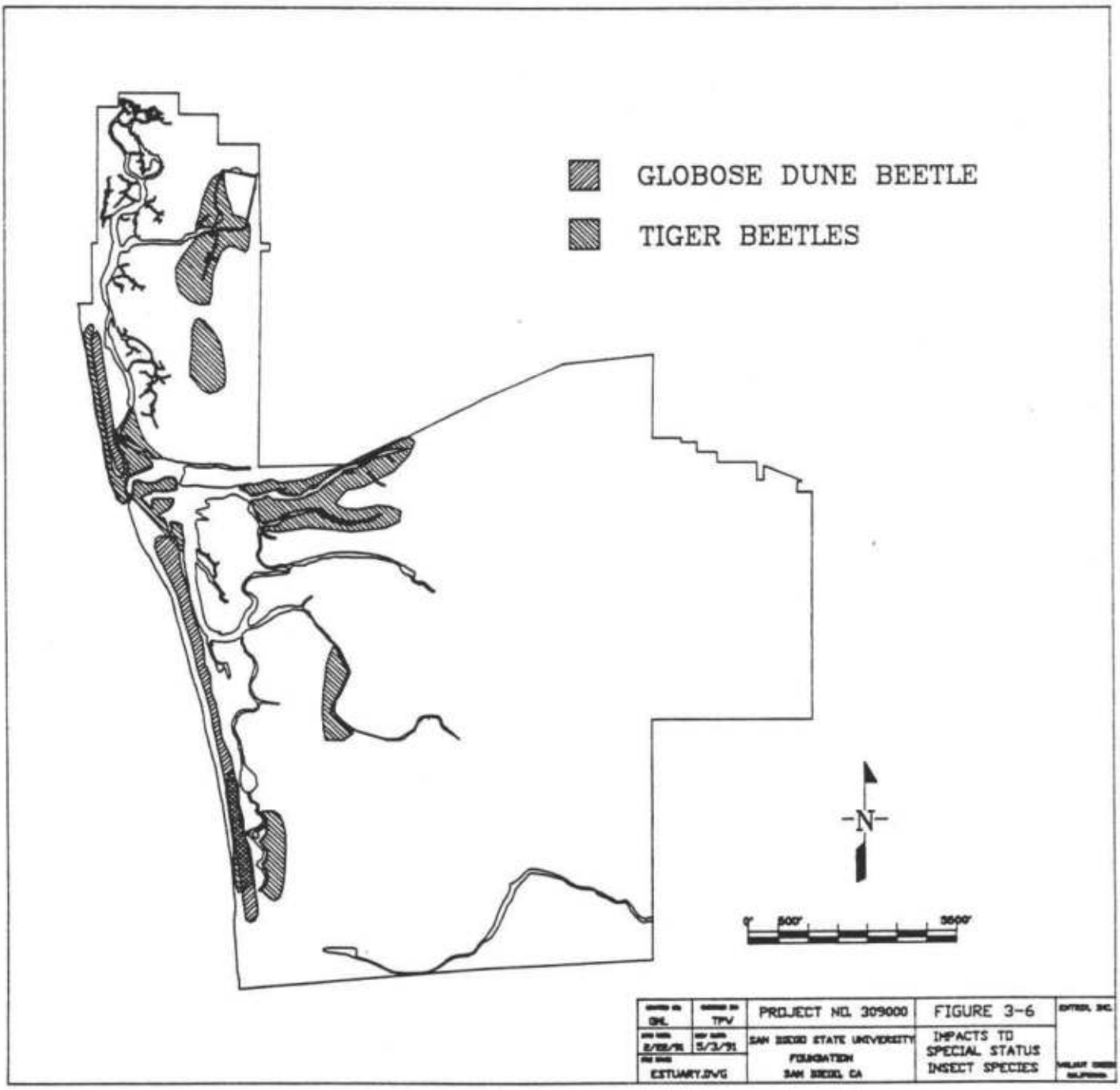
Salt panne areas provide habitat for a number of regionally rare insects. The sand dune tiger beetles (*Cicindela latesignata latesignata*) and Gabb's tiger beetles (*Cicindela gabbi*) have been reported recently from the salt pannes in the southern portion of the estuary (Figure 3-6). Several species of rove beetles (*Bledius* spp.) are also found in the salt panne areas as well as just above the high tide line. These beetles appear to prefer soils dampened by tidal inundation, but not soils covered by standing water.

The upland plants found in the transition areas may be an important nectar source for wetland and upland insects. Fourteen orders of arthropods were found in the transition zone. Like the mixture of plants, the orders present show similarities with the adjacent uplands and wetlands.

The native vegetation associated with coastal dune habitat provides habitat for a number of insects. During an 1988-1989 survey of the area, 12 orders of arthropods were collected in the dunes. As in other habitat areas, Araneida, Coleoptera, Collembola, Diptera, Homoptera, Hymenoptera and Lepidoptera were the more common orders. Heteroptera, Orthoptera and Tricoptera were uncommon. The greater habitat values were typically associated with the native stands of vegetation. The salt marsh wandering skipper butterfly (*Panoquina panoquinoides errans*), a candidate for listing as endangered, was collected in the backdunes and observed feeding on nectar from coastal dune plants. The globose dune beetle (*Coelus globosus*), a sensitive species, is typically found under dune ragweed. While not collected during this study, other sensitive dune species have been reported from the dunes in the Tijuana Estuary and in the sparsely vegetated areas along the lower reaches of Oneonta Slough (Figure 3-6). These include the sand dune tiger beetle (*Cincindela latesignata latesignata*), sandy beach tiger beetle (*Cincindela hirticollis gravida*), and the mudflat tiger beetle (*Cicindela trifasciata sigmoidia*) (Nagano, 1982).

The coastal sage scrub habitat associated uplands appear to have the greatest richness of insects in terms of orders found. Eleven orders were present in the fall, seven orders in the winter and eighteen orders in the spring. The most common orders included Hymenoptera (especially the Formicidae - ants), Diptera, Homoptera, Collembola and Araneida. Uncommon orders included Acarina (mites and ticks), Dermaptera, Heteroptera, Isopods (pillbugs), Odonata (dragon and damselflies), Psocoptera (psocids or book lice), Thysanura (silverfish) and Tricoptera.

Figure 3-6. Location of Sensitive Species of Beetles.



**Reptiles and Amphibians**

Espinoza (Appendix K.4) presented the results of a recent study of the reptiles and amphibians found in the Reserve. He found the diversity and density of the herpetofauna in the estuary to be low and attributed this to geographical, hydrological and human disturbance factors. He found 13 species of an expected 25 to 30 species (based on the habitats present) in the estuary. The 13 species included four species of frogs, six species of lizards, and three species of snakes. One of the species of lizards (the San Diego coast horned lizard - *Phrynosoma coronatum blainvillei*) is considered sensitive due to the loss and disturbance of its habitat. This species appears to be dependent on the abundance of wood or harvest ants upon which it feeds and is found in habitats characterized by soft sand or dirt.

Riparian areas with ponded water and freshwater marsh or ponds were found to provide habitat for the California toad (*Bufo boreas halophilus*), the Pacific tree frog (*Hyla regilla*), and two introduced species - the African clawed frog (*Xenopus laevis*) and bullfrog (*Rana catesbeiana*). The dune system provides suitable habitat for the aforementioned San Diego coastal horned lizard and the silvery legless lizard (*Anniella pulchra pulchra*). The ubiquitous side-blotched lizard (*Uta stansburiana*) also inhabits the dune habitat.

The coastal sage scrub and transitional habitat provided habitat for the Great Basin fence lizard (*Sceloporus occidentalis biseriatus*), and San Diego Alligator Lizard (*Gerrhonotus multicarinatus webbi*), the California kingsnake (*Lampropeltis getulus californiae*) and San Diego gopher snake (*Pituophis melanoleucus annectens*).

**Mammals**

The mammals of the Reserve were recently studied by Taylor and Tiszler (Appendix K.5). They found a total of 16 species from four orders and eight families. Of the 16 species, ten were found in the marsh. The opossum (*Didelphis virginianis*) was found as a road kill on Dairy Mart Road and another carcass was observed near PERL. Two species of rabbits/hares were commonly observed throughout the marsh. The desert cottontail (*Sylvilagus audubonii*) was most common in the area of PERL, while the jackrabbit (*Lepus californicus*) was common throughout the estuary.

Nine species of rodents were observed during the Taylor and Tiszler study (Appendix K.5). The California ground squirrel (*Spermophilus beecheyi*) was found throughout the southern end of the estuary in the transitional and upland areas. Salt panne areas were found to support three species of rodents - the house mouse (*Mus musculus*), the western harvest mouse (*Reithrodontomys megalotis*) and the deer mouse (*Peromyscus maniculatus*). These were the only species of rodents found on the marsh surface. Other species of rodents were found in the transitional and upland areas and included the agile kangaroo rat (*Dipodomys agilis*), the San Diego pocket mouse (*Perognathus fallax*), the cactus mouse (*Peromyscus eremicus*), the brush mouse (*Peromyscus boylii*), the dusky-footed woodrat (*Neotoma fuscipes*), and California vole (*Microtus californicus*).

Mound-like topography is found at several locations bordering the north arm of the estuary. The mounds are concentrated in the marsh-upland transition zones. The vegetation of the mounds is conspicuously different from intermound areas. Mound tops show extensive tunneling and digging by mammals. The mounds modify salinity and moisture relationships and create islands of habitat suitable for upland plants and animals, making the delineation of the wetland/upland boundary difficult. Thirty-four species of vascular plants were recorded on the mounds; 11 were low marsh species and 23 were high marsh or upland species whose lower limits occurred within the elevational range sampled. Burrows of the Valley pocket gopher (*Thomomys bottae*), the California ground squirrel (*Spermophilus beecheyi*) and the striped skunk (*Mephitis mephitis*) have been found in association with the mounds (Cox and Zedler, 1986). It is also thought that historically these disturbances may have been essential for seedling establishment of salt marsh bird's beak by creating openings within the dense upper marsh canopy (J. Zedler, personal communication).

### 3.5.1.3 Special Status Species

Pursuant to the requirements set out in the Endangered Species Act of 1973, as amended (ESA), the following text reviews the potential impact that the Tijuana Estuary Tidal Enhancement Project may have on federally-listed and proposed endangered and threatened species found in the subject area of San Diego County, California. The species identified as federally listed or proposed are discussed under the direction of the U.S. Fish and Wildlife Service following a request for listed species in the area (Reply # 1-6-88-SP-247). In addition, pursuant to Sections 1901, 2062 and 2067 of the California

Fish & Game Code, this section addresses potential impacts to State listed or proposed endangered and threatened species, as indicated. These species were identified from recent lists and discussions with personnel with the California Department of Fish & Game. Listed and proposed endangered or threatened species and candidate species of plants that may occur in the Reserve are presented in Table 3-3. Listed and proposed endangered or threatened species of wildlife and candidate species that may occur in the Reserve are presented in Table 3-4.

**PLANTS**

**Coastal Dunes Milk-vetch (*Astragalus tener* var. *titi*)**

Status: Federal Candidate species, category 2, State Endangered.

Habitat: Sandy areas near the coast, coastal strand areas.

Presence: Not present.

Description: The coastal dunes milk-vetch has been found historically from Monterey Bay and San Diego County. In recent years, the dune habitat supporting the two remaining populations of the dunes milk-vetch along the Silver Strand Beach in San Diego County was eliminated by a residential development. This species is believed extinct in San Diego County.

**Salt Marsh Bird's Beak (*Cordylanthus maritimus maritimus*)**

Status: Federally Endangered, State Endangered.

Habitat: Higher reaches of coastal salt marshes.

Presence: Present.

Description: Salt marsh bird's beak is a diffusely branched annual that is evident only for a short time during the spring and summer growing season. This species is hemiparasitic and is believed able to obtain

**Table 3-3. Listed and Proposed Endangered or Threatened Species of Plants and Candidate Species that may Occur in the Reserve.**

| SPECIES | STATUS |
|---|---|
| *Cordylanthus maritimus* ssp. *maritimus* (Salt marsh birds beak) | FE, SE |
| *Astragalus tener* var. *titi* (Coastal dunes milk-vitch) | C2, SE |
| *Ferocactus viridescens* (San Diego barrel cactus) | C2 |
| *Dudleya variegata* (Variegated dudleya) | C2 |
| *Opuntia parryi* var. *serpentina* Snake cholla | C2 |

KEY TO STATUS:

FE = Federally-Endangered species

SE = State-Endangered species

C2 = category 2 candidate species for listing. These are species for which existing information indicates they may warrant listing, but for which substantial biological information to support a proposed rule is lacking

**Table 3-4 Listed and Proposed Endangered or Threatened Species of Wildlife and Candidate Species that may Occur in the Reserve.**

| SPECIES | STATUS |
|---|---|
| *Pelecanus occidentalis californicus* (California brown pelican) | FE, SE |
| *Rallus longirosteris levipes* (light-footed clapper rail) | FE, SE |
| *Sterna antillarum browni* (California least tern) | FE, SE |
| *Falco peregrinus anatum* (American peregrine falcon) | FE, SE |
| *Vireo bellii pusillus* (least Bell's vireo) | FE, SE |
| *Perognathus longimembris pacificus* (Pacific pocket mouse) | C2 |
| *Egretta rufescens* (reddish egret) | C2 |
| *Charadris alexandrinus nivosus* (western snowy plover) | C2 |
| *Numenius americanus* (long-billed curlew) | C2 |
| *Passerculus sandwichensis beldingi* (Belding's Savannah sparrow) | C2, SE |
| *Passerculus sandwichensis rostratus* (large-billed Savannah sparrow) | C2 |
| *Charadrius montanus* (mountain plover) | C2 |
| *Polioptila californica californica* (California gnatcatcher) | FPE |
| *Campylorhynchus brunneicapillus couesi* (cactus wren) | C2 |
| *Agelauis tricolor* (tri-colored blackbird) | C2 |
| *Coccyzus americanus occidentalis* (yellow-billed cuckoo) | C2, SE |
| *Eucyclogobius newberryi* (tidewater goby) | C2 |
| *Cnemidophorus hyperthrus* (orange-throated whiptail) | C2 |
| *Phrynosoma coronatum blainvillei* (San Diego horned lizard) | C2 |
| *Rana aurora draytoni* (California red-legged frog) | C2 |
| *Tryonia imitator* (California brackish water snail) | C2 |
| *Panoquina panoquinoides errans* (salt marsh wandering skipper butterfly) | C2 |
| *Coelus globosus* (globose dune beetle) | C2 |

KEY TO STATUS:

FE = Federally-Endangered species

SE = State Endangered species

C2 = category 2 candidate species for listing. These are species for which existing information indicates they may warrant listing, but for which substantial biological information to support a proposed rule is lacking

FPE = Federally-Proposed Endangered species

water and nutrients from the roots of other plants. Bird's beak is found at several scattered locations throughout Tijuana Estuary, most of which are in the north arm (Figure 3-2). Subpopulations of bird's beak subpopulations are patchy, sometimes spreading, and sometimes disappearing for a year or more (Zedler and Nordby, 1986). Seedling establishment appears enhanced by minor disturbances, and small mammals may be an important of the plant's ecology.

Salt marsh bird's beak was historically widespread in coastal marshes from Morro Bay, San Luis Obispo County to San Diego County and Northern Baja California. It is presently restricted to scattered sites in fewer than ten remnant salt marshes. In San Diego County, it is currently found only at Tijuana Estuary. It is being transplanted at Sweetwater Marsh (B. Fink, PERL, personal communication). Its decline is due to modification of upper marsh habitats by filling, dredging, creation of roads and off-road vehicle activity. The natural populations at Tijuana Estuary are not likely to be negatively impacted by the project, and additional habitat will be created for this species.

**Variegated Dudleya** (***Dudleya variegata***)

Status: Federal Candidate species, category 2.

Habitat: Dry stony places below 500 feet mean sea level, coastal sage scrub, chaparral.

Presence: Present near project site.

Description: Variegated dudleya is present in the coastal scrub areas west of the U.S. Navy Outlying Landing field at Tijuana Estuary. Because it is above tidal influence and located away from the activity areas of the project, the variegated dudleya is not expected to be influenced by the project.

**San Diego Barrel Cactus (*Ferocactus viridescens*)**

Status: Federal Candidate species, category 2.

Habitat: Dry hills, coastal sage scrub, valley grasslands.

Presence: Present near project site.

Description: The San Diego barrel cactus is found along the bluffs to the south and southeast of the Tijuana Estuary and near Spooner's Mesa. The river training berm is proposed to extend from the base of one of these bluffs. Whether the San Diego barrel cactus would be found at the proposed extension site when the berm is built out to meet the bluff is unknown; however, the habitat type is potentially suitable for its occurrence.

**Snake Cholla (*Opuntia parryi var. serpentina*)**

Status: Federal Candidate species, category 2.

Habitat: Sandy areas and dry slopes, coastal sage scrub, chaparral, canyons in San Diego County.

Presence: Unlikely.

Description: Nearest known location is at Otay Mesa, which is east of the project area, outside the Tijuana River Valley.

**INVERTEBRATES**

**Salt Marsh Wandering Skipper Butterfly (*Panoquina panoquinoides errans*)**

Status: Federal Candidate species, category 2.

Habitat: Salt marshes near freshwater seeps, any habitat with *Distichlis spicata* including landward fringe of coastal dunes, wetland

transition areas, middle marsh, brackish marsh and adjacent to freshwater seeps.

Presence: Present.

Description: The salt marsh wandering skipper butterfly is found at scattered locations throughout the western end of the estuary (Figure 3-5). Primary larval foodplant is *Distichlis spicata* but larvae were found occasionally on *Spartina foliosa*, *Monanthochloe littoralis* and *Cynodon dactylon*. Larvae and adults were found in all habitat types where *D. spicata* occurs. In April and May 1989, adults were patchily distributed within all habitats, and approximately twice as many were found in the northern point of the north arm and south arm regions as were found in southern north arm regions (Appendix K.3). Three adult skippers were collected from the back dune habitat pan traps (south arm region) in spring. In March and April, adults were found clustered around patches of *D. spicata*, where occasional oviposition was documented. Adults use flowers of dune and transition zone habitats as nectar hosts including: *Lotus scoparius*, *Heliotropium*, *Carpobrotus* sp., *Jaumea carnosa*, *Cakile* sp., and *Chrysanthemum* sp. In salt marsh areas, adults were found mostly on *Frankenia grandifolia* and *Jaumea carnosa*.

In his August 1982 survey, Nagano (1982) found wandering skippers in fewer areas than in 1979. In spring 1989, the butterflies were found in low numbers, but in many of the same areas in where they were seen in both of the earlier surveys.

**Globose Dune Beetle (*Coelus globosus*)**

Status: Federal Candidate species, category 2.

Habitat: Coastal fore dunes and sand hummocks, burrowing beneath the surface of the sand, and most common under native dune vegetation.

Presence: Present.

Description: The globose dune beetle is believed to feed on the roots of native dune plants (Nagano, 1982). Larvae and adults are found under *Ambrosia chammissonis, Abronia umbellata, Cakile maritima* and rarely under or near *Carprobrotus edulis* along the fore dunes and sand hummocks south of the mouth of the Tijuana River (Figure 3-6). The suitability of *Cakile* and *Carprobrotus* as hosts is questionable, and Williams recommends their removal (Appendix K.3). Nagano found very low numbers of globose beetles along the south barrier beaches in August 1982 (Nagano, 1982), and in 1989 Williams et al. found them limited to distributions of suitable host plants, which were rare (Appendix K.3).

**California Brackish Water Snail (*Tryonia imitator*)**

Status: Federal Candidate species, category 2.

Habitat: Small brackish-water habitats, primarily in central California.

Presence: Not present.

Description: This small hydrobiid snail has not been documented in the Tijuana River Valley and is not believed to be present.

**AMPHIBIANS**

**California Red-legged Frog (*Rana aurora draytoni*)**

Status: Federal Candidate species, category 2.

Habitat: Low-lying riparian areas with cattails and other pond vegetation to provide cover.

Presence: Possibly present, but undetected.

Description: The red-legged frog is currently rare, especially at low elevation this near the coast. It has not been reported within the Tijuana Estuary. If this species is present, it would not be expected to be impacted because its habitat is isolated and upstream from the project.

**REPTILES**

**Orange-throated Whiptail (*Cnemidophorus hyperythrus*)**

Status: Federal Candidate species, category 2.

Habitat: Sandy washes, coastal sage scrub, chaparral.

Presence: Unlikely.

Description: Approximately 90 percent of the orange-throated whiptail's diet consists of a single termite species that lives in decaying, fallen trees. Consequently, the lack of older and dying trees has probably caused the numbers of termites seen in the region to remain relatively low. This lizard probably is no longer present in this system due to lack of its preferred food source, but other factors may have also been involved. Goat Canyon is the one area that this species may be found; however it was not detected during recent surveys (Appendix K.4).

**San Diego Horned Lizard (*Phrynosoma coronatum blainvillei*)**

Status: Federal Candidate species, category 2.

Habitat: Brushland, sandy washes, vegetated dunes. Habitat always includes soft sand or dirt in which they burrow to escape predation.

Presence: Present in isolated areas.

Description: Espinoza found specimens on the dunes south of the horse trail leading from the kiosk in 1989 (Appendix K.4). Feces of *Phyrnosoma* were also found on northern side of the same road. S. Lockhart (personal communication) reported a sighting in the wind row of drift wood near the dirt road west of southwestern end of the Naval Helicopter Base. These lizards were once abundant on this road (M. McGill, personal communication).

Presence is crucially dependent on the abundance of wood or harvest ants on which this species feeds almost exclusively. They rely on camouflage for protection and rarely run when encountered. Baharav (1975) found movement of a related species (*P. solare*) averaged only 20m annually. Another factor which is important to consider is that horned lizards burrow just below the sand surface during periods of inactivity. Consequently, they are vulnerable to foot and hoof traffic in the dunes.

**FISHES**

**Tidewater Goby (*Eucyclogobius newberryi*)**

Status: Federal Candidate species, category 2.

Habitat: Brackish coastal lagoons to one km inland in slow moving waters and in nontidal lagoons.

Presence: Not Present.

Description: This goby has not been reported in the Tijuana River Valley and it is unlikely that it is present. Its reported southern range limit is Agua Hedionda creek, San Diego County. Tidewater gobies are sensitive to streambed alterations, and historic natural and man-caused alterations have decreased the likelihood that they will found here in the future.

## BIRDS

### Light-footed Clapper Rail (*Rallus longirostris levipes*)

Status: Federally Endangered, State Endangered.

Habitat: Lower salt marsh, particularly cordgrass. Forages along intertidal channels. Requires middle-to-upper marsh for high-tide refuge.

Presence: Present.

Description: The light-footed clapper rail is a permanent resident of the estuary, nesting and foraging in the low marsh (Figure 3-3). Most of the local population is found in the north arm where a majority of the cordgrass habitat is; however, occasional individuals have been found in the mouth and southern areas. This species has been increasing at Tijuana Estuary after dramatic decrease in numbers after the 1984 mouth closure. A spring 1990 vocalization count estimated 16 to 17 pairs present, mostly in the north arm, and a highwater visual identification count on December 3, 1990 found 82 rails in the refuge (P. Jorgensen, personal communication). The 1991 Spring census located 108 individuals, including 47 pairs. The project will create new low marsh habitat for the clapper rail in areas that are not currently tidally influenced. The project is intended to be beneficial to the clapper rail, although the few individuals found occasionally in the south arm will likely be temporarily displaced during construction.

### California Brown Pelican (*Pelecanus occidentalis californicus*)

Status: Federally Endangered, State Endangered.

Habitat: Ocean coastline, large channels, intertidal flats.

Presence: Present.

Description: This species is common throughout the year foraging along the ocean adjacent to the estuary, and occasionally along the larger channels near the mouth. Pelicans also roost along the sand banks near the mouth at low tide. The project will not impact any existing pelican habitat but may disturb roosting pelicans during construction; however, the newly created channels may have an indirect beneficial affect on this species by increasing forage-species habitat.

**California Least Tern (*Sterna antillarum browni*)**

Status: Federally Endangered, State Endangered.

Habitat: Barrier dunes, channels, tidal lagoons and nearshore waters.

Presence: Present.

Description: Least terns nest along the barrier dunes (Figure 3-3) and use the nearshore waters, tidal ponds and larger channels for foraging. Their nesting habitat is extremely sensitive to foot and horse traffic, and needs substantial protection from human activity. The project will not directly impact the existing least tern habitat. The dune revegetation and stabilization efforts will be coordinated in order not to interfere with nesting seasons, and the restricted access required for the revegetation project will help protect nesting habitat. In addition, the increase in tidal channels in the south arm will provide additional foraging habitat for the terns.

**Least Bell's Vireo (*Vireo bellii pusillus*)**

Status: Federal Endangered, State Endangered.

Habitat: Riparian woodland vegetation.

Presence: Possibly present , but not recorded.

Description: Least Bell's vireo is dependent on high quality riparian habitat for nesting. This species has been reported nesting throughout most of the length of the river valley. Singing males have been reported in the Reserve; two in 1986 and one in 1987. In the most recent survey, three breeding pairs and four singing males were reported to occur in the Reserve (M. Kenney, personal communications). The presence of a singing male typically indicates a nest site. The westerly most report of a singing male was in riparian habitat east of the Pacific Estuarine Research Laboratory in 1986 and 1989 (M. Kenney and P. Jorgensen, personal communication) [Figure 3-4]. The project will not directly displace any of the current habitat for least Bell's vireo. However, the indirect effect of the project on the salinity regime within the western end of the river valley and the limit of saltwater intrusion is unknown. Additional studies are needed to determine the effect of the project on the upstream riparian habitats.

**American Peregrine Falcon (*Falco peregrinus anatum*)**

Status: Federally Endangered, State Endangered.

Habitat: Open upland/transition, riparian areas.

Presence: Rarely present.

Description: The peregrine falcon has been infrequently observed in the estuary in open areas, and occasionally using the riparian wetlands in the river valley. A hacking (fledgling) program is currently underway on the Point Loma peninsula, approximately 12 miles north of the project site. The project is not expected to impact this rare visitor to the estuary.

**Belding's Savannah Sparrow (*Passerculus sandwichensis beldingi)***

Status: Federal Candidate species, category 2, State Endangered

Habitat: Nests in the middle salt marsh, and peripheral areas for foraging.

Presence: Present.

Description: The Belding's Savannah sparrow is another permanent resident of the salt marsh at Tijuana Estuary, nesting in the *Salicornia*-dominated middle marsh and foraging throughout the marsh (Figure 3-4). A recent spring survey (1989) counted 299 singing males with a possible high estimated to be 320 singing males (Appendix K.1). A prime area was found along the southern arm near the international border where 89 males were counted. This area is vegetated with a dense mixture of *Salicornia subterminalis*, *Frankenia grandifolia* and *Monanthochloe littoralis*, with only a minor portion of *Salicornia virginica*. The project was moved inland to avoid impacts to this prime area. The project will result in a large net increase of intertidal salt marsh habitat for the Belding's Savannah sparrow by introducing tidal flushing to areas currently beyond tidal influence. There will be some loss of habitat but the lost habitat will be replaced as part of the project.

**Western Snowy Plover (*Charadrius alexandrinus nivosus*)**

Status: Federal Candidate species, category 2.

Habitat: Barren sandy beaches, dunes and flats.

Presence: Present.

Description: Snowy plovers have been censused simultaneously with the California least terns, with which they share nesting habitat on the dunes. They occasionally forage near the tidal ponds in the north arm (M. Weitzel, personal communication). The impact area of the project will affect the dune system by implementing a revegetation and stabilization program which will be implemented only during the non-breeding season (October-March). As the

southern channel system is expanded, forage area for the plover should increase.

**Mountain Plover** (*Charadrius montanus*)

Status: Federal Candidate species, category 2.

Habitat: Plowed bare fields.

Presence: Not present.

Description: This species is a winter resident to San Diego County. Mountain plovers are usually found in fields of plowed bare dirt (Unitt, 1984). Although mountain plovers have not been recorded in the Tijuana Estuary, the Tijuana River Valley is the only area in San Diego County where they are regularly observed. While this species could potentially occur within the project boundaries, no impacts are expected. The project will not adversely affect the preferred habitat of this species.

**Reddish Egret** (*Egretta rufescens*)

Status: Federal Candidate species, category 2.

Habitat: Shorelines of sloughs and river channels.

Presence: Rare.

Description: Reddish egrets forage along the refuge slough channels, small pools, tidal lagoons and gravel ponds. When they appear at Tijuana Estuary, they are usually solitary. The project is expected to increase foraging habitat for this species by creating new intertidal habitat.

**Long-billed Curlew (*Numenius americanus*)**

Status: Federal Candidate species, category 2.

Habitat: Salt marsh and intertidal channels.

Presence: Present.

Description: Long-billed curlews are one of the more common and conspicuous birds at Tijuana Estuary, foraging throughout the tidally-influenced areas of the refuge. The project will create substantial new forage habitat for this species by reintroducing expansive tidal flushing to the south arm of the estuary.

**Large-billed Savannah Sparrow (*Passerculus sandwichensis rostratus*)**

Status: Federal Candidate species, category 2.

Habitat: Salt cedar scrub near mouths of rivers.

Presence: Present.

Description: This species has been observed along Seacrest Drive during the winters of 1989-90 and 1990-91 (R. Ryno, personal communication). This sparrow winters primarily in Mexico, but the wintering area in the United States has been most in the Salton Sea for the last 50 years. In recent years it has been observed at the Tijuana Estuary, south San Diego Bay, and Sweetwater Marsh National Wildlife Refuge.

**California Gnatcatcher (*Polioptila californica californica*)**

Status: Federal Proposed Endangered species.

Habitat: Coastal sage scrub.

Presence: Present nearby.

Description: The California gnatcatcher is found in Smuggler's Gulch and Goat Canyon and on the hillsides of Spooner's Mesa just south of the estuary (E. Taylor, and E. Copper, personal communication). The proposed river training structure will extend from the base Spooner's Mesa. Whether the California gnatcatcher would be found at the proposed extension site when the river training structure is built out to meet the bluff is unknown; however, the habitat type is potentially suitable for its occurrence and it will be assumed that the bird is present for purposes of assessing impacts and developing mitigation.

**Cactus Wren** (***Campylorhynchus brunneicapillus causei***)

Status: Federal Candidate species, category 2.

Habitat: Coastal sage scrub with cactus species interspersed.

Presence: Believed to be present.

Description: The cactus wren is found throughout the year in coastal sage scrub habitat, generally within 30 km of the coast. This species appears to prefer areas dominated by California sagebrush (*Artemisia californica*) and flat-top buckwheat (*Erigonum faciculatum*) that also contains *Opuntia* cactus (Rea and Weaver, 1990). The cactus wren's diet includes insects supplemented with the fruit of two species of *Opuntia* in the fall and winter. The cactus wren nests in three species of *Opuntia* (*D. prolifera, O. littoralis, O. oricola*). Appropriate habitat occurs in the Reserve along the slopes of Spooner's Mesa.

**Tricolored Blackbird** (***Agelaius tricolor***)

Status: Federal Candidate species, category 2.

Habitat: Freshwater marshes dominated by cattails, sedges, and willows.

Presence: Not Present.

Description: Tricolored blackbirds are a resident species in San Diego County (Unitt, 1984). Dense, localized colonies can be found in cattail marshes. Foraging areas are concentrated in agricultural areas, lakeshores and damp lawns. The nearest known breeding colony to the project site is at the Tijuana River bed adjacent to Dairy Mart Road. Additionally, large concentrations in the non-breeding season have been recorded in the Tijuana River Valley. The project will not affect any breeding or foraging habitat of the tricolored blackbird; thus, no impacts to this species are expected.

**Yellow-billed Cuckoo** (***Coccyzus americanus occidentalis***)

Status: Federal Candidate species, category 2; State Endangered.

Habitat: Riparian forests with willow-cottonwood thickets.

Presence: Not present.

Description: Yellow-billed cuckoos were once a rare summer resident, but they are now extirpated from San Diego County (Unitt, 1984). Since 1950 there have been two sightings of cuckoos near Batiquitos Lagoon and San Luis Rey. The habitat requirements for nesting and foraging of yellow-billed cuckoos include riparian vegetation, especially willow-cottonwood thickets ranging from 100 to 300 meters in length and a minimum area of ten hectares. These cuckoos feed primarily on caterpillars and insects inhabiting riparian woodlands. Since the riparian habitat within the Reserve does not contain the habitat conditions necessary to support populations, no impacts to this species are anticipated. Moreover, there have no recent records of this species in the region.

## MAMMALS

**Pacific Pocket Mouse** (*Perognathus longimembris pacificus*)

Status: Federal Candidate species, category 2.

Habitat: Salt marsh and transitional scrub.

Presence: Believed not present.

Description: The project area was censused for this species in 1988 by the Fish and Wildlife Service and in 1989 by PERL staff from San Diego State University and both surveys failed to detect any specimens. It is not believed that this species is currently present within the estuary; however, the target habitat to be expanded and created by the project could make this a candidate area for reintroduction.

In addition to the special status species listed above, the estuary provides habitat for a number of species of special concern including the following.

**Sandy Beach Tiger Beetle** (*Cicindela hirticolis gravida*)

Status: Species of Special Concern.

Habitat: Sand dune and beach areas away from wave action.

Presence: Present.

Description: The sandy beach tiger beetle was found along the beach at the Tijuana River mouth, on slightly moist sand around the mouth and tidal inlets, and on the back dunes near Border Field State Park (Figure 3-6). This beetle lays its eggs in the sand, and the larvae construct vertical burrows approximately the same diameter as the head, from which they trap food. These beetles are found in only two or three other localities in southern California and the population at Tijuana Estuary is the largest known in the U.S. tiger

beetles of the genus *Cicindela* have been identified as being in danger of extinction from human activities in Southern California coastal areas (Nagano, 1982).

**Sand Dune Tiger Beetle (*Cicindela latesignata latesignata*)**

Status: Species of Special Concern.

Habitat: Sand dune and beach areas away from wave action.

Presence: Present.

Description: The sandy beach tiger beetle was found on mudflats and sandy areas around the Tijuana River mouth and eastward along the tidal channels, on the back dunes near the mouth, on the beach at Border Field State Park, and on the salt flats near the helicopter field (Figure 3-6). Like *Cicindela hirticolis gravida*, this beetle is found in only two or three other localities in southern California. The population at Tijuana Estuary is believed the largest U.S. population. Tiger beetles of the genus *Cicindela* have been identified as being in danger of extinction from human activities in southern California coastal areas (Nagano, 1982).

**Mudflat Tiger Beetle (*Cicindela trifasciata sigmoidia*)**

Status: Species of Special Concern.

Habitat: Mudflats and moist sand near estuarine channels.

Presence: Present.

Description: In 1982, mudflat tiger beetles were found on mudflats and moist-to-wet sand around the mouth and north barrier beach, near tidal ponds off of the north tidal channel, and near a tidal channel just west of Monument Road (Figure 3-6). In 1984-86, they were found at estuarine channel margins in Border Field State Park and

near the river mouth on wet, dark colored sand near water. Tiger beetles of the genus *Cicindela* have been identified as being in danger of extinction from human activities in southern California coastal areas (Nagano, 1982). The current range includes nine known locations ranging from San Luis Obispo to San Diego County.

**Gabb's Tiger Beetle (*Cicindela gabbi*)**

Status: Species of Special Concern.

Habitat: Salt pannes and dark colored mud in the intertidal zone.

Presence: Present as recently as 1986.

Description: Gabb's tiger beetles were not found by Nagano in 1982, but were seen in 1979 on salt flats east of the south tidal channel in Border Field State Park (Nagano, 1982). In 1984-86, D McIntyre (personal communication) found some Gabb's on salt pannes in all parts of the estuary (Figure 3-6), although they were seen most often in north arm area. Tiger beetles of the genus *Cicindela* have been identified as being in danger of extinction from human activities in southern California coastal areas (Nagano, 1982). Only three other locations are known: Seal Beach in Orange County, and Chula Vista and Silver Strand in San Diego County.

**Silvery Legless Lizard (*Anniella pulchra pulchra* )**

Status: Species of Special Concern.

Habitat: Vegetated dunes and sand hummocks.

Presence: Present.

Description: Recorded only on the dunes in the same habitat as *Phrynosoma*. This species seems to prefer lower lying areas off the high dredge

spoil dunes at Tijuana Estuary. This species is difficult to detect due to secretive, arenicolous (sand dwelling) lifestyle, but presence can be noted by surface tracks. It seems to associate with natural surface debris and low-lying dune vegetation which provides some moisture and shade from direct sun. *Anniella* depends upon the root systems of the low-lying vegetation of the dunes to conserve a moisture level which can sustain their invertebrate prey (C. Miller, 1944). This species shares the same vulnerability to trampling as the horned lizard due to its lack of speed and sub-surface lifestyle.

**Swainson's Hawk (*Buteo swainsoni*)**

Status: State Threatened.

Habitat: Open plains, prairie and desert.

Presence: Very rare in the area.

Description: Swainson's hawk soars over open plains and grasslands found primarily in the central plains and rocky mountain states. This species is an occasional visitor to San Diego County and is seen very rarely at Tijuana Estuary, presumably using the open areas for foraging. Because of its infrequent use of the estuary, Swainson's hawks are not expected to be impacted by the project.

### 3.5.1.4 Regional Perspective

The Tijuana Estuary is not only an important local resource, but one with regional and national importance. The preceding discussion describes the biological resources of the estuary as well as the interaction of these resources with the physical and chemical environment. The national importance of the estuary was recognized when, in 1982, the National Oceanic and Atmospheric Administration designated the Tijuana Estuary a National Estuarine Sanctuary. This action recognized the estuary as a regionally-important habitat. The fact that this estuary is one of the few remaining examples of

tidally-flushed coastal wetlands in southern California supports the need to preserve the resource and its values.

To address the impacts of the project adequately, it is necessary to recognize the regional value of the estuary as well as its local value. It is important to recognize the changes that other coastal wetland systems in the region have undergone relative to the changes in the Tijuana Estuary and what the future changes might be, based on the historic changes. The occurrence of a number of special status species in these coastal systems underscores the importance of these systems to the local and regional landscape in maintaining biotic diversity.

An evaluation of the regional importance and significance of the Tijuana Estuary to the regional resource base is necessary to adequately assess the impacts of the project. Since the Tijuana Estuary and other coastal wetlands along the southern California coast have been seriously degraded in recent decades, it is necessary to view them as a bioregion and to assess projects which will affect a particular local wetland in terms of the project's impact on the regional resource base.

Because of the loss in quality of southern California wetlands, efforts are now being undertaken to enhance, restore or create coastal wetland habitats. The State of California recently passed a Senate Concurrent Resolution 28 (Chaptered at 92, Statutes of 1979) to increase the amount of wetlands in the state by 50 percent. In addition to Tijuana Estuary, there are three wetland enhancement, restoration or creation projects nearing implementation in San Diego County: Batiquitos Lagoon, Sweetwater Marsh, and Los Penasquitos Lagoon. Planning also is underway for enhancing three other wetland systems in San Diego County: (1) Famosa Slough; (2) San Dieguito Lagoon; and (3) San Elijo Lagoon. Since the results of wetland enhancement, restoration and creation efforts can still not be predicted and the existing resource base is small, concerns have been raised on the effect of these efforts on the regional resource base. Three basic issues have been raised during the planning and review of these projects: (1) what should be the wetland mix planned for a particular wetland, (2) what wetland habitat mix should be considered from a regional perspective and (3) what would be the environmental consequences of the actions.

Resource enhancement or restoration projects in the United States have typically been directed at a single species or a single habitat type. In recent years projects have been

focused on the preservation of rare and endangered species. The species by species management approach, however, tends toward a never ending marathon of salvage operations (Harris, 1984). There is now a concern for maintaining and conserving the broad genetic diversity. This goal requires that healthy, viable populations be maintained in the environment in which they coevolved. The essential argument for conserving entire biological communities is that this seems to be the level of hierarchy needed to conserve a community level of ecological diversity thus ensuing the conservation of:

(1) known endangered species,

(2) genetic diversity,

(3) the full gamut of native vertebrates,

(4) natural animal community interactions,

(5) unknown species and processes, and

(6) known ecosystem processes.

To document the potential effects of proposed projects on the maintenance of ecological diversity, Gosselink and Lee (1987) recently proposed a methodology to assess cumulative impacts on bottomland hardwood wetlands in the southeast United States. The approach chosen by Gosselink and Lee is based on landscape ecology rather than a species management approach. In choosing this approach, they point out that the human values that are associated with wetlands arise from the ecological process of functions that are by nature scaled to the landscape. Through the long evolution of the landscape, the physical, chemical and biotic processes have reached a harmonious interrelationship that essentially optimizes for all functions. It is therefore presumptuous to assume that humans can improve on that overall ecosystem with their limited understanding of the details of its dynamic processes. This is especially true for the biotic component; individual species are known to be highly adapted to their environments and many have exacting and unknown requirements that depend intimately on the natural landscape in which they evolved.

This type of an assessment methodology is critical to developing an understanding of the southern California coastal wetland system. It is estimated that between 75 and 90 percent of the coastal wetlands in southern California have been destroyed. If general principles of island biogeography hold true, this would mean that there may already have been a 50 percent reduction in species richness for many of the individual wetlands and, possibly, for the entire system.

In addition, those wetlands that remain have been altered hydrologically by increased sedimentation and/or diking. These modifications have typically led to a reduction of their tidal prism and periodic to permanent closure of their mouths. These hydrologic modifications have caused a reduction of available habitat and a shift in the systems from estuarine to lagoonal. Three wetland dependent species and a fourth that utilizes wetlands have now been listed under the federal Endangered Species Act. These species include the California brown pelican (*Pelecanus occidentalis*), California least tern (*Sterna antillarum browni*), light-footed clapper rail (*Rallus longirostris levipes*) and salt marsh bird's beak (*Cordylanthus maritimus* spp. *maritimus*). The State of California also considers these species as well as another species, Belding's Savannah sparrow (*Passerculus sandwichensis beldingi*) to be endangered. In addition over twenty wetland dependent species are considered candidates for listing as endangered. The lack of coastal wetlands for wintering waterfowl and shorebirds in also considered to be limiting populations of birds using the Pacific Flyway.

The parameters chosen by Gosselink and Lee to evaluate bottomland hardwoods are not directly applicable to southern California coastal wetlands. However, their approach can serve as the basis for a regional evaluation. They recommend that five technical issues need to be addressed to conduct a regional analysis. The first two issues relate to scale of the study area; the second two attempt to define landscape structure and function and the last element uses the developed information to define resource goals. The five identified issues are as follows:

(1) **Boundary, both spatial and conceptual** - This issue attempts to address the size of the study area needed to provide a reliable picture of a functional landscape. The appropriate size of the study area to consider or the appropriate scale needed is that required to encompass the range of the animals of concern. The selected size should be based on a natural unit. For wetlands, because of the importance of flowing water, the watershed

usually makes desirable management units. For migratory birds, a continental scale would be more appropriate.

(2) **Time scale** - This issue attempts to define the timeframe needed to develop the biological landscape pattern.

(3) **The ecological complexity of the system** - This issue relates to the identification of "valued ecosystem components" around which an assessment can be built. The selection of these components should insure that a resilient, viable ecosystem is maintained rather than selected component parts. This may require an understanding of the historic changes in the system . An assessment of previous losses may also show the major causes of change in the resource base and provide information of the potential of the unit. This analysis may be based either on habitat structure or functions.

Indices used to characterize the landscape in order to assess its complexity should consider both the structure of the unit and its functions. Historic information on coastal wetland systems may include the following parameters:

(a) acreage and habitat types,

(b) hydrologic regime, and/or

(c) biotic diversity and species abundance.

(4) **Importance of pattern in the landscape** - Relevant aspects of this issue are habitat patch size, patch continuity and contiguity needed to conserve environmental resources. A regional survey of the present state of the system is needed to understand how spatial patterns contribute to the maintenance of the system. The purpose of this analysis is to provide a context within which the regulation of specific management units can proceed.

Indices used to characterize the landscape to assess its current health should consider both the structure of the unit and its functions. Indices to assess the current status of coastal wetland systems may include the following information:

(a) Habitat patterns - An understanding of the size frequency of the wetland patches in the assessment unit is needed. If the units are widely separated, this too must be considered.

(b) Habitat contiguity - The extent to which the wetland is contiguous to either an adjacent stream, to an adjacent upland habitat or to other habitat areas must be considered.

(c) Biotic diversity - The existing fish and wildlife habitat values should be documented for the unit. This may include information on:

- habitat types,
- endangered and threatened species,
- indicator species and negative indicator species (exotics that have invaded the area), and
- existing patterns of usage.

(d) Tidal regime and the degree that regime is currently impacted - This defines the flow and/or flooding characteristics of the wetland. Information, if available, should state whether or not the mouth of the system is open and if so, for how long.

(5) **Increment of the environmental change** - This issue focuses on setting goals and/or limits of permitted development to maintain the desired resource base.

For this analysis, the information on southern California coastal wetlands and their functions that have been recently summarized in Zedler (1982) and Zedler and Nordby (1986) were reviewed as well as available literature. In addition, acreage data on existing wetland resources within the County of San Diego was digitally planimetered from the 1985 draft National Wetlands Inventory Maps prepared by the U.S. Fish and Wildlife Service. This mapping effort is based on aerial photography flown in 1985; the mapping scale is one inch equals 24,000 feet. Except for the Tijuana River Valley and estuary, the area planimetered was generally from the mouth of the coastal wetland to the first major break in wetland habitats.

**Scale.** Because of the need to understand the impacts to the estuary due to upstream activities and the interrelationship to other coastal wetlands, the area selected to serve as the regional resource base for the Tijuana Estuary is bidirectional. While the optimal evaluation area would include the entire Tijuana River watershed and all the Pacific Coast wetlands that provide habitat for birds using the Pacific Flyway, the selected evaluation area is composed of the drainage basin from the Mexican border to the mouth of the estuary and the 76 miles of the county's coastal shoreline. Twenty-three coastal wetlands are included in this evaluation.

Based on the 1985 draft National Wetland Inventory (NWI) maps prepared by the U.S. Fish and Wildlife Service, coastal wetlands within the county totalled approximately 19,828 acres. The wetlands within the lower drainage basin of the Tijuana River totalled approximately 916 acres; 702 of these wetland acres are located in the estuary.

**Time Scale.** Most of the coastal estuaries have evolved over the last 12,000 years. However major documented changes have occurred in the last century due to coastal and watershed development. The destruction of a system brings about obvious, immediate and permanent changes. Modification of the hydrologic regime may produce permanent changes to the system, but these changes may be subtle, the impacts may occur over a period of years. These changes may maintain the area as wetland but change its character. For example, closure of several mouths of the coastal lagoons has been attributed to altered hydrology of these systems caused by the construction of Pacific Coast Highway and/or the railroad. These changes have been taking place over the last 80 years and are still occurring. However, in other instances the response to a changed hydrology can be fairly immediate. For example, cattails (*Typha domingensis*) invaded

the San Diego River salt marsh in 1980 following a period of unseasonable freshwater inflows due to reservoir discharge.

Preston and Bedford (1988) suggest that the temporal scale should be based on the recovery times for the processes controlling the particular wetland functions of concern. However, this information is not available. The time required for a southern California coastal wetland to recover from a major perturbation is unknown. Recent monitoring of several wetland systems indicates that recovery may require ten to 50 years, perhaps longer. Therefore, the prudent approach is to look at available historic information in an attempt to evaluate changes in the system with time.

**Ecological Complexity of the System.** The historic record for southern California coastal wetlands and San Diego County has not been well documented. Around 1900 there were 28 sizable estuaries between Morro Bay, California and Ensenada, Mexico (Orme, 1973). Since then 15 have been modified either slightly or moderately, ten have been altered drastically and three have been destroyed (Speth, 1969 and Macdonald, 1977). Purer (1942) estimated that tidal marsh in San Diego County covered about 32,000 acres. If this figure is based on total wetland systems, there has been an approximately 40 percent reduction in the coastal wetland resource base in the last 45 years.

More difficult to quantify is the loss of wetland functions - hydrologic, water quality, and food chain support. Much of the information is anecdotal, describing changes in diversity and/or abundance of fish and wildlife. The changes in the Tijuana Estuary since 1952 provide an indication of the magnitude of change that has occurred in coastal tidal wetlands during this century. It was estimated that the Tijuana Estuary consisted of about 870 acres of intertidal wetlands (Appendix D). Over 55 percent of this wetland area has now been filled or otherwise modified and removed from tidal influence. The decline of intertidal wetland translates into about an 80 percent loss of potential tidal prism and an even greater loss in actual tidal exchange and circulation. The estuary now contains an estimated 176 acres of intertidal salt marsh wetlands and 173 acres of tidal channels and ponds, and 33 acres of intertidal mudflats.

Besides the reduction in size, coastal wetlands have been impacted by hydrologic modification of their watersheds. Impoundment of and development in the watersheds and the construction of Pacific Coast Highway and the railroad has caused many of the

coastal wetlands to become lagoonal (i.e., mouths permanently closed or only intermittently open during extreme storm events or by man) rather than remain as estuaries (i.e., mouths permanently open or only intermittently closed). It appears that only 100 years ago most, if not all, of the major coastal wetlands would have been classified as estuaries (Purer, 1942; Browning and Speth, 1973; Metz, 1978 a,b; Bradshaw et al., 1976).

Most of the estuaries and coastal drainages supported southern steelhead (*Salmo gairdnerii*) runs. Cordgrass (*Spartina foliosa*) and the light-footed clapper rail , both good indicator species of a regular tidally flushed salt marsh, had a wider distribution. Cordgrass was found not only in the Tijuana Estuary and San Diego and Mission Bays, but also in Los Penasquitos and in Buena Vista Lagoons (Purer, 1942). Light-footed clapper rails were collected from Los Penasquitos and in the north county lagoons (Wilbur and Tomlinson, 1976). These authors estimated that Los Penasquitos Lagoon had an estimated rail population of 50 birds in the mid-1970's.

**Patterns in the Landscape.** In understanding the current spatial patterns of the coastal wetlands, it is important to look at the composition of the major components of the coastal wetland systems. Six habitat types have been selected to describe these systems - bay habitats; channel habitat; salt marsh; fresh and brackish water wetlands; lacustrine systems and other wetlands. Table 3-5 summarizes the acreage of various habitat components for the county's coastal wetland systems based on the USFWS wetland classification of habitat types. More up-to-date estimates are available for selected wetlands, but the USFWS draft National Wetland Inventory maps (1985) was used to provide a common basis for comparing systems.

Tijuana Estuary is the southern-most system; San Mateo Creek is the northern-most. The mean wetland size in the county is calculated to be approximately 822 acres. However, only two wetlands are larger than this value - San Diego Bay and Mission Bay. Tijuana Estuary, the third largest wetland in the county, is only approximately 700 acres in size. The mode (most common size) is 211 acres.

If acres of subtidal habitats are subtracted from the total, another view of the distribution of coastal wetland habitats emerges. The remaining habitat types in decreasing order of abundance are approximately 1,869 acres of salt marsh habitats found in ten of the 23 coastal wetland system, approximately 1,809 acres of fresh and brackish water

**Table 3-5. Acreages of Habitat Types in San Diego County Wetlands Based on the draft National Wetland Inventory Maps, 1985.**

| LOCATION | ACREAGE OF BAY HABITAT | ACREAGE OF CHANNELS | ACREAGE OF SALT MARSH | ACREAGE OF FRESH AND BRACKISH | ACREAGE OF LACUSTRINE | ACREAGE OF OTHER TYPES | TOTAL WETLAND ACREAGE |
|---|---|---|---|---|---|---|---|
| Tijuana Estuary | 0 | 58 | 423 | 218 | 0 | 4 | 702 |
| San Diego Bay | 11078 | 0 | 27 | 58 | 1065 | 0 | 12315 |
| Sweetwater | 0 | 5 | 287 | 46 | 0 | 2 | 340 |
| Famosa Slough | 0 | 6 | 4 | 0 | 0 | 0 | 10 |
| San Diego River | 155 | 0 | 116 | 49 | 0 | 3 | 323 |
| Mission Bay | 1532 | 0 | 87 | 99 | 0 | 0 | 2219 |
| Los Penasquitos | 0 | 8 | 323 | 124 | 0 | 0 | 454 |
| San Dieguito | 74 | 0 | 71 | 91 | 0 | 2 | 238 |
| San Elijo | 0 | 78 | 216 | 183 | 0 | 0 | 478 |
| Batiquitos | 106 | 247 | 21 | 130 | 0 | 0 | 504 |
| Agua Hedionda | 262 | 0 | 78 | 67 | 0 | 0 | 406 |
| Buena Vista | 0 | 0 | 0 | 39 | 159 | 0 | 198 |
| Loma Alta | 2 | 0 | 0 | 2 | 0 | 0 | 2 |
| San Luis Rey | 0 | 2 | 0 | 204 | 0 | 5 | 211 |
| Oceanside Harbor | 211 | 0 | 1 | 0 | 0 | 0 | 211 |
| Santa Margarita | 75 | 0 | 216 | 195 | 0 | 0 | 486 |
| Cockleburr Canyon | 0 | 0 | 0 | 5 | 0 | 0 | 5 |
| French Canyon | 0 | 0 | 0 | 2 | 0 | 0 | 16 |
| Aliso Creek | 0 | 0 | 0 | 25 | 0 | 0 | 25 |
| Unnamed Canyon | 0 | 0 | 0 | 9 | 0 | 0 | 9 |
| Las Pulgas Canyon | 0 | 0 | 0 | 116 | 0 | 1 | 117 |
| San Onofre Creek | 0 | 0 | 0 | 22 | 0 | 37 | 58 |
| San Mateo Creek | 0 | 0 | 0 | 114 | 0 | 80 | 194 |
| TOTAL | 13492 | 405 | 1869 | 1809 | 1224 | 133 | 19421 |

wetlands found in 20 of the wetlands, approximately 1,224 acres of lacustrine wetlands found in two of the wetlands, approximately 404 acres of intertidal channel habitat found in six of the wetlands and approximately 133 acres of other wetland types.

Another way to view the distribution of wetland habitat types in the 23 coastal wetlands is the percent of each habitat in a given system. The data indicate that the Tijuana Estuary, Sweetwater Marsh Complex and Los Penasquitos Lagoon contain not only most of the salt marsh found within the county but each is also largely emergent wetlands. Located within these three wetlands are 16 percent of the channel habitat, 54 percent of the salt marsh habitat, 20 percent of the fresh and brackish water habitat and 5 percent of the other wetland habitat. These areas contain no bay or lacustrine habitats. Of these three, the Tijuana Estuary contains the largest percent of channel, salt marsh and fresh and brackish water habitats.

The largest habitat units in the county are associated with subtidal habitats. San Diego Bay contains approximately 11,077 acres of continuous subtidal habitat; Mission Bay contains approximately 2,033 acres of continuous subtidal habitat. However, patch size of saltmarsh habitats is highly variable.

Another important element in describing the coastal wetlands and their associated habitats, especially in the context of contiguity, is the current mouth dynamics. Changes in the mouths of the coastal wetlands has been dramatic over the last century. Historic and existing status, where known, is presented in Table 3-6.

The general pattern has been that many of the wetlands have lost or are in the process of losing their natural connections to the ocean. The 23 San Diego County coastal wetlands were always a small disjunct series of wetlands located at the end of drainages from the coastal range. The average distance between each wetland is approximately 3.3 miles. However, the ocean served as a link between the systems, especially for fishes and invertebrates. This link , and thus the contiguity between the systems, is being lost. Of the eleven coastal wetlands still containing salt marsh habitats, only six remain continuously open. They are Tijuana Estuary, San Diego Bay, Sweetwater Marsh Complex, San Diego River, Mission Bay and Agua Hedionda. One is now continually closed - San Elijo.

**Table 3-6 Historic and Current Status of the Mouths of the San Diego County Coastal Wetlands**

| Location | Historic Condition | Current Condition |
|---|---|---|
| Tijuana Estuary | Permanently Opened | Typically Opened |
| San Diego Bay | Permanently Opened | Permanently Opened |
| Sweetwater Marsh | Permanently Opened | Permanently Opened |
| Famosa Slough | Permanently Opened | Levees/tide gates |
| San Diego River | Permanently Opened | Typically Opened |
| Mission Bay | Permanently Opened | Permanently Opened |
| Los Penasquitos Lagoon | Permanently Opened | Typically Closed |
| San Dieguito Lagoon | Permanently Opened | Typically Opened |
| San Elijo Lagoon | Permanently Opened | Closed |
| Batiquitos Lagoon | Permanently Opened | Typically Closed |
| Agua Hedionda | Permanently Opened | Permanently Opened |
| Buena Vista Lagoon | Permanently Opened | Typically Closed |
| Loma Alta Lagoon | Status Unknown | Status Unknown |
| San Luis Rey River | Status Unknown | Diked with culverts |
| Oceanside Harbor | Not Applicable | Permanently Opened |
| Santa Margarita River | Permanently Opened | Typically Closed |
| Cockleburr Canyon | Status Unknown | Closed |
| French Canyon | Status Unknown | Closed |
| Aliso Creek | Status Unknown | Closed |
| Unnamed Creek | Status Unknown | Closed |
| Las Pulgas Creek | Status Unknown | Closed |
| San Onofre Creek | Status Unknown | Closed |
| San Mateo Creek | Status Unknown | Closed |

In southern California, a major concern relating to the loss of wetlands and the change in hydrology is the loss of food chain support functions for native plant populations and for resident and migratory wetland-dependent wildlife species. These concerns are especially important since several habitat functions are closely correlated to the size of wetland area. Habitat diversity within a system appears to be directly correlated to the size of the system. Figure 3-7 plots the number of habitat units against the total size of an area.

Size of a wetland also seems to be important in the support of large numbers of migratory waterfowl. This group of migratory birds is typically thought to have broad habitat requirements. Comprehensive waterfowl data for the County are scarce; available waterfowl data is over ten years old (U.S. Fish and Wildlife Service, 1979). Nevertheless, these data tend to support the concept that size is important. San Diego Bay and Mission Bay, the counties two largest coastal wetlands, support significant waterfowl populations (i.e., a total of 61.4 percent). Other important waterfowl areas include Batiquitos Lagoon with 11.3 percent, Buena Vista Lagoon with 7.5 percent, San Elijo Lagoon with 8.2 percent, Tijuana Estuary with 5.8 percent and Los Penasquitos Lagoon with 4.4 percent. The same trend appears to be true for migratory shorebirds (Warnock et al., 1989).

Size alone, however, does not explain all relationships. Salt marsh plant species lists for selected wetlands have been compiled (Table 3-5) (Zedler, 1982). From this table and Table 3-7, a pattern emerges. While size is important to maintaining a large number of species, those wetlands that are no longer fully tidal appear to be losing low salt marsh species. Cordgrass (*Spartina foliosa*), annual pickleweed (*Salicornia bigelovii*) and fasswort (*Batis maritima*) is no longer present in those wetlands lacking tidal flushing. Also of importance is the presence of salt marsh bird's beak, an endangered plant. This plant is only found in the Tijuana Estuary and the Sweetwater Marsh.

Fishery and invertebrate abundance may also not be correlated directly to size; depth, channel diversity and tidal regime may also be important (M. Horn, personal communication). Recent comprehensive inshore fishery data for San Diego County is lacking. However, comparing several large tidally flush estuaries shows similarities in number of species and species composition (see Table 3-8).

Figure 3-7. Relationship Between Habitat Units and Total Size of Wetland.

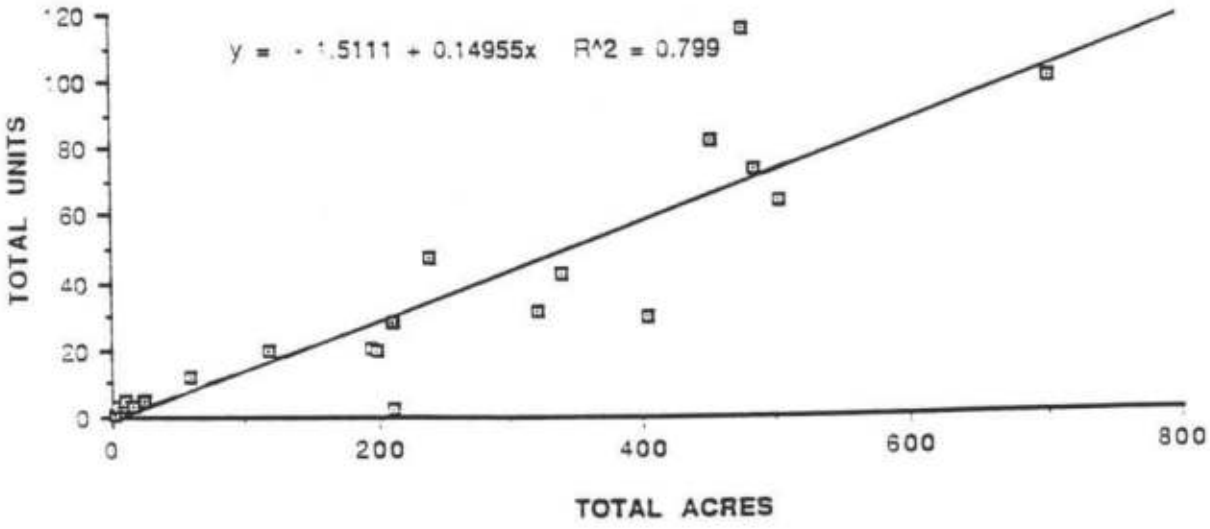


**Table 3-7 Native Wetland Plant Species Found in Selected Coastal Wetlands.**

| LOCATION | HIGHER MARSH | | | | | | | | LOWER MARSH | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JA | LG | CT | AW | SS | CM | LC | ML | FG | TC | SE | DS | CS | JC | BM | SB | SV | SF |
| Tijuana Marsh | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Sweetwater Marsh | X | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| Mission Bay | | | | | X | | X | X | X | X | X | X | X | X | X | X | X | X |
| Los Penasquitos | X | X | X | | X | | X | X | X | | X | X | X | X | | | X | |
| San Dieguito | X | X | X | | X | | X | X | X | | X | X | | X | | | X | |
| San Elijo | | X | | X | | | | X | | | X | | X | | | X | | |
| Batiquitos Lagoon | X | X | X | | X | | X | X | X | | | X | | X | | | X | |
| Agua Hedionda | X | | X | | X | | | X | X | | X | X | X | X | | | X | |
| San Luis Rey River | X | | | | | | | | X | | | X | | X | | | X | |
| Santa Margarita River | X | X | X | X | X | | X | | X | | X | X | X | X | | | X | |
| San Mateo Marsh | | | | | | | | | X | | | X | X | X | | | | |

JA - *Juncus acutus*
LG - *Lasthenia glabrata*
CT - *Cressa truxillensis*
AW - *Atriplex watsonii*
SS - *Salicornia subterminalis*
CM - *Cordylanthus maritimus*
LC - *Limonium californicum*
ML - *Monanthochloe littoralis*
FG - *Frankenia grandifolia*
TC - *Triglochin concinnum*
SC - *Suaeda esteroa*
DS - *Distichlis spicata*
CS - *Cuscuta salina*
JC - *Jaumea carnosa*
BM - *Batis maritima*
SB - *Salicornia bigelovii*
SV - *Salicornia virginica*
SF - *Spartina foliosa*

from Zedler, 1982

**Table 3-8. Number of species, dominant species, resident species and commercially important species of fish in selected southern California wetlands. (Zedler 1982)**

| Location | Number | Dominant Species | Resident Species | Commercial Species |
|---|---|---|---|---|
| Tijuana Estuary Pre - 1984 | 29 | arrow goby<br>cheekspot goby<br>California killifish<br>topsmelt<br>striped mullet | arrow goby<br>cheekspot goby<br>California killifish<br>topsmelt<br>striped mullet | California halibut<br>diamond turbot<br>kelp bass<br>spotted sand bass<br>barred sand bass |
| Upper Newport Bay | 46 | topsmelt<br>California killifish<br>mosquitofish<br>arrow goby<br>deep body anchovy | topsmelt<br>California killifish<br>mosquitofish<br>arrow goby<br>longjaw mudsucker | not assessed |
| Anaheim Bay | 44 | topsmelt<br>gobies<br>California killifish<br>deep body anchovy<br>shiner surfperch | topsmelt<br>mosquitofish<br>shiner surfperch<br>staghorn sculpin<br>gobies | deep body anchovy<br>shiner surfperch<br>California halibut<br>diamond turbot |
| Mugu Lagoon | 39 | shiner surfperch<br>topsmelt<br>staghorn sculpin<br>California killifish<br>California halibut<br>diamond turbot<br>white croaker<br>bay pipefish<br>longjaw mudsucker | topsmelt<br>California killifish<br>California halibut<br>diamond turbot<br>longjaw mudsucker<br>grey smoothound<br>bay blenny<br>shadow goby | shiner surfperch<br>California halibut<br>diamond turbot |

The distribution of the bird species dependent on coastal wetlands, Belding's Savannah sparrow, the light-footed clapper rail and the California least tern, also cannot be explained by total size of a wetland. The most sensitive species to fragmentation are the stenotopic (interior or area sensitive) species that generally characterize individual communities. Some avian species simply do not occur in small fragmented patches of habitat that are dominated by edge characteristics and edge species. This may be the case for these avian species.

Belding's sparrow and light-footed clapper rail are both resident species; the least tern is a migratory species that breeds in southern California and winters in Central and south America. Figure 3-8 provides a summary of county-wide censuses taken of these two resident species in 1986 and the California least tern in 1984. The light-footed clapper rail is present in five coastal wetlands. All five contain salt marsh vegetation; four are continuously opened to tidal flushing. Typically, the Tijuana Estuary supports the largest percent of the county's rail population (Figure 3-9). Belding's Savannah sparrows are present in 12 coastal wetlands. All wetlands containing salt marsh vegetation provides some habitat for this species. The Tijuana Estuary appears to be one of the most important habitat areas, supporting approximately 25 percent of the county's population of the species; Los Penasquitos Lagoon and Sweetwater Wetlands Complex supported 17 and 15 percent of the population, respectively.

The California least tern has recently used with some regularity seven of the county's coastal wetlands - Tijuana Estuary, San Diego Bay, Sweetwater Wetlands Complex, Mission Bay, San Elijo, Batiquitos and Santa Margarita. Based on 1984 census data, the largest colony is at the Santa Margarita Estuary. It supports approximately 44 percent of the county's breeding effort of this species. San Diego Bay, Tijuana Estuary and Mission Bay then follow in importance with approximately 22, 12.4, and 11.3 percent of the population, respectively.

**Summary.** Only a tiny fraction of the region's historic coastal wetland habitat remains. Several attributes of Tijuana Estuary give it major significance within the region, despite its modified condition and substantially diminished tidal prism:

(1) It supports the largest area of marshes in San Diego County. Large habitat units can attract and support greater numbers of species.

Figure 3-8. San Diego County Census of Three Endangered Species -- California Least Tern, Belding's Savannah Sparrows, and Light-footed Clapper Rail.

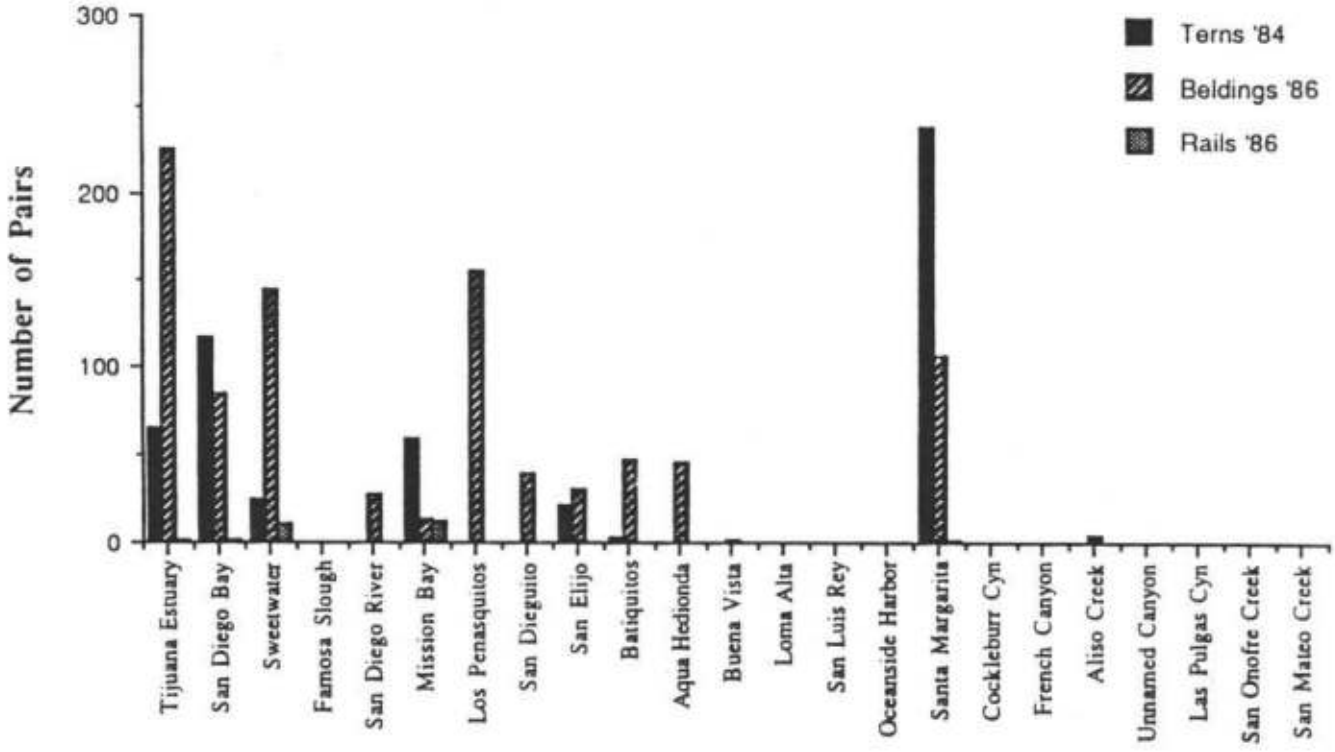
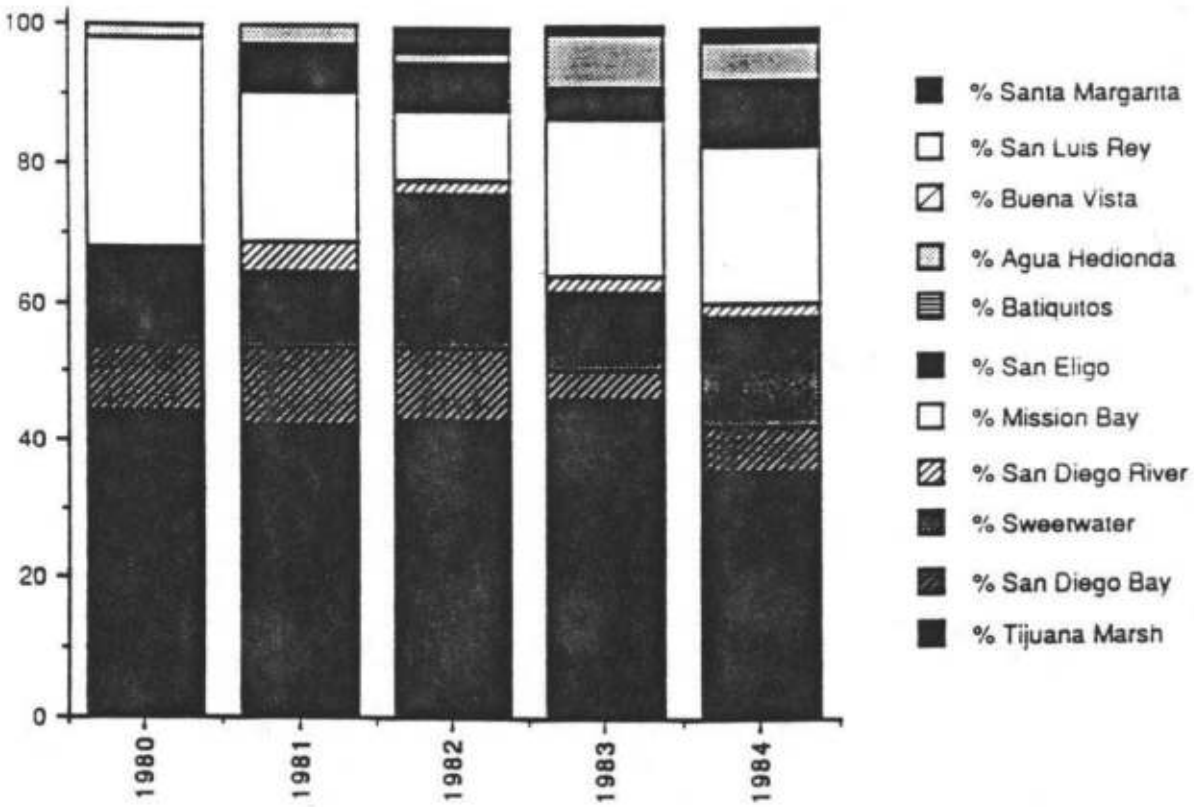


Figure 3-9. Percent of Light-footed Clapper Rail Population in San Diego County Coastal Wetlands, 1980-1984.



(2) The fact that Tijuana Estuary retains its ocean connection, and is nearly always tidally flushed, distinguishes this wetland from most others in the region. Tidal flushing is a key environmental factor for support of biodiversity; systems that are typically closed to tidal flushing have diminished species lists.

(3) Several rare and endangered species persist at Tijuana Estuary; many of them require continual tidal influence for continued survival.

(4) Tijuana Estuary is directly connected to a large river floodplain, with adjacent habitats that enrich the species lists of the estuary and provide refuges during extreme events and disturbances within the estuary.

Tijuana Estuary thus continues to support populations of species that have been extirpated elsewhere in the county. Providing large areas of coastal wetland habitat is a major challenge in a county with a rapidly expanding population, intense development pressure, and continuing modifications along the coast and within coastal watersheds. There is evidence that the habitat value of the estuary has declined, and that many birds, plants, insects, fishes and invertebrates have an uncertain future. Their existence depends on the long-term maintenance of the entire complex of natural habitats present within the estuary, and these ecosystems, in turn, depend on the maintenance of tidal flushing.

The importance of Tijuana Estuary in supporting regional biodiversity is clear, and the mandate for its future management is straightforward: tidal flushing must be maintained.

#### 3.5.1.5 Waters of the United States

The extent of Waters of The United States, which includes wetlands, was determined for the Reserve (Appendix L). Waters of the United States are subject to the jurisdiction of the Corps of Engineers pursuant to its authority under Section 404 of the Clean Water Act. This study also determined the extent of the Corps of Engineers jurisdiction pursuant to its authority under Section 10 of the Rivers and Harbors Act. The findings of that study are summarized below.

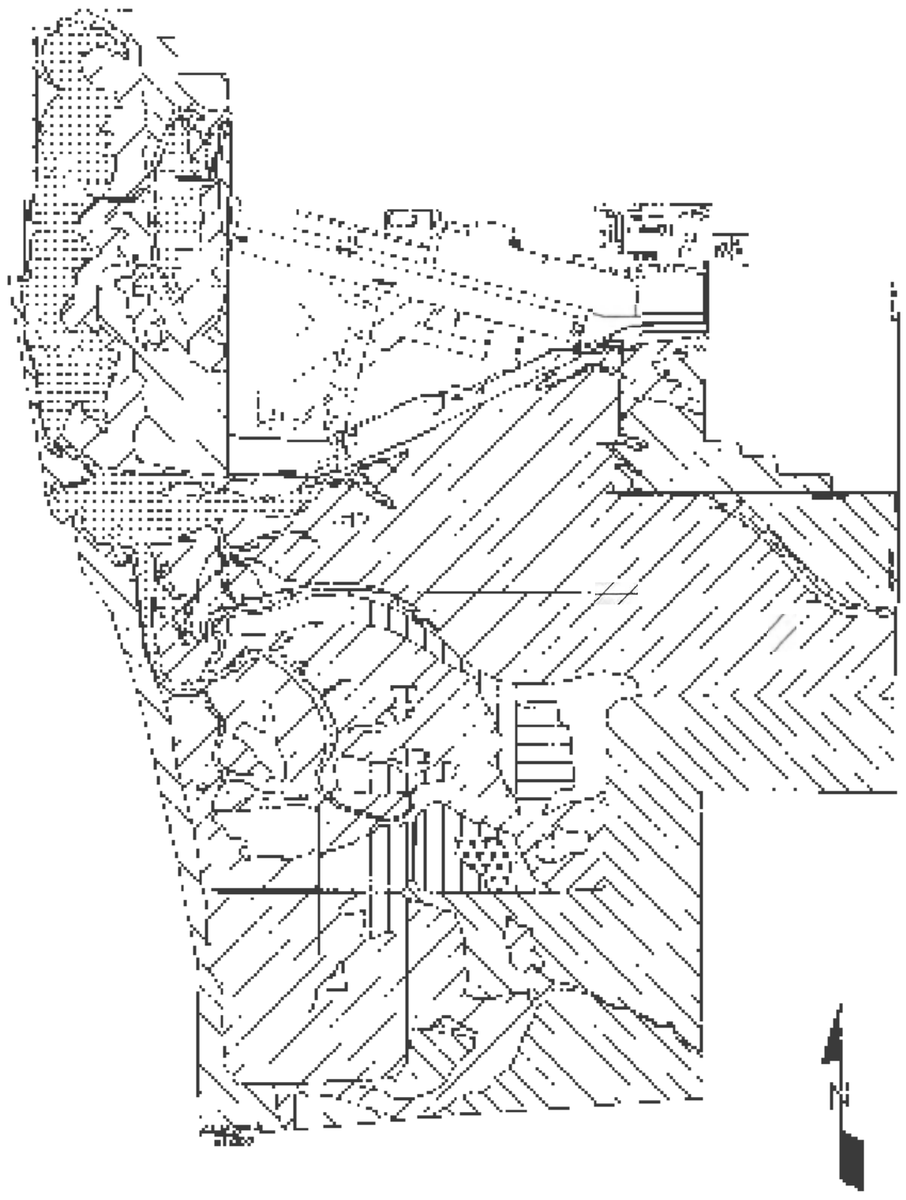
The areas shown as Section 404 Wetlands on Figure 3-10 meet the technical criteria for wetlands as defined in the Federal Manual. The total area of wetlands that meet the technical criteria is 1207 acres. These areas are dominated by obligate and facultative wet species. Most of this area is flushed by the diurnal tides. Soils within the main tidal area exhibit obvious hydric characteristics. In those areas that lie above the high tide line that qualified as wetlands, soils and hydrology were assumed based on the vegetation.

The areas designated as Section 404 Wetlands With Isolated Non-wetland Areas occur at elevations that are above the tidal zone and contain a mixture of Section 404 technical wetlands and uplands. Within this category there were areas dominated by upland species and that, therefore, did not meet the technical definition necessary to be considered Section 404 wetlands. Non-wetland areas in this category were not delineated separately since they were generally restricted in size, accounting for less than approximately 10 percent of the area, collectively. There are an estimated 222 acres in this category with an estimated 200 acres being Section 404 wetlands.

There are 231 acres of Section 10 and Section 404 Other Waters of the United States in the study area. These areas include the intertidal mudflats, tidal channels, small ponds associated with the historic quarry operation, and unvegetated sandy beaches associated with the barrier beach along the western part of the study area.

There are nine acres of Developed/Disturbed Areas in the study area primarily associated with the site of the former model airplane use area. The Pacific Estuarine Research Laboratory (PERL) experimental area accounts for 23 acres. There are areas in the PERL area that support wetland vegetation and could qualify as Section 404 wetlands and would likely be jurisdictional if these areas were to retain wetland characteristics after being abandoned.

The remaining areas were found to be uplands and not subject to the Corps jurisdiction. The acreage of non-jurisdictional areas totals 870 acres plus another 23 acres associated with PERL. This total of 870 acres includes the estimated 22 acres of non-jurisdictional lands associated with the category noted on Figure 3-10 as Section 404 Wetlands With Isolated Non-wetland Areas, the 9 acres associated with the former site of the model airplane club, and 839 acres in the category of Non-jurisdictional Lands.




## LEGEND

| KEY | DESCRIPTION | ACREAGE |
|---|---|---|
| | SECTION 404 WETLANDS | 207 |
| | SECTION 404 WETLANDS WITH ISOLATED NON-WETLAND AREAS | 222 |
| | SECTION 10 AND SECTION 404 OTHER WATERS (TIDAL CHANNELS/MUD FLATS) | 231 |
| | PACIFIC ESTUARINE RESEARCH LAB | 13 |
| | DEVELOPED/DISTURBED AREAS IN FLOOD PLAIN (NON-JURISDICTIONAL) | 9 |
| | NON JURISDICTIONAL LANDS | 839 |

N

0 2000 4000 8000

Scale (ft)

TIJUANA ESTUARY TIDAL RESTORATION Program

PROJECT NO. 3000000 FIGURE 3-13

SAN DIEGO STATE FOUNDATION

SAN DIEGO, CA

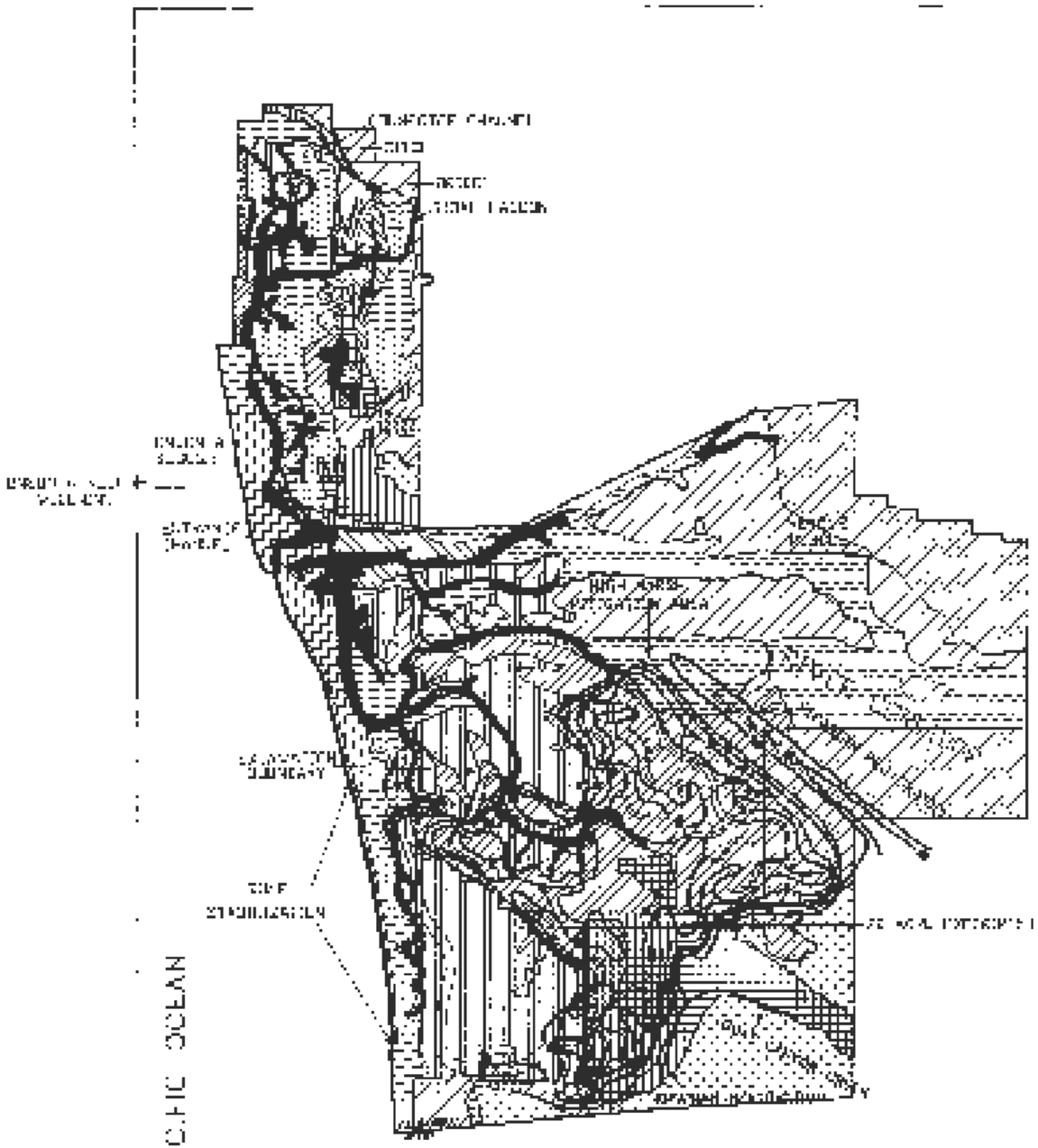
## 3.5.2 IMPACTS AND MITIGATION

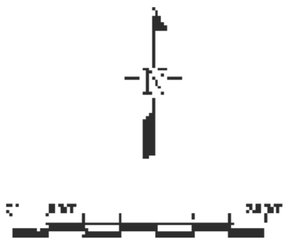
### 3.5.2.1 Impacts of the Model Project

**Vegetation.** Construction of the Model Projects will result in loss of some wetland vegetation (Figure 3-11), including intertidal salt marsh and some sensitive species habitat. Since the program is being implemented using an adaptive management approach, the information gained from early work will be used to design latter components so that they have less impact on the resources of the estuary. Therefore, the short-term loss of vegetation will be further offset in the construction of future modules as a result of the refining of techniques inherent with the adaptive management approach. This will mitigate for the potentially-significant impact to marsh vegetation that is habitat for sensitive wildlife species. Construction of the Model Project will not impact any known populations of the salt marsh bird's beak (Figure 3-12).

Widening of Oneonta Slough will result in the loss of approximately 0.2 acres of intertidal pickleweed marsh and 2.4 acres of non-tidal salt marsh (Table 3-9). Portions of the non-tidal salt marsh have been disturbed and currently support little vegetation. Other parts of the high marsh contain salt grass, which is the preferred larval food plant for the wandering skipper butterfly, a federal candidate for listing as an endangered or threatened species. Although the area of salt grass that will be lost represents a small portion of the butterfly's range in the estuary, the loss is considered potentially significant because regional losses in the insect's habitat have resulted in uncertainty about the status of the species. Salvaging of the plant material before construction and replanting the salvaged material will be undertaken to mitigate impacts to marsh vegetation.

Construction of the connector canal will result in the loss of approximately 0.1 acres of cordgrass and 0.1 acres of pickleweed marsh (Table 3-9). This represents a small portion of the entire acreage of these species in the estuary. The loss of cordgrass marsh is expected to be offset by increased growth of cordgrass in the tidal lagoons as a result of increased tidal flushing and the growth of new cordgrass along the margins of the new connector channel. Cordgrass is the preferred habitat for the endangered light-footed clapper rail. Sightings have been reported in the general project area. Measures will be taken in the construction of the project to assure there are no adverse impacts to the species. These measures are described below in the wildlife section of this chapter.




Coastal Dunes & Beaches

Tidal Channels and Brackish Ponds

Intertidal Mud Flats

Intertidal Salt Marsh

Salt Marsh/Salt Panne

Transition

Disturbed

Mixed Transitional/Disturbed

Brackish Marsh

Riparian

Coastal Sage

Figure 3-12. Impact of Model Project on Salt Marsh Bird's Beak.

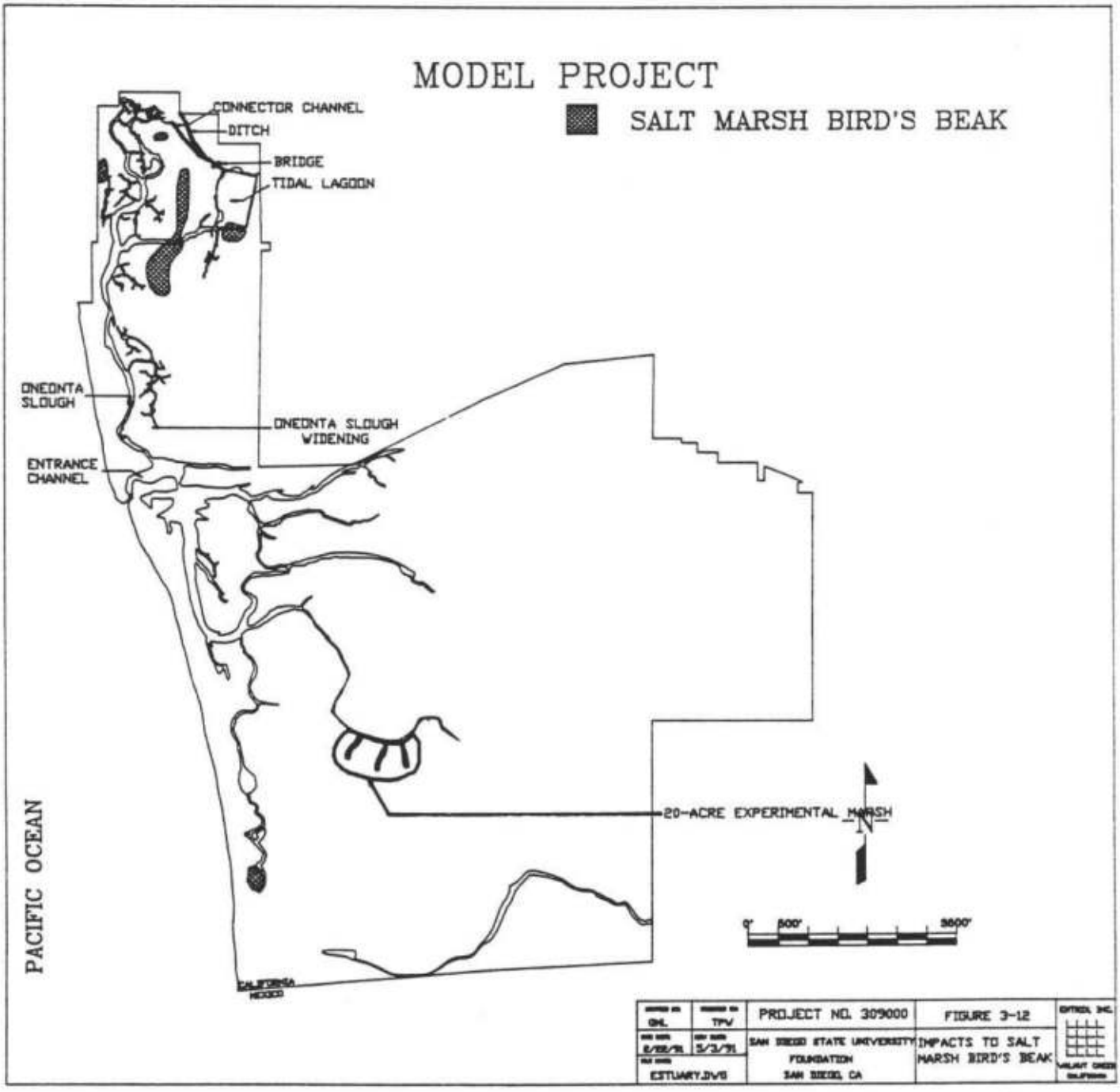


**Table 3-9. Acreage of Habitat Lost and Created by the Model Project.**

| Habitat Type | Total Acreage in Estuary | Acreage Impacted: Oneonta Slough Widening | Acreage Impacted: Connector Channel | Acreage Impacted: 20-Acre Marsh | Total Acreage Gained |
|---|---|---|---|---|---|
| Coastal Dunes and Beaches | 124 | | | | |
| Tidal Channels and Ponds | 173 | | | | 4 |
| Intertidal Mudflats | 33 | | | | |
| Intertidal Salt Marsh | 176 | 0.2 | 0.2 | | 24.6 |
| Salt Marsh/Salt Panne | 439 | 2.4 | | 12 | |
| Transition | 610 | | | 12 | |
| Disturbed | 366 | | 1.3 | 0.5 (berm) | |
| Mixed Transition/Disturbed | 181 | | | | |
| Brackish Marsh | 30 | | | | |
| Riparian | 248 | | | | |
| Coastal Sage | 151 | | | | |

A ditch designed to carry stormwater runoff from west of the Visitor's Center will be extended to intersect with the new connector channel. The ditch will be constructed through disturbed areas having little apparent habitat value. This areas may be used by marsh-dwelling species as a refuge during periods of high water, however, construction is not expected to significantly alter the area.

Construction of the 20-acre experimental marsh will impact approximately 24 acres of marsh and transitional habitat. This wetland habitat will be converted to intertidal marsh with small tidal channels. The loss of salt marsh/salt panne and transitional habitat represents a small acreage relative to the total acreage of these habitat types in the Reserve (Figure 3-11). Although this loss could be considered significant because of the cumulative loss of wetlands in the area, this loss will be offset by the benefits gained by construction of the 20-acre experimental marsh both in term of its improved wetland habitat value and in the refinement of restoration techniques expected as an outgrowth of the project. This information will be used in designing future components of the 495-acre Restoration Project to ensure a minimum of adverse impacts and the greatest possibility of success.

Construction of the experimental berm likely will occur in disturbed habitat and will not have a significant impact on the resources in the Reserve. The two likely locations are the PERL property (preferred location), or the disturbed area south of Monument Road across from the model airplane field. The berm will use only a small portion of the dredged material generated by the project. The disposition of the remainder of the dredged material will be determined after the sediment study has been completed.

The experimental berm will provide valuable information about the appropriate techniques to be used to vegetate the river training berm after it has been constructed can be considered to be a net benefit.

Access to the construction area for the widening of Oneonta Slough will be across a portion of the marsh surface. The likely access route across the marsh surface will run north-south along an existing wide path, following the western fence line of the U.S. Navy facility, then south along the existing trail that runs parallel to the dead end slough just north of the Tijuana River Slough (Figure 1-1). Access to the connector channel likely will be through the Visitor's Center parking lot and across disturbed areas, The

result would be minimal impact to the marsh vegetation in the vicinity. After construction, any areas adversely affected by access routes will be restored.

Access to the 20-acre marsh will be along Monument Road to the Kiosk and then north along the existing horse trail. Project impacts to this existing access route will be minimal. However, if the access route should require expansion, there would be a short-term impact to high marsh and transitional habitat. After construction, this area would be restored.

**Wildlife.** Wildlife in the Reserve in the vicinity of the Model Project will be affected by the loss of habitat associated with construction of the project, noise from the heavy equipment used during construction, and possibly by increased sediments entering the tidal waters near the construction areas. This section will address the first two subjects. The possible impacts resulting from sediments being released into the tidal waters during construction will be addressed in a subsequent report to the San Diego Regional Water Quality Control Board (RWQCB) concerning sediment analysis. Necessary measures to protect water quality during construction will be undertaken as a condition of permit approval. The sediment quality study is described in Appendix G.

The widening of Oneonta Slough will convert 2.6 acres of salt marsh to tidal channel habitat. The light-footed clapper rails forage in this site (Figure 3-13), but no suitable clapper rail nesting habitat occurs there. The nearest clapper rail nesting habitat is approximately 210 m to the north-east. During Spring 1991, light-footed clapper rails nested 360 m to the north-east (B. Holton and P. Jorgensen, personal communication). Currently, Belding's Savannah sparrows breed at this site. On 18 April 1991, six males were counted in Area A and two males were counted in Area B (U.S. Fish and Wildlife Service), and on 21 May 1991 four males were observed displaying in area A and one male was observed displaying in Area B (J. Boland, personal communication). Other sensitive species reported to occur in the area are the wandering skipper (Figure 3-15) and tiger beetles (Gabb's tiger beetle and mudflat tiger beetle) (Figure 3-16). In addition, the California least tern forages in Oneonta Slough.

The area of habitat for the light-footed clapper rail and Belding's Savannah sparrow affected by Oneonta Slough widening represents a small percentage of the total habitat for these species in the estuary. Construction will be planned to avoid breeding and nesting periods. However, to assure that the project does not result in direct impacts to

protected species, an inventory will be undertaken to determine the existence of nesting pairs in the project area. The inventory will be coordinated with federal and state endangered species representatives and any additional measures deemed necessary to protect the species will be undertaken. Impacts to salt grass due to the widening of the Oneonta Slough will be offset by salvaging the plants before excavation proceeds and replanting either in the disturbed roadway or other disturbed areas that currently support little vegetation.

Tiger beetles in the area of the Oneonta Slough widening project could be adversely affected by construction unless the appropriate measures are taken. The tiger beetles are active during warm periods in the spring, summer, and fall. During this time the beetles are most susceptible to impacts. The loss of tiger beetles can be avoided by restricting construction to the cooler times of the year. This restriction in construction also would help reduce impacts to the light-footed clapper rail and Belding's Savannah sparrow, which are more susceptible to impacts during the spring, summer and early fall months.

By exercising the necessary precautions, impacts to sensitive resources resulting from construction of the Model Project will be kept to a minimum. Impacts to the resources of the estuary will be offset by creating new potential habitat in association with the connector channel marsh and the 20-acre experimental marsh.

Construction of the connector channel will affect a small area (0.2 acres) of salt marsh. This habitat is reportedly used by the light-footed clapper rails and Belding's Savannah sparrows. During Spring 1991, neither species appeared to breed in the area but both species bred nearby. The nearest light-footed clapper rail nest was 70 m to the north-west (B. Holton and P. Jorgensen, personal communication), and the nearest displaying male Belding's Savannah sparrow was approximately 80 m to the south-west of the western edge of the site, on 18 April 1991 (U.S. Fish and Wildlife Service), and on 21 May 1991 (J. Boland, personal communication).

Noise related to construction could disrupt breeding of these species near the project area although they would likely avoid the area because of the associated human activities. Construction will be planned in the fall and winter months to avoid breeding and nesting periods. However, to assure that the project does not result in direct impacts to protected species, an inventory will be undertaken to determine the existence of nesting pairs in the project area. The inventory will be coordinated with federal and state endangered species

representatives and any additional measures deemed necessary to protect the species will be undertaken.

Additional measures will be taken during fall and winter seasonal high tides. During high tide periods clapper rails move into the transitional habitat and upland areas for refuge from the high water. In fact, this is frequently a time when clapper rail surveys during the non-breeding season are done because the high water causes this secretive bird to move into more exposed habitat. These high water periods can be predicted and construction during these periods will be avoided.

Construction of the 20-acre experimental marsh will affect approximately 12 acres of salt marsh/salt panne habitat and 12 acres of transition habitat. During Spring 1991, a few Belding's Savannah sparrows appeared to breed on the site. On 18 April 1991, three singing males were counted in the area (U.S. Fish and Wildlife Service), but on 21 May 1991 no male Belding's Savannah sparrows were observed in the area and the nearest singing male was more than 600 m away (J. Boland, personal communication), although light-footed clapper rails are reported to forage in this site no suitable clapper rail nesting habitat occurs there. The nearest clapper rail breeding habitat and nest were more than 1,200 m away (B. Holton and P. Jorgensen, personal communications).

The project will impact clapper rail habitat associated with the Old River Slough; however, careful construction scheduling and implementation is expected to minimize impacts. To minimize impacts on both species, an inventory will be undertaken prior to construction to determine the existence of clapper rail and Belding's Savannah sparrow nesting pairs in the construction area. The inventory will be coordinated with the state and federal endangered species representatives and any additional measures deemed necessary to protect the species will be undertaken.

Any adverse impacts to wildlife as a result of construction-related noise and human activity is expected to be short-term. Construction and scheduling will reduce chances for disruption to birds' breeding and nesting activity. The project is expected to enhance clapper rail habitat along Old River Slough by increasing tidal flushing.. The 20-acre experimental marsh also will provide an opportunity to offset impacts to sensitive resources associated with construction of the other elements of the Model Project, including providing potential habitat for tiger beetles, light-footed clapper rail and

Belding's' Savannah sparrow, and possibly additional areas of salt grass, which is the preferred larval food plant for the wandering skipper butterfly.

**Special Status Species.** The Model Project will affect habitat for several special status species; however, as described above, these impacts are expected to be negligible. The special status species are:

- light-footed clapper rail
- Belding's Savannah sparrow
- salt marsh wandering skipper butterfly
- Gabb's tiger beetle
- mudflat tiger beetle

Impacts to these species have been discussed previously in this section and will result from construction noise and related human activities near or in habitat for these species. Habitat for all of these species will be eliminated but this loss will be offset by the construction of additional habitat in the 20-acre experimental marsh and the connector channel. Additionally, enhancement to existing habitat for the clapper rail, and tiger beetles may occur in those areas with increased tidal flushing, such as Old River Slough and the tidal lagoons. Finally, construction-related impacts can be minimized by restricting the area directly impacted by construction, constructing only during the fall and winter months and by not constructing during periods of high spring tides. By implementing the necessary precautions, and with the anticipated benefits that will result from the project, the net impact of the Model Project on the special status species in the estuary will be kept to a minimum.

**Regional Impacts.** The Model Project will contribute to the limited habitat available for special status species that rely on marsh habitat in the region. The Model Project also will contribute to the maintenance of regional biodiversity. The knowledge gained from the Model Project will benefit not only development of the 495-acre Restoration Project but other restoration projects in southern California. The more that we learn from controlled experiments like that being proposed in the Model Project, the closer we can

come to making restoration more predictable, especially when special status species are involved. These are all considered to be significant beneficial regional impacts of the Model Project.

**Waters of the United States.** Construction of the Model Project will affect approximately 27 acres of lands considered to be water of the United States, which includes wetlands. Most of these lands will be affected by construction of the 20-acre experimental marsh (approximately 24 acres of waters of the United States) and widening of Oneonta Slough (approximately 2.6 acres of waters of the United States). Widening of Oneonta Slough will convert approximately 2.6 acres of jurisdictional wetlands to other waters of the United States. Also, most of the created other waters of the United States will become Section 10 waters. The result will be the loss of 2.6 acres of jurisdictional wetlands and a gain of other waters of the United States and Section 10 waters.

Construction of the connector channel will affect approximately 0.2 acres of jurisdictional wetlands. These wetlands will be affected by construction but additional jurisdictional wetlands will be created in the channel. The acreage that will be created in the channel will be approximately three acres and will include intertidal pickleweed marsh and possibly cordgrass marsh. As a result there will be a net increase in jurisdictional wetlands as a result of constructing the connector channel. There also will be other waters of the United States created in the non-vegetated channel.

Most of the 24-acres that will be affected by construction are currently considered to be jurisdictional wetlands. Portion of the area are not jurisdictional but those areas are isolated and account for about 10 percent of the total. Construction of the 20-acre marsh will convert the area to intertidal marsh and high marsh and, as a result, there will be a slight gain in jurisdictional wetland. There also will be an increase of other waters of the United States associated with the tidal channels as well as an increase in Section 10 waters.

### 3.5.2.2 Impacts of 495-Acre Restoration Project

**Vegetation**

The 495-acre marsh restoration in the south arm of the Tijuana Estuary is designed to increase the wetland habitat values of the estuary and to keep the impacts to existing wetland habitat values to a minimum. While increasing wetland habitat values in the south arm, the project will at the same time increase the tidal prism for the entire estuary. The increased tidal prism will serve to invigorate the created tidal channels and wetlands in the south arm and the existing channels and wetlands in the north arm. The river training structure will protect the restored wetlands from flood-borne sedimentation.

Construction will result in losses to several habitat types (Table 3-10), however, these losses will be largely offset by the restored habitats created by the project (Table 3-10). These include intertidal salt marsh, intertidal mudflats, tidal channels, coastal sage and riparian habitats (Figure 3-11). The following discussion describes the impacts to the various habitats that will be affected by the project.

Habitat types affected most by the project are transition habitat and disturbed areas. Areas characterized as transition habitat are former wetland and channel areas which, having filled with sediment, are now developing upland characteristics. Disturbed areas include developed areas, agricultural areas, and existing major trails. The loss of habitat for the project with an erodible berm would be greater than the loss associated with the rip-rapped levee (Table 3-10). The berm has a footprint of 46 acres and would result in the loss of transition (seven acres), disturbed (16 acres), and riparian (14 acres) habitats in the Reserve boundaries and nine acres of coastal sage scrub on the north facing slopes of Spooner's Mesa. The rip-rapped levee, with its smaller footprint (12 acres), would result in the loss of a lower number of acres of the same habitats (Table 3-10). The slopes of the river training structures would be vegetated with native coastal sage scrub species using techniques developed in the Model Project.

The restoration of tidal marsh will affect approximately 495 acres, including salt marsh/salt panne (37 acres), transition (252 acres), disturbed (157 acres), mixed transition/disturbed (35 acres), and riparian (14 acres) habitat. However, unlike the river training structure, the affected habitats will be converted to other habitat types, including

**Table 3-10. Acreage of Habitat Lost and Created by the 495-Acre Restoration Project.**

| Habitat Type | Total Acreage in Estuary | Acreage Impacted by Project | | | Total Acreage Created by Project With Erodible Berm | Total Acreage Created by Project With Levee |
|---|---|---|---|---|---|---|
| | | Tidal Restoration | Berm | Levee | | |
| Coastal Dunes and Beaches | 124 | | | | | |
| Tidal Channels and Ponds | 173 | | | | 60[c] | 60[c] |
| Intertidal Mudflats | 33 | | | | 91[d] | 91[d] |
| Intertidal Salt Marsh | 176 | | | | 399[e] | 399 |
| Salt Marsh/Salt Panne | 439 | 37 | | | | |
| Transition | 610 | 252 | 7 | 2 | | |
| Disturbed | 366 | 157 | 16 | 4 | | |
| Mixed Transition/Disturbed | 181 | 35 | | | | |
| Brackish Marsh | 30 | | | | | |
| Riparian | 248 | 14[a] | 14[a] | 3[a] | 115[f] | 115 |
| Coastal Sage | 151 | | 9[b] | 3[b] | 44[f] | 10[g] |

[a] Primarily mulefat-dominated riparian habitat on upper part of flood plain.

[b] Areas of impacted coastal sage scrub occur outside of Reserve on Spooner's Mesa.

[c] Areas created below 0 foot NGVD.

[d] Approximate area between 0 and 1 foot NGVD.

[e] Approximate area created between 1 foot and 8 feet NGVD.

[f] Includes anticipated willow-dominated riparian acreage to be created east of river training berm (100 acres) and acreage to be created west of the berm (15 acres).

[g] Estimated acreage on face of berm or levee.

tidal channels (60 acres), intertidal mudflats (91 acres), and intertidal salt marsh (399 acres). In addition, new riparian habitat (115 acres) will be developed (Table 3-10).

Transitional habitat affected by the project represents between 42 and 44 percent of the total for this habitat type in the Reserve, depending on which river training structure is constructed, and most of this habitat type occurs in the south and central areas of the estuary. The project will replace lost transition habitat with tidal channels and tidal salt marsh, habitats more representative of the historic condition of the estuary. The large number of acres of transition habitat is due, no doubt, to the increased sedimentation rate in the estuary in recent years and is one of the indicators of the deterioration of the estuary. Without the project, much of the areas currently considered transition habitat would develop into upland, thus changing the character of the estuary.

Transitional habitat in the south arm of the Reserve may provide storm-high water refuge for non-aquatic species that use the intertidal marsh habitat as well as a roosting area for shorebirds and other water birds during storms and periods of high water. These values will be lost as a result of the restoration. Additionally, the restoration will reduce areas of high elevation that might in time offset the combined effects of accelerated sea level rise and reduced sedimentation rates. If sea level rises as is projected, elevations now supporting transitional habitat would be suitable elevations for marsh habitats to develop.

However, the loss of disturbed areas and mixed transition/disturbed habitat in the south arm will contribute to the overall net benefit of the project and help to offset the rapid deterioration experienced by the Reserve in the past several decades (Table 3-10). The affected areas will be converted to tidal channels, salt marsh, riparian, or coastal sage scrub habitat as a result of the project. The need for high ground near the new marshes will be assessed after construction of the Model Project and the first several modules and interactions between wetlands and transition/upland habitats are quantified and adjustments made in the design of subsequent modules.

The potential rise in sea level is an issue of profound concern for the long-term well-being of the estuary. However, given current uncertainty concerning the rate and extent of sea level rise and the critical decline in evidence in the estuary now, the proposed restoration is believed to be the prudent approach. Overall the project's impact to transition habitat, disturbed habitat, and mixed transition/disturbed habitat is not viewed as significant.

It may take up to an estimated 30 years or more for the restored tidal marshes to assume the functional characteristics and structure of natural marshes, once restoration has been completed. Included in the unpredictable constraints is the actual rate of sea level rise during the 30-year time period and whether the sedimentation rate in the marsh will be sufficient to keep up with increasing intertidal water levels. Monitoring of the restored marsh surface will help document the rise in sea level and resulting change in intertidal water elevations as well as sedimentation rates in the intertidal marsh surface. These data will be used to identify the need to implement additional remedial actions in keeping with the adaptive management approach to management of the Reserve. Prior to construction of additional project elements, the new information will be presented in a supplemental environmental assessment to allow a more detailed review then of the impacts of the proposed work.

The riparian habitat that will be affected by the project represents between seven and 11 percent of that habitat type in the Reserve depending on which river training structure is constructed. The riparian habitat that will be affected is dominated by mulefat and is considered to be potential habitat for the endangered least Bell's vireo. The loss of the riparian habitat will be replaced with riparian habitat dominated by willows to be created east of the river training structure and at the mouth of Goat Canyon. The willow-dominated riparian habitat will cover at least 100 acres and be located between the river training structure and the existing willow-dominated riparian habitat in the Tijuana River and will be developed on land currently being used for sod farming. The intent will be to create this riparian habitat by expanding the existing riparian habitat associated with the Tijuana River. The loss of riparian habitat would be significant but will be offset by the establishment of new riparian habitat. There is some question about the number of acres of riparian habitat that would be impacted by the 495-acre Restoration Project because of recent unpermitted filling of jurisdictional wetlands in the Reserve. Because of this, the final mitigation acreage will be determined in construction with the USFWS because of possible non-permitted (Section 404 of the Clean Water Act) fills into jurisdictional waters of the U.S., including wetlands that have occurred in the past three to five years.

The salt marsh/salt panne habitat that will be affected by the project, most of the acreage is salt panne. The salt panne habitat will be converted to tidal channel and salt marsh habitat. The loss of the salt panne will be permanent since there are no plans to restore salt panne habitat. The salt marsh affected by construction will eventually be restored and converted to tidal salt marsh.

Research indicates that the salt pannes result from historic disturbances to the area and that the area does not demonstrate the qualities typically associated with naturally-occurring salt panne habitat. The salt panne in the south arm is primarily non-tidal because the elevation is too high and the lack of channel connections. The area has been elevated by major sedimentation events (Appendix D). The area also has a long history of disturbance by agricultural, military and equestrian uses (Zedler and Nordby, 1986). Sewage spills currently lower the salinity of these pannes and allow weedy exotic plants to invade and further reduce habitat quality (Zedler et al., 1990). Surveys for native burrowing insects (e.g., tiger beetles) failed to show that the southernmost salt pannes had the values typically associated with tidal salt pannes.

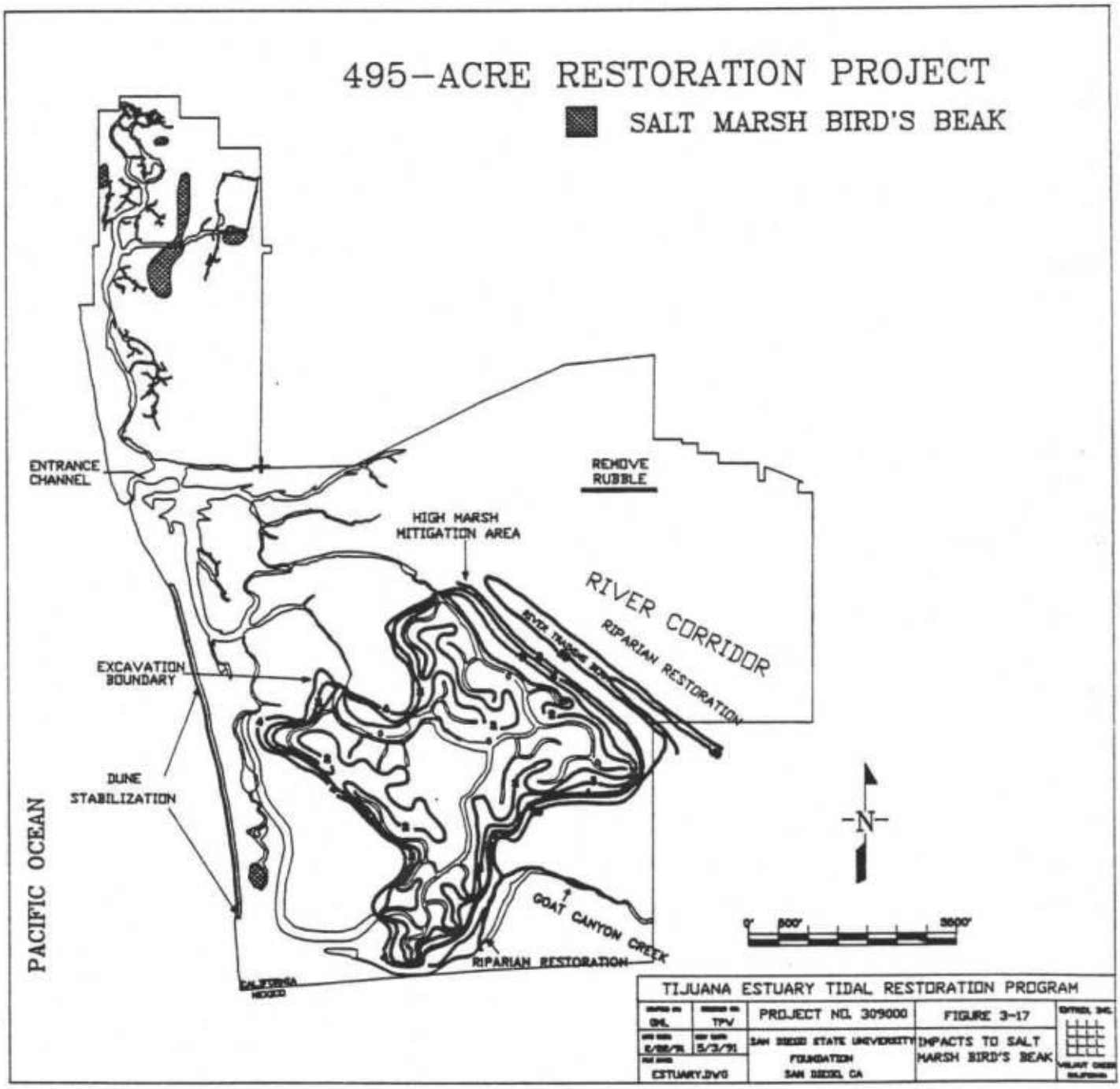
Horse corrals are visible in air photos of the salt panne area taken in 1970. Physical alterations to the land are still evident, including old berms and concrete structures. Historic maps suggest that much of the southernmost salt panne habitat was vegetated salt marsh. Because of the long history of disturbances, it is not clear how much of the salt panne habitat is natural and how much results from the combination of vegetation removal by farming and trampling, soil compaction from vehicles and the horse exercise track, sedimentation, and poor tidal flushing. While the project's impact to this habitat type is potentially adverse, the existing habitat value clearly is not high. The proposed restoration to tidal salt marsh will, to a large degree, restore historic conditions. The project will have a significant beneficial impact for salt marsh habitats at the expense of marginal salt panne areas. The loss to salt panne habitat may be significant but will be compensated for by the net environmental benefits resulting from the project.

The project will not affect natural populations of the endangered salt marsh bird's beak. Current information indicates that the salt marsh bird's beak does not occur within the boundaries of the project (Figure 3-17). Access roads will be routed to avoid known and possible habitats of all sensitive species, especially salt marsh bird's beak. This will be a particular concern in the area adjacent to the tidal channel extension proposal for the western portion of the south arm.

**Wildlife**

Wildlife in the Reserve will be affected by the loss of habitat associated with construction of the project, noise from the heavy equipment used during construction, and possibly by

Figure 3-17. Impact of 495-Acre Restoration Project on Salt Marsh Bird's Beak.



increased sediments entering the tidal waters near the construction areas. This section will address the first two subjects. The impact of sediments being released into the tidal waters will need to be addressed once the quality of the sediments is known.

**Birds.** During construction, birds probably avoid the immediate area of construction due to the presence of activity and the generation of noise. The largest habitat area affected will be the transition habitat. The birds using this habitat are characteristic of upland habitats. The project will result in the conversion of between 254 and 259 acres of transition habitat to tidal channels and salt marsh habitat (Table 3-11). Only a few of the birds, primarily raptors such as the northern harrier and black-shouldered kite, currently using the transition habitat will continue to use the area after restoration of the tidal habitats. The other birds will need to seek other areas. It is likely that the river training structure, once revegetated, will provide suitable habitat for many of these species.

The birds using disturbed habitats and mixed transition/disturbed habitats are similar to those using the transition habitat, although the numbers may be smaller due to the disturbed nature of the habitat. It is likely that these species also will use the upland areas of the river training berm.

Riparian habitat and salt marsh/salt panne habitat provide valuable habitat for birds. Riparian habitat that will be directly impacted by construction (Figure 3-18) is considered suitable, but currently not occupied. The riparian habitat outside the construction area that supports a greater diversity of plants, including willows, provides habitat for numerous species of birds including the endangered least Bell's vireo. Territory for the nearest breeding pair of least Bell's vireo occurred approximately 500 meters east of the northwest end of the river training structure (Figure 3-18). Other sensitive bird species reported to use the riparian areas in the Reserve include the golden eagle, peregrine falcon, and black-shouldered kite.

While the other sensitive species forage in the riparian habitat, the least Bell's vireo nests in it. Least Bell's vireos have been reported to occur in the riparian habitat east of the present PERL facilities in the south arm. Although outside the immediate area of construction, noise from the construction could affect the breeding of the Vireo. Decibel levels above 60 can mask the singing males and affect their ability to acquire a mate and breed. Currently, the landing field activities (helicopter flyovers) generate noise levels that may exceed the 60 decibel level. The construction-generated noise will contribute to

**Table 3-11. Change in Habitat Types and Acreage Resulting from the 495-Acre Restoration Project.**

| Habitat Type | Current acreage | Acreage After Project Implementation | | Net Change | |
|---|---|---|---|---|---|
| | | With Berm | With Levee | With Berm | With Levee |
| Coastal Dunes and Beaches | 124 | 124 | 124 | 0 | 0 |
| Tidal Channels and Ponds | 173 | 233 | 233[a] | +60 | +60 |
| Intertidal Mudflats | 33 | 124[b] | 124[b] | +91 | +91 |
| Intertidal Salt Marsh | 176 | 575[c] | 575[c] | +399 | +399 |
| Salt Marsh/Salt Panne | 439 | 254 | 254 | -185 | -185 |
| Transition | 610 | 351 | 356 | -259 | -254 |
| Disturbed | 366 | 193 | 205 | -173 | -161 |
| Mixed Transition/Disturbed | 181 | 131 | 131 | -50 | -50 |
| Brackish Marsh | 30 | 30 | 30 | 0 | 0 |
| Riparian | 248 | 335[d] | 346[d] | +87 | +98 |
| Coastal Sage | 151 | 195[e] | 161[e] | | |

[a] Areas created below 0 foot NGVD.

[b] Approximate area between 0 and 1 foot NGVD.

[c] Approximate area created between 1 foot and 8 feet NGVD.

[d] Includes anticipated willow-dominated riparian acreage to be created east of berm or levee (100 acres) from disturbed habitat and acreage to be created west of the berm or levee (15 acres).

[e] Estimated acreage on face of berm or levee.

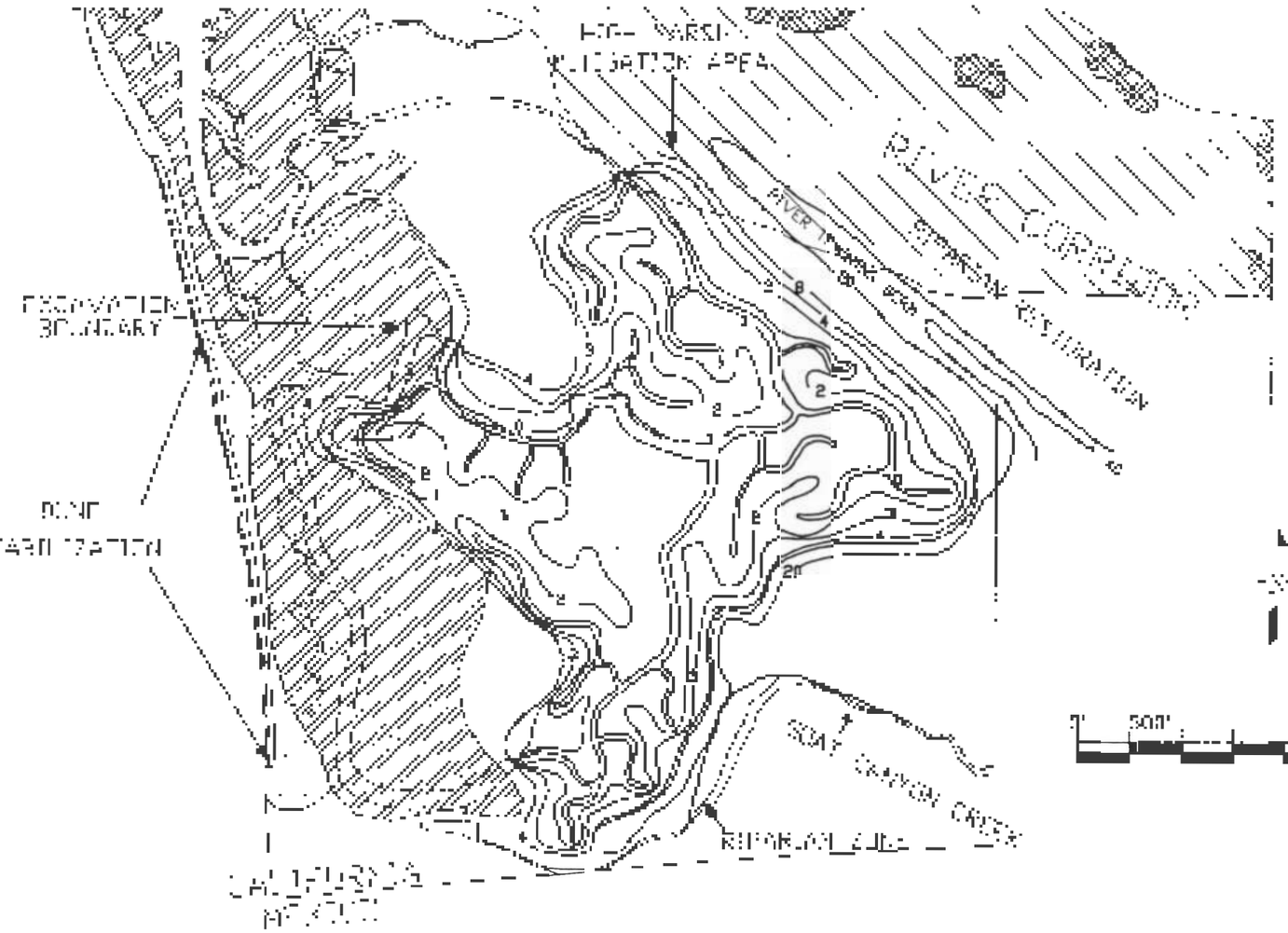
# 495-ACRE RESTORATION PROJECT

LEAST BELL'S VIREO POTENTIAL HABITAT

LEAST BELL'S VIREO NESTING TERRITORIES 1993

BELDING'S SAVANNAH SPARROW HABITAT (NESTING AND FORAGING)

BELDING'S SAVANNAH SPARROW FORAGING HABITAT




| | | | | |
|---|---|---|---|---|
| | | PROJECT NO. 309300 | FIGURE 3-12 | |
| | | SAN DIEGO STATE UNIVERSITY FOUNDATION SAN DIEGO, CALIFORNIA | HABITAT IN SPECIAL STATUS BIRD SPECIES | |

overall noise impacts to the vireo. Any such impact will be considered significant. However, assessment of the significance of this impact will need to be made after the detailed construction schedule is established and the types of heavy equipment to be used have been identified. This impact will be mitigated by phasing construction to avoid vireo breeding times, but the mitigation action will have to be developed in coordination with the U. S. Fish and Wildlife Service, Endangered Species Office.

The endangered (state) Belding's Savannah sparrow (Figure 3-18) and endangered light-footed clapper rail (Figure 3-19) have been reported to occur in the salt marsh/salt panne habitat areas that will be impacted by construction of the restoration marsh in the south arm. The impact areas represent only a small part of the full range of these species in the estuary. It is likely that these species will avoid the construction areas during active periods of construction. However, construction will be phased to avoid breeding and nesting periods, especially for the clapper rail. Once restoration of individual modules have been completed, monitoring will provide opportunities to study the colonization of created marshes by these species. Clapper rails have yet to use the 12-acre Connector Marsh within San Diego Bay and the Sweetwater Marsh National Wildlife Refuge or the cordgrass areas at the Chula Vista Wildlife Refuge. Therefore, it will be necessary to reduce impacts to these species during construction to the extent possible.

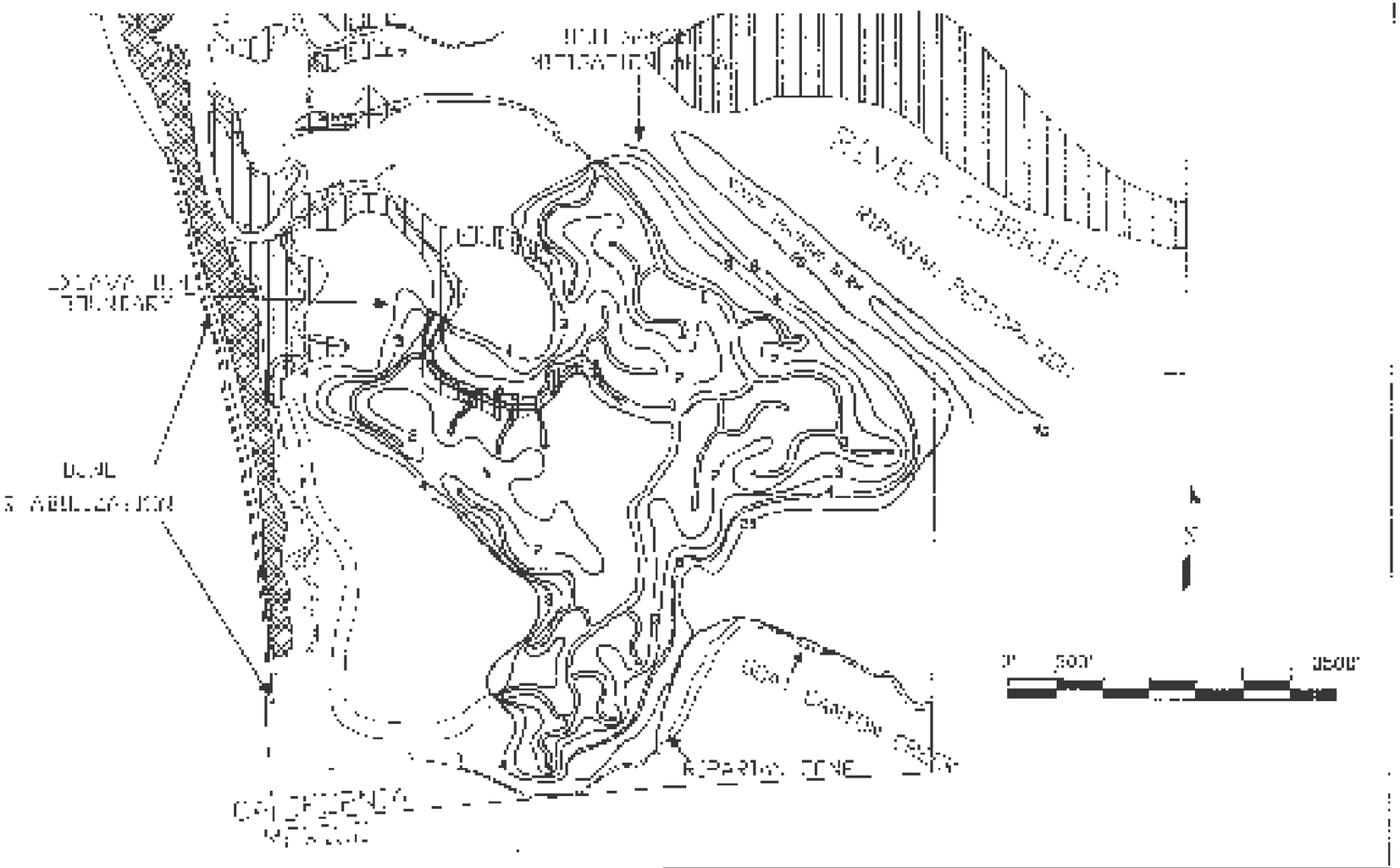
The endangered California least tern (Figure 3-19) and western snowy plover nest on the barrier beaches on the north and south side of the mouth of the estuary. The least tern forages in the main tidal channel of the estuary, including the sloughs in the central and southern part of the Reserve. The least tern is a visual predator and sediment plumes generated during construction could obscure the presence of potential prey in the water. This impact will be avoided, especially in the Reserve, by restricting construction to the time of the year that the tern are not present and implementing measures to reduce sediment entering the water.

The project will result in the development of more acreage of preferred habitat for these special status species, and other species that also depend on tidal salt marsh and tidal channel and mudflat habitat, than is currently present in the Reserve, especially in the south arm. In fact, the project is needed in order to preserve preferred habitat for these species. Without the project these species, especially the light-footed clapper rail, will be at greater risk of being eliminated from the estuary.

# 195-ACRE RESTORATION PROJECT

LIGHT FOOTED CLAPPER RAIL HABITAT

CALIFORNIA LEAST TERN NESTING HABITAT




| | | | |
|---|---|---|---|
| | PROJECT NO. 30900 | FIGURE 3-10 | |
| | SAN DIEGO STATE UNIVERSITY FOUNDATION | | |

The project is designed to provide additional habitat for endangered species and to insure that existing habitats remain tidally influenced. However, connecting new channels to existing channels in the north arm will require construction near rail and sparrow habitats; dredging the Oneonta Slough will occur in foraging habitat for terns and habitat for rails; work in the south arm will occur near sparrow habitats. Careful construction management and commitment to an adaptive management design approach will make it possible to avoid jeopardizing the very species for which this restoration project is designed. Several measures to be taken are listed below:

- Project construction in areas affecting habitat occupied or utilized by the California least tern, light-footed clapper rail, and Belding's Savannah sparrow will occur between September 16 and February 14.

- New channels will be constructed from their inland extent downstream toward tidal areas, with tidal flows blocked until connection is imminent.

- Any dewatering effluent will be disposed of in ways that will avoid impacts to adjacent habitats.

- Valuable vegetation and sod will be salvaged and transplanted.

- Data obtained in the Model Project phase will be used to improve plans for the build out.

- Problems identified in early modules will be corrected before proceeding with later modules.

- Unexpected benefits identified early in the restoration program can be capitalized upon in later modules.

**Fish.** The project likely will have a short-term impact on fish in the Reserve but this effect will be localized and not significant because few fishes remain in the south arm. The project will have a net beneficial effect on the fish in the estuary by increasing the area of channel habitat and increasing the quality of the tidal waters. By maintaining continual tidal flushing, the Reserve also will provide increased habitat value for coastal marine fish that depend on, or prefer, the estuarine systems for some part of their life

cycle. The major adverse impact to fish will result from the release of sediments into the tidal waters during construction. Potential effects of this impact will be assessed once the quality of the sediments has been determined. However, it is unlikely that the impacts would be significant because the impact will be temporary and the sediment plume quickly diluted in the tidal waters. A detailed assessment of impacts of project construction on fish will be presented as design components of the 495-acre Restoration Project are refined and supplemental impact assessments prepared.

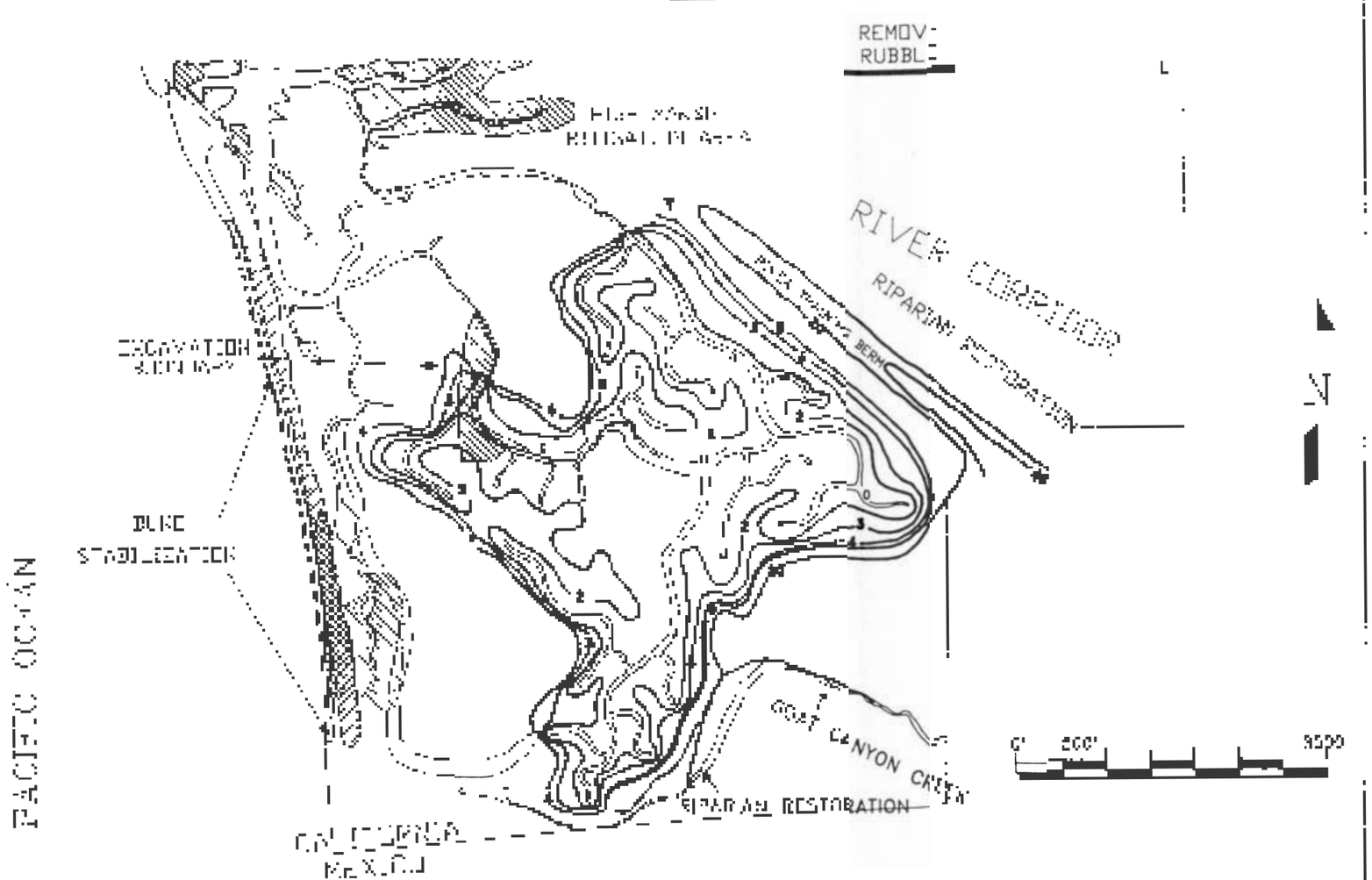
**Benthic Invertebrates.** The project likely will have a short-term impact on benthic invertebrates in the Reserve but this effect will be localized and not significant. The project will have a net beneficial effect on the benthic invertebrates in the estuary by providing more channel and intertidal habitat, and increasing the water quality. The project should eventually allow the structure of the invertebrate population to resemble that present in the tidal channels prior to 1978. The major adverse impact to benthic invertebrates would result from the release of sediments into the tidal waters during construction. Increased sediment load during dredging operations could affect the respiratory structures of the benthic invertebrates, especially those that rely on gills for respiration. However, the species likely to occur in this area of the Reserve are adapted to episodes of increased sediment loads in the water and subject to such conditions during periods of runoff following major storm events. Increased tidal flushing that will result from the project will produce a long-term beneficial impact and offset the short-term adverse impacts to benthic invertebrates resulting from project construction.

**Insects and other Arthropods.** The project will have minimal impacts on known populations of the more sensitive insects. Construction of the 495-acre Restoration Project in the south arm will affect known habitat for two species of tiger beetles (mudflat tiger beetle and Gabb's tiger beetle) (Figure 3-20) and the salt marsh wandering skipper butterfly (Figure 3-21). The loss of habitat for these species will be offset by the development of tidal marsh habitat. Although the ability of tiger beetles to invade new intertidal flats is unknown, as is their potential for deliberate transplant, they should be able to colonize the appropriate habitat in the vicinity of the newly created tidal marsh and mudflat habitat in the restoration areas. This is one of the hypotheses that will be tested as part of the Model Project and the findings used to provide beneficial conditions for the tiger beetle, and other beetle species, in later modules so that the project can benefit these beetles.

# 495-ACRE RESTORATION PROJECT

GLOBOSE DUNE BEETLE

TIGER BEETLES

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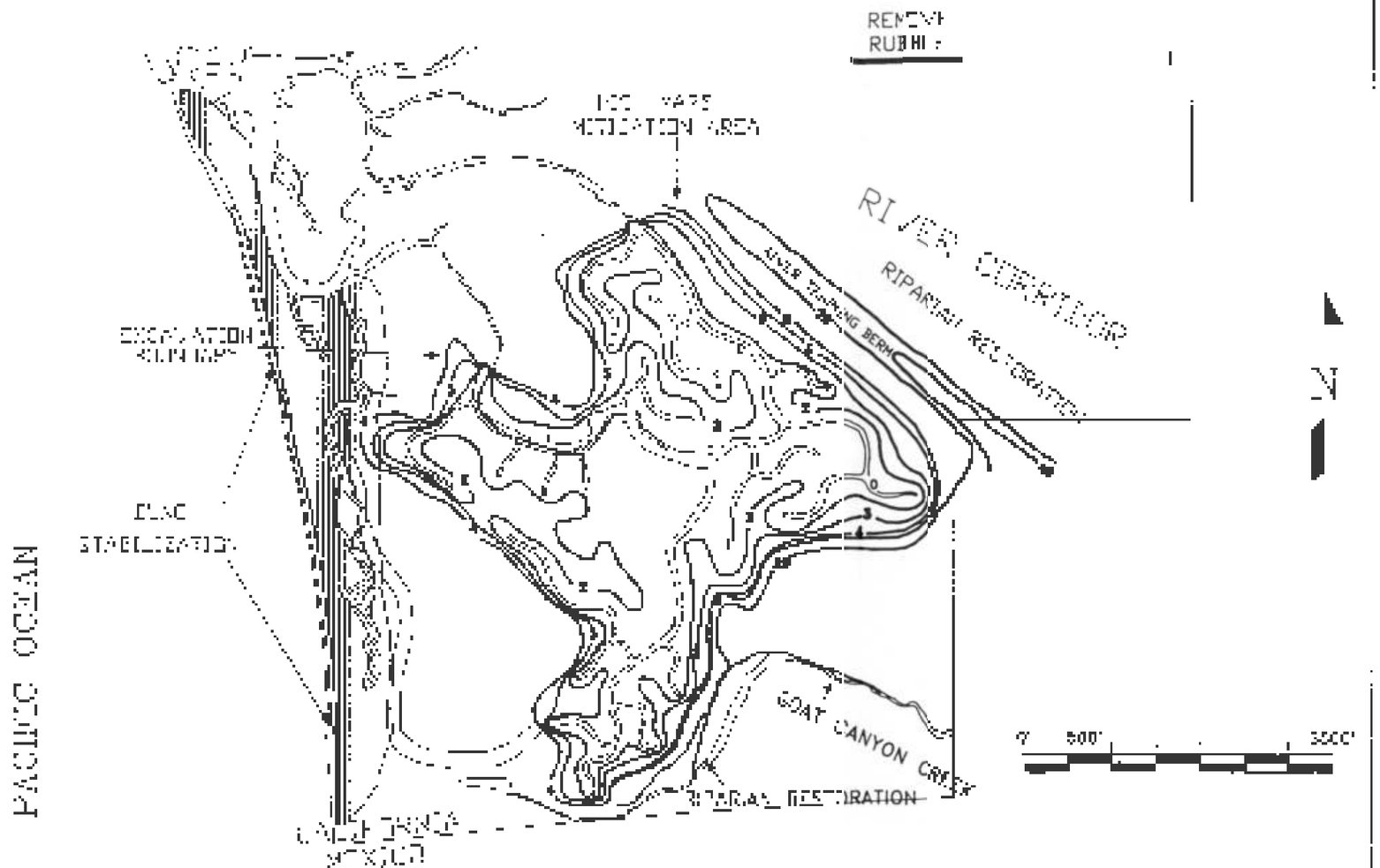
| | | | |

# 195 ACRE RESTORATION PROJECT

## WANDERING SKIPPER




| | | | |
|---|---|---|---|
| DRAWN BY: TAL | CHECKED BY: TPO | PROJECT NO: 90000 | FIGURE 3-12 |
| DATE: 2/25/91 | SCALE: 1" = 3/8/91 | SAN DIEGO STATE UNIVERSITY FOUNDATION SAN DIEGO, CA | IMPACTS TO SPECIAL STATUS INSECT SPECIES |
| FILENAME: 90000.DWG | | | |

The project will provide new acreage for salt grass, and any salt grass with the potential to be affected by construction will be salvaged and transplanted. If the salt marsh wandering skipper butterfly does not move, in of its own accord, transplantation of larvae will occur as part of an experimental pilot program. If successful it will be implemented in a larger-scale program. Due to the present uncertainties, it is important that steps be taken to avoid altering existing habitat for the butterfly.

**Reptiles and Amphibians.** Construction will eliminate the snakes and lizards that currently use the area. If the project results in an increase in the salinity of the ponded areas associated with historic channels of the Tijuana River that currently support amphibians, they will be eliminated from the ponds. The only sensitive species of reptile known to occur in the Reserve is the San Diego coast horned lizard. This species is not reported to occur in the area to be impacted by the tidal marsh restoration or model project but occurs in the dunes that will be stabilized. Stabilization of the dunes should benefit the horned lizard by providing additional refuge and possibly increased food supply that would be associated with the stabilized dunes. Loss of habitat for other species of reptiles and amphibians that are found in the estuary would not be considered significant. Upland slopes associated with the river training structure likely would provide habitat for the species of reptiles that occur in the Reserve.

**Mammals.** Mammals observed in the estuary are found primarily in habitats that flood infrequently, such as salt panne areas, transition areas, disturbed areas, and upland areas. None of the mammals reported to occur in the Reserve is considered sensitive. The project will result in the elimination of habitat for mammals, especially in the south arm. Species that will be affected are abundant in the area and the loss of habitat will not result in a significant impact. Once the project is completed, the river training berm will provide habitat for the species lost due to construction of the project.

**Special Status Species**

The project will likely have some level of impact on the following special status species:

- light-footed clapper rail
- California least tern

- Belding's Savannah sparrow
- least Bell's vireo
- salt marsh wandering skipper butterfly
- Gabb's tiger beetle
- mudflat tiger beetle

**Light-footed Clapper Rail.** The endangered light-footed clapper rail occurs in the tidal salt marsh habitat areas that will be impacted by construction of the restoration project in the south arm (Figure 3-19). Although the impact areas represent only a small part of the full range of these species in the Reserve, steps will be taken to reduce impacts to the clapper rail. Construction will be phased to avoid the nesting and breeding season of the clapper rail. Inventories of nesting areas will be performed prior to construction and occupied nesting areas that could be impacted identified. These studies and development of specific mitigation will be done in consultation with the USFWS, Endangered Species Office. Once construction has been completed, the newly created intertidal marsh habitat will be available to the clapper rails. Use of the adaptive management approach will allow scientists to assess the ability of clapper rails to move into newly restored areas and to use the new information to guide design of later modules.

**California Least Tern.** The endangered California least tern nests on the barrier beaches on the north and south side of the mouth of the estuary. The least tern forages in the main tidal channels of the Reserve (Figure 3-19). The least tern is a visual predator and sediment plumes generated by the project could obscure the presence of potential prey in the water. This impact would occur primarily during active construction and would not be expected to have a long-term affect on the terns. This impact will be mitigated by restricting construction to the time of the year that the terns are not present and by implementing measures to reduce sediment entering the water.

**Belding's Savannah Sparrow.** The endangered (state) Belding's Savannah sparrow have been reported to occur in the upper tidal salt marsh and salt panne habitat areas that will be impacted by construction of the project in the south arm (Figure 3-18). Although the impact areas represent only a small part of the full range of these species in the

estuary, impacts to the bird's habitat could be considered significant, especially if the impact leads to fragmentation of presently continuous habitat. It is likely that Belding's Savannah sparrow will avoid the construction areas during active periods of construction. Phasing of construction activity to avoid breeding and nesting periods will help reduce impacts to sparrow populations. Inventories of nesting areas will be performed prior to construction and findings coordinated with state Department of Fish and Game, Endangered Species Office representatives. It is expected that these impacts will be short-term and that impacts that do occur will be offset by the long-term benefits of the project. Data generated during the Model Project will be used to design future modules to reduce potential impacts to the sparrow as well as define appropriate measures to make the restored areas more attractive to the sparrow.

**Least Bell's Vireo.** While other sensitive species forage in the riparian habitat, the least Bell's vireo nests in it. Least Bell's vireos nesting territories have been reported to occur in the riparian habitat east of the present PERL facilities in the south arm (Figure 3-18). Although this area is outside the immediate area of construction, noise from the construction could affect the breeding of the vireo. Decibel levels above 60 can mask the singing males and affect their ability to acquire a mate and breed. Any such impact will be considered significant. Additionally, suitable habitat for the vireo will be impacted by project construction. However, assessment of the significance of this impact will need to be made after the detailed construction schedule is established and the types of heavy equipment to be used have been identified. This impact will be mitigated by avoiding construction during the breeding season and other mitigation action will be developed in coordination with the U. S. Fish and Wildlife Service, Endangered Species Office, if necessary. Land currently in agricultural use will be revegetated to create riparian habitat as mitigation for riparian habitat impacted by the project. This revegetation work, once established, is expected to result in a significant expansion of least Bell's vireo habitat in the eastern area of the Reserve.

**Salt Marsh Wandering Skipper Butterfly.** The preferred food plant for the larvae of the salt marsh wandering skipper butterfly (salt grass) occurs in the area of the project as well as the adult of the species (Figure 3-21). Construction of the marsh will result in the temporary loss of the larval food plants in the project area. This represents a negligible impact to the salt grass population of the preserve. However, because of the plant's significance to the salt marsh wandering skipper butterfly, special steps will be taken to safeguard it. Existing salt grass will be salvaged, to the extent possible, during

construction and transplanted when construction is completed. If the wandering skipper does not move of its own accord, transplantation of larvae will occur as part of an experiment. If successful it will be implemented in a larger-scale program.

**Gabb's Tiger Beetle and Mudflat Tiger Beetle.** Construction of the restoration marsh in the south arm will affect known habitat for tiger beetles (Figure 3-20). The loss of habitat for these species will be offset by the development of potential new habitat. Although the ability of tiger beetles to invade new intertidal flats is unknown, as is their potential for deliberate transplantation, we expect them to colonize the appropriate habitat in the vicinity of the newly created tidal marsh and mudflat habitat in the restoration areas. This hypothesis will be tested in the Model Project and the earlier modules and the findings used to provide beneficial conditions for the beetles in subsequent modules. This is a basic component of the adaptive management approach and should result in defining actions that will be beneficial to tiger beetles and other similar species.

## Regional Impacts

The preceding discussion of impacts to biological resources occurring in the Reserve addressed local impacts. This section addresses the impacts of the project on regional habitat values present in the Reserve. The discussion of the regional importance of the Reserve as a habitat for biological resources addressed four technical issues following the approach developed by Gosselink and Lee (1989). The first two issues, Boundary and Time Scale, relate to the scale of the study area to be used in establishing the baseline for performing a regional analysis and were discussed previously. The other two issues, Ecological Complexity of the System and Importance of Pattern in the Landscape, define landscape structure and function. The focus of the following assessment is on these latter two technical issues.

**Ecological Complexity of the System.** To address the ecological complexity of the system, the assessment should consider both the structure of the unit and its function. This can be accomplished by identifying: (1) acreage and habitat; (2) hydrologic regime; and (3) biotic diversity and species abundance, and assessing the regional change in these parameters resulting from the impacts of the project on the resources in the project area.

As wetlands are impacted and lost, the value of the remaining wetlands increases. This is because the remaining wetlands become a rare element in the regional landscape and those biological resources that depend on the wetland habitat also become rare on a regional level. The historic loss of coastal wetlands in San Diego County has been discussed in Section 3.5.1.4. Further loss of wetlands becomes significant because of the magnitude of past losses.

The 495-acre Restoration Project is designed to increase wetland resources in the region by reversing the local deterioration of the Tijuana Estuary. The project will result in the loss of a large number of acres of transition and disturbed habitat (Table 3-10). However, much of the transition habitat has formed as a result of increased sedimentation rate in the Reserve. Historically, most of what is now transition habitat was tidal salt marsh. This conversion to transition habitat has contributed to the loss of wetland resources in the region and the project is designed to reverse this trend in the Reserve. The 495-acre Restoration Project will reverse this trend by converting a substantial portion of the transition habitat to intertidal marsh.

The project will create approximately 399 acres of salt marsh habitat, 91 acres of intertidal mudflats, and 60 acres of tidal channels (Table 3-10). When added to the existing tidal habitat in the Reserve, there will be a total of approximately 260 acres of tidal channels, 124 acres of intertidal mudflats, and 575 acres of tidal salt marsh. This represents approximately a 67 percent increase in tidal habitat in the Reserve and a nearly 20 percent increase in the regional acreage of salt marsh (see Table 3-5), which is a significant increase both at the local and regional level. Additionally, approximately 115 acres of willow-dominated riparian habitat will be created to mitigate the loss of about 28 acres of mulefat-dominated riparian habitat.

One of the major contributing factors in the loss and deterioration of coastal wetlands in San Diego County has been alteration of the hydrologic characteristics of the various wetland systems. Construction of roads and other linear structures across the mouth of many of these systems has resulted in the permanent or near permanent closure of the mouth of many of the coastal wetland systems. Major modification of the mouth and interior portion of the affected wetland systems would be necessary to return them to a tidally-flushed system.

The Reserve is noteworthy in that the mouth is not constrained by construction at or near its mouth. The project will increase the tidal prism, thereby decreasing the risk of mouth closure, by creating tidal channels in the Reserve and not by constructing major structures at the mouth. The hydrologic design is not a reconstruction of channels as indicated on the 1852 map but rather an attempt to expand the remaining channels in areas that will have maximum negative impact on existing biota.

The one unnatural project feature, the river training structure, is designed to prevent sedimentation resulting from flood flows in the Tijuana River. Without the structure, sedimentation would fill the restored marsh, reduce the tidal prism and result in the need for an ongoing maintenance dredging program in order to keep the mouth open. Loss of tidal flushing would again lead to rapid deterioration of the tidal marsh system throughout the estuary and would threaten the existence of special status species such as the light-footed clapper rail and Belding's Savannah sparrow. Because of the regional importance of the Tijuana Estuary as habitat for several endangered species, maintaining an open tidal inlet and full tidal flushing is an important benefit of the project.

Without the project, the diversity of habitats and species likely would be lower as indicated by the present ongoing processes. Sedimentation would eventually elevate most of the tidal marsh areas above the normal tidal range. A large area of the Reserve would be transition habitat and an ever decreasing area would be tidal marsh. High wave action would contribute to the deterioration, as it has in the past, by transporting large volumes of sand into the main tidal channels that occur along the east side of the barrier beaches.

Because the Tijuana Estuary is one of the few relatively natural coastal tidal marsh systems in the region, its loss or continued deterioration would reduce the diversity of habitat in the region. Also, because of its relatively undisturbed nature, the Tijuana Estuary supports one of the most diverse arrays of biological resources in the region, including probably the largest number of special status and sensitive species reported to occur in coastal wetlands. The project will not only contribute to the continued existence of these species in the Reserve, but in the region as well.

**Patterns in the Landscape.** In Section 3.5.1.4 the existing patterns in the regional landscape was assessed by looking at habitat patterns, habitat contiguity, biotic diversity, and tidal regime. As described above, the project will change the habitat patterns in the

Reserve. Transition habitat will decrease by about 60 percent but tidal habitat (tidal channels, tidal mudflats, and tidal marsh) will increased by about 67 percent. This represents a significant change in habitat pattern but the result will be beneficial. Tidal marsh will increase by nearly 400 acres at the Reserve, which represents nearly a 25 percent increase in tidal marsh habitat in the region. Because of the value of tidal marsh habitat to the special status species and other sensitive species, this increase represents a significant beneficial impact of the project on a local and regional scale.

Tidal flushing contributes to the value of coastal wetland habitats. Marshes that are tidally flushed usually support larger and more diverse populations of plants and animals. The adverse impacts of reduced or no tidal flushing was readily evident from the studies performed by Dr. Joy Zedler and other researchers from PERL during 1983 and 1984 when the mouth to the estuary closed (see Zedler and Nordby, 1986). Keeping the mouth open will contribute to the diversity of habitats present at the Reserve, the wildlife that utilize these habitats, and the special status and other sensitive species that rely on the tidal marsh system for their existence.

The 495-acre Restoration Project will result in an increase in tidal marsh habitat at the Reserve and in the region. Any increase in tidal marsh habitat is a benefit as long as it is not accomplished to the detriment of other important habitats. The loss of transition and disturbed habitats as a tradeoff for the creation of tidal marsh habitat is an acceptable loss because the transition and disturbed habitats have relatively lower habitat value, and have developed at the expense of tidal marsh habitat.

Transition habitat is usually less important to marsh organisms than intertidal habitat, but higher ground is essential for pollinators of the salt marsh bird's beak, and higher ground becomes critical to marsh animals during extreme high water. In the long-term, higher ground will be needed for the salt marsh to migrate as sea level rises. Thus, a mixture of habitat types is needed. The restoration program preserves sites of high-value transition habitat (e.g., south of the tidal ponds). The river training berm will provide high ground along the eastern periphery of the restoration project. Completion of early modules will allow an opportunity to determine what new sites begin to serve as high-tide refuges for wetland birds.

**Waters of the United States**

The number of acres of Waters of the United States that will be affected by the project is presented in Table 3-12 and shown in Figure 3-22. The project will result in the short-term loss of approximately 200 acres of Section 404 wetlands, three acres of Section 10 (Rivers and Harbors Act) and Section 404 Other Waters of the United States, and an additional 124 acres of Section 404 wetlands in the category of Section 404 Wetlands with Isolated Non-wetland Areas (non-wetland areas account for an estimated 10 percent of the total in Table 3-12). The total acreage of potentially jurisdictional wetlands and other waters of the United States is 334 acres.

The project, once construction of all modules has been completed, will create 502 acres of jurisdictional lands including 411 acres of Section 404 wetlands and 91 acres of Section 10 and Section 404 Other Waters of the United States.

As originally stated (National Wetlands Policy Forum, 1988), the "no net loss" policy calls for maintenance of both acreage and function, and for an increase in the quality and quantity of the nation's wetlands base. This project will have short-term negative impacts to the functioning of habitats near the construction site, and long-term benefits to function of the estuary as a whole. It will show a net increase in the area of wetland. Thus, it fulfills the intent of the no net loss policy. This will produce a net increase in Section 404 wetlands of 211 acres, and 91 acres of Section 10 and section 404 other waters. The project will result in a net increase of jurisdictional areas of 299 acres.

### 3.5.2.3 Mitigation

**Model Project.** Vegetation will be salvaged from the areas to be impacted by the Oneonta Slough widening and construction of the connector channel and transplanted along the connector channel and other suitable locations. The constructed 20-acre marsh will be allowed to develop into a tidal marsh system, which will result in an increase in intertidal marsh habitat. Areas impacted by construction-related activities (access roads) will be rehabilitated after construction. To the extent possible, repeated impacts to the marsh will be avoided.

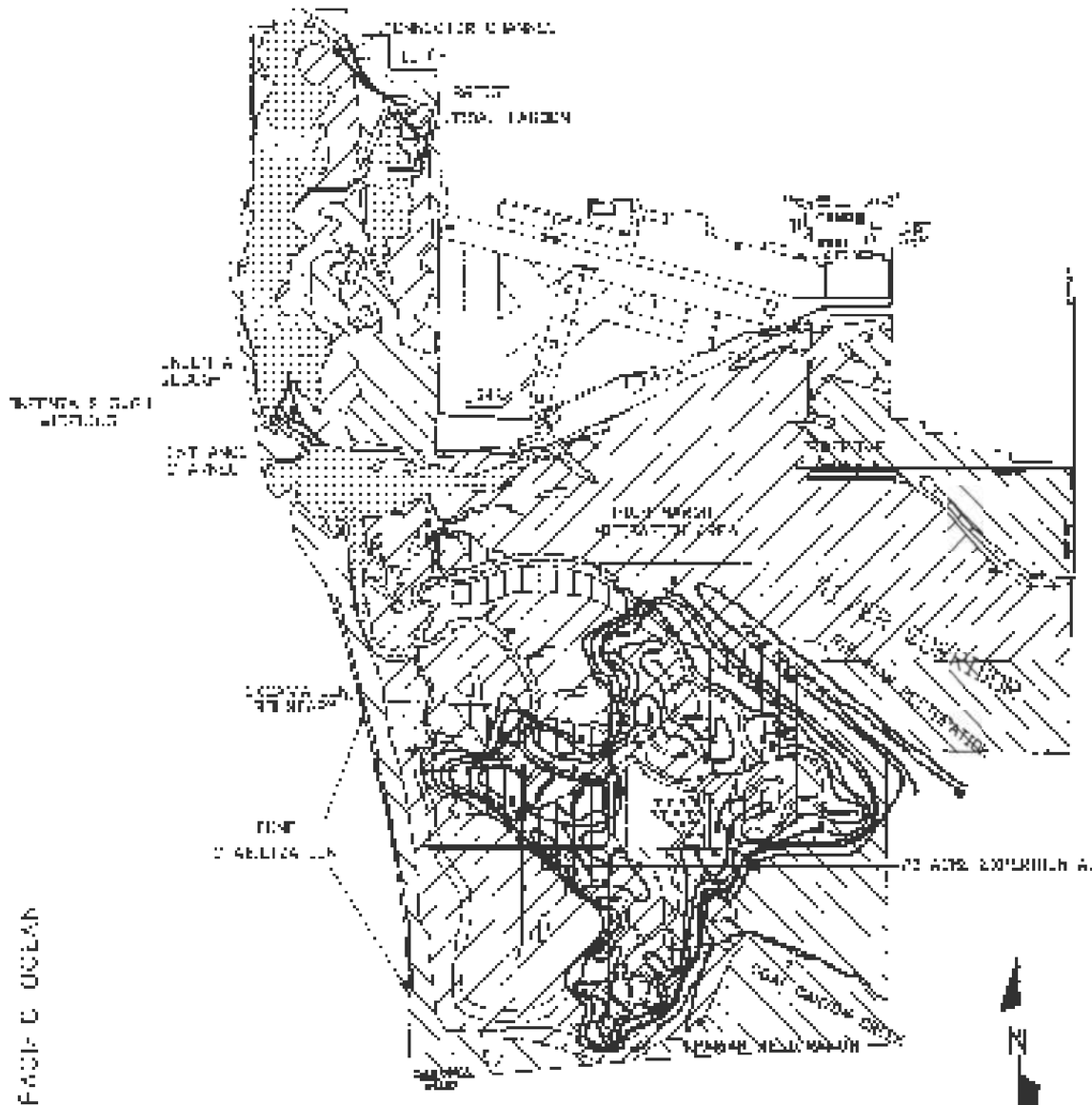
**Table 3-12. Acreage of Waters of the United States Affected by the Project.**

| Category | Acreage in Estuary | Acreage Impacted by Project: Tidal Restoration | Acreage Impacted by Project: Berm | Acreage Impacted by Project: Levee | Projected Acreage Created by Project: With Berm | Projected Acreage Created by Project: With Levee | Net Increases in Jurisdictional Areas: With Berm | Net Increases in Jurisdictional Areas: With Levee |
|---|---|---|---|---|---|---|---|---|
| Section 404 Wetlands | 1,207 | 172 | 15 | 4 | 411 | 411 | 224[c] | 235[c] |
| Section 404 Wetlands with Isolated Non-Wetland Areas | 222 | 127 | 6 | 1 | | | | |
| Section 10 and Section 404 Other Waters | 231 | 3 | 0 | 0 | 91 | 91 | 88 | 88 |
| PERL | 23 | 23 | 0 | 0 | | | | |
| Disturbed | 9 | 9 | 0 | 0 | | | | |
| Non-Jurisdictional Lands | 839 | 140 | 18 | 5 | 44[c] | 10[b] | | |

[a] Total project footprint for project with berm is 540 acres; with levee - 507 acres.

[b] Estimated acreage on face of berm or levee.

[c] Does not include 100 acres of riparian habitat that would be created east of the river training structure as mitigation for project impacts to existing riparian habitat. Riparian mitigation would occur primarily on non-jurisdictional lands and some jurisdictional lands.



## LEGEND

| KEY | DESCRIPTION | ACREAGE |
|---|---|---|
| | SECTION 404 WETLANDS | 1307 |
| | SECTION 404 WETLANDS WITH ISOLATED NON-WETLAND AREAS | 242 |
| | SECTION 10 AND SECTION 404 OTHER WATERS (TIDAL CHANNELS/MUD FLATS) | 251 |
| | PACIFIC ESTUARINE RESEARCH LAB | 93 |
| | DEVELOPED/DISTURBED AREAS IN FLOOD PLAIN (NON-JURISDICTIONAL) | 9 |
| | NON-JURISDICTIONAL LANDS | 859 |

0 2000 4000 6000

Scale (ft)

Sensitive habitat (i.e., coastal salt marsh, riparian) will be replaced at a *minimum* of 3:1. The replacement foraging and nesting habitats will be developed in the connector channel, which will be expanded to accommodate additional marsh habitat, and at the 20-acre marsh. In addition, areas of marsh, such as in the vicinity of the Oneonta Slough widening, that are degraded and would benefit from rehabilitation, will be rehabilitated. The timing of construction will be restricted so as to avoid affecting nesting and foraging behavior of special status species. Widening of Oneonta Slough and construction of the connector channel will be restricted to the months of November through the first half of February.

**495-Acre Restoration Project.** The Tijuana Estuary Tidal Restoration Program has been designed to solve problems associated with the ongoing deterioration of the Tijuana Estuary. Although the project will, itself, impact some present values, the long-term impact of the project will be beneficial to the overall value of the estuary. The Model Project will explore methods for facilitating restoration of the intertidal marsh. Information developed from the Model Project will be useful in defining the specific restoration protocol such as soil amendment procedures, planting procedures, local network of channels. Supplemental environmental impact assessments will benefit from the information obtained from experiments and monitoring associated with the Model Project and will allow a more detailed analysis of the impact of the proposed work.

The project will create 399 acres of intertidal salt marsh habitat, 44 acres of coastal sage scrub (if the river training berm is constructed), 91 acres of mudflats, and 60 acres of tidal channels. Additionally, over 115 acres of willow-dominated riparian habitat will be created. Up to 10 acres of coastal sage scrub would be created if the levee is constructed.

Clapper rail and Belding's Savannah sparrow habitat impacted by excavation and construction will be mitigated at a *minimum* of 3:1. The 495-acre tidal marsh will provide the area to develop the mitigation habitat. Riparian habitat will be developed east of the river training structure or levee and at the mouth of Goat Canyon. This habitat will mitigate for the loss of mulefat-dominated riparian habitat and disturbance (noise) to least Bell's vireo habitat. Habitat for insect species of concern will be created at the 495-acre tidal marsh. The timing of construction will be limited to October, November, January, and the first half of February to avoid disturbing special status species.

Construction of the individual modules in the south arm may present special problems because of the nature of the substrate. Depending upon the load bearing capacity of the substrate to be excavated or dredged, special low-load bearing heavy equipment may be necessary to prevent the equipment from sinking. The need to use such special equipment will be determined on a case-by-case basis and will be addressed in the supplemental environmental documents developed for each module.

During construction, the size of the construction area will be kept to the minimum to avoid unnecessary impacts to the marsh surface. Any stockpiling of dredged or excavated material will be off the marsh surface, to the extent possible. Access roads will be routed to avoid the more sensitive marsh surfaces, especially intertidal areas. The route of the access roads will be selected under direction of the Management Authority using guidance from the scientists at PERL.

Subsequent to construction, the surface of the marsh disturbed by access roads, stockpiling, and other construction activities will be rehabilitated. Restoration of compacted areas will be accomplished by first loosening of compacted soil (perhaps with a post-hole digger) and immediate replanting of the loosened area with plugs of appropriate native vegetation following protocols established by the scientists at PERL (e.g., Zedler, 1984).

The success of the restoration will be monitored to insure success of restoring the areas affected by construction. The details of the marsh monitoring plan are discussed below.

**Tidal Marsh Monitoring.** The monitoring program will continue for several years, to include the year of implementation for each module and at least five years thereafter. Construction may begin on subsequent project modules upon the approval of the Management Authority and permitting agencies once the first year of assessment of the Model Project has been completed. Should large gaps in time develop between modules, the monitoring program may be reduced in scope until the next module is implemented. Then, a resumption of the full-scope monitoring program is required for the project year and five following years. During year ten after the initial phase project and after the final module, a reassessment shall take place to determine if long-term goals are met.

Throughout the monitoring program, results must be reviewed by university scientists, agency biologists, and other interested parties for adequacy of sampling and

understanding of results. The monitoring program follows an adaptive management approach that allows for adjustments depending on findings and problems encountered along the way (PERL, 1990).

The monitoring plan will address a number of subject areas that are felt to be key to the successful development of artificial marsh systems. These areas are addressed below.

1. **Hydrology:** Each increment of tidal prism increase should expand the area influenced by tidal flow and increase the probability that the mouth will remain open to tidal flushing.

*Assessment Criteria:*

Tidal monitoring at selected stations before and after dredging/grading should show rising and falling water levels; tidal lags and damped amplitudes (relative to stations at the mouth) to be quantified. Water column characteristics to indicate improved vertical mixing. Potential tidal prism should approximate that predicted by the chosen alternative. Cross-sectional area at mouth to indicate low probability for closure on neap tides during non-river-flood conditions.

*Measurements to be Taken:*

- Tidal channel cross-sections at select locations in channels
- Depth and duration of tidal inundation at select locations in channels
- Measure cordgrass heights and cover all plant species and compare to data for natural sites being monitored in Oneonta Slough (Zedler et al., 1990; Langis et al., 1991).

2. **Water Quality:** Dredging should expand the area influenced by tidal seawater, resulting in improved water quality and less frequent periods of stagnation.

*Assessment Criteria:*

At stations within and immediately upstream and downstream of the channel dredging sites, several variables should show increased similarity with conditions at the estuary mouth:

- salinity should be closer to 34 ppt during the non-rainy season and between riverflow events,
- salinity and water temperature should be less variable than before dredging,
- the bottom of the water column should not become anoxic, and
- phytoplankton should not accumulate.

*Measurements to be Taken:*

- Measure vertical profiles of temperature, salinity and dissolved oxygen in channels at select locations within the marsh and adjacent channels.

3. **Soils:** The soils in areas that are brought under tidal influence by dredging/grading should develop physical and biological conditions that are more similar to those for the intertidal marsh near Oneonta Slough.

*Assessment Criteria:*

Nutrient concentrations (particularly nitrogen) to become more similar to those of the marsh along Oneonta Slough; redox conditions and sulfide concentrations to develop similar patterns as in Oneonta Slough marsh soils, and soil organic matter to have concentrations similar to marsh soils of Oneonta Slough.

*Measurements to be Taken:*

- Sample soil salinity quarterly and other measures annually along pre-determined transects (10-12 m) at selected elevations,

- Measure bulk density, soil pore water nitrogen, soil pore water salinity, redox potential, water content.

4. **Vegetation Composition and Growth:** Native salt marsh plants (using salvaged material, other material from local gene pools and best-available propagation procedures) will be transplanted to appropriate locations of each construction module, based on the findings of the experimental marsh. From these transplantations, and from any "volunteer" establishment events, the salt marsh vegetation should expand into areas of suitable intertidal elevation and subjected to increased tidal flushing. Populations to show expansion initially, and persistence through time. Species composition to mimic that of Tijuana Estuary before inlet closure (Zedler, 1977) or that of Sweetwater River Marsh, as described in the assessment protocol defined in PERL (1990).

*Assessment Criteria:*

Total vascular plant cover and height characteristics to mimic that at Tijuana Estuary prior to inlet closure. This goal should be achieved within five years of dredging. The presence of populations of all marsh species known to inhabit Tijuana Estuary under conditions of good tidal flushing to be present at their respective intertidal (i.e., inundation/salinity) sites and approximate relative abundances to be achieved within 10 years of dredging.

*Measurements to be Taken:*

- Use aerial photographs to estimate vegetative cover and open space,

- Set up 30-m permanent transects along elevation contours relative to vegetation communities (low, middle, high marsh) and measure species occurrence and abundance using the line-transect method at the end of each growing season.

5. **Marsh Insects:** Selected species to invade habitats newly opened to tidal influence. The full complement of insect and other arthropod guilds (pollinators, predators, prey, herbivores) is expected to develop, such that essential functions

(e.g, pollination, herbivore control) are carried out and no irruptions of herbivores develop.

*Assessment Criteria:*

Sampling to determine if functional groups are present in each habitat, with similar orders as in comparable habitats along Oneonta Slough. More detailed sampling of rare species (e.g., wandering skipper, tiger beetles, globose dune beetle) to determine if suitable habitats are being used at approximately the same intensity as comparable sites along Oneonta Slough.

*Measurements to be Taken:*

- Pantraps set out in January and July for 48 hours (only in areas that could not house sensitive species such as tiger beetles),
- Sweep net samples of marsh areas along pre-determined transects,
- Visual surveys of sensitive species for presence/absence and relative abundance,
- Visual surveys to document herbivory problems.

6-7. **Fishes and Aquatic Invertebrates:** Fishes and invertebrates to become established in new channels and mudflats, with communities initially similar to those of northern Oneonta Slough (5-year goal) and eventually (10-year goal) similar to those of Tijuana Estuary prior to inlet closure or similar reference wetlands provided in the Assessment Protocol (PERL, 1990).

*Assessment Criteria:*

Populations of fish and invertebrate species to increase rapidly to relative abundances in Oneonta Slough; eventually to include species previously abundant at Tijuana Estuary and still abundant at reference wetlands. Exotic species to be documented and control measures identified or developed.

*Measurements to be Taken:*

- Macroinvertebrates sampled quarterly with replicate cores,
- Fish sampled in channels quarterly using blocking nets and a beach seine (fish measured, identified and released).

8. **Birds:** Shorebirds, waterfowl, Belding's Savannah sparrows, California least terns and the light-footed clapper rail will expand into areas of new tidal influence. Documented uses to include feeding, especially by the shorebirds and California least tern.

*Assessment Criteria:*

Censuses of birds to show increased habitat use in areas of increased tidal flushing. Foraging studies to document feeding success in newly tidal areas.

*Measurements to be Taken:*

- Transects will be sampled with sightings recorded at specified distances along the "belt" of the transect (sampled monthly except during migratory periods, which will be sampled weekly).

9-10. **Herpetofauna and Mammals:** With conversion of non-tidal, disturbed transition and/or upland habitats to intertidal influence, the area suitable for use by herpetofauna and mammals will most likely decrease.

*Assessment Criteria:*

These losses (impacts of tidal enhancement) will need to be documented through censuses for snakes, lizards, amphibians and small mammals. Stations sampled during the pre-project census should be resampled after implementation, at comparable seasons. The value of the river training berm as habitat for herpetofauna and mammals will be assessed. The association of valued species with measured habitat characteristics would suggest improvements over larger areas of the berm.

*Measurements to be Taken:*

- Pitfall traps will be used to sample reptiles along the periphery of the tidal marsh (see Appendix K.4).

- Mammals will be sampled along the periphery using sherman traps and mark and recapture methods.

- Visual observations of both phyla, cumulative species lists maintained.

## 3.6 CULTURAL RESOURCES

### 3.6.1 ENVIRONMENTAL SETTING

A cultural resources survey of the Model Project area was conducted by archaeologists from Affirmis in July and August, 1991. Their findings are presented in Appendix M and summarized below. A separate study will be necessary for the 495-acre Restoration Project.

Masters' reconstruction of the paleo-coastlines of the San Diego Bight indicates that at 10,000 years ago, the Otay and Tijuana Rivers both opened onto the coast, and the valleys formed tidally flushed lagoons for at least part of the year. "The period between 10,000 and 8,000 years B.P. may have coincided with a peak in such habitats for the San Diego Bight" (Masters, 1988). The coastline at 10,000BP (before present) was approximately 2.5 miles (4 km) farther west than at present (Masters, 1988). Two thousand years of more rapidly rising sea level followed, and by 6,000BP the paleo-bay extended essentially the full length of the modern bay (Masters, 1988). The bay environment was well-developed by 3,500BP with modern habitats and dimensions similar to the present situation. The Chollas, Sweetwater, and Otay Rivers all emptied into the bay (Masters, 1988).

In the Santa Barbara region, it has been suggested that between roughly 12,000 and 8,000 years BP the Coastal Plains supported a pine forest. After 8,000 years BP, as the climate became warmer and drier, the pine forest was replaced by oak and non-arboreal

communities, and more open habitats were available. Optimal conditions for this development appear to have occurred around 5,000 years ago. After 2,200 years BP, the coastal sage scrub and chaparral communities seem to have become increasingly prominent, perhaps related to increased manipulation of the environment by aboriginal populations. A similar sequence of climatic change could be expected for the San Diego area.

The diverse habitats discussed above support (and would have supported during prehistoric times) a diversity of faunal species. Deer and small mammals make use of grassland, chaparral, and coastal sage scrub communities. The estuary itself, the nearby open coast, and San Diego Bay provide a number of finfish, shellfish, and bird species, and invertebrates as well as salt marsh plants.

Several recent summaries discuss the prehistory of San Diego County and provide a reasonable background for understanding the archaeology of the general area of the Reserve. Moratto's (1984) review of the archaeology of California contains important discussions of Southern California, including the San Diego region. Papers by Bull (1983, 1987), Carrico (1987), Gallegos (1987), Smith (1987), and Warren (1985, 1987) provide summaries of recent work and interpretations.

The general area surrounding the project has produced a large number of archaeological remains. Proponents of the controversial "Early Man" stage, a period also called the American Lower Paleolithic (Carter, 1978), have recorded sites they believe are related to this stage along the international border near San Ysidro (Minshall, 1976). While it has been suggested that this stage may date to the Pleistocene (Carter, 1957, 1980), most archaeologists do not accept most of the material as having been produced by humans, and do not accept such early dates for humans in the Americas.

The San Dieguito complex, generally accepted by regional archaeologists as the earliest archaeological manifestation in San Diego (Warren, 1967), is also represented on sites in the general area of the project site. San Dieguito remains were reported by Malcom Rogers from the Tijuana River Valley (Rogers, 1966;181) and they were also recovered in excavations at Border Field State Park (Bingham, 1978). This excavation was not recorded with either SCIC or the San Diego Museum of Man. Sites representative of the remainder of the recognized complexes in coastal southern San Diego County have also been reported in the area (cf. Bingham, 1978, Robbins-Wade et al., 1987, Wade, 1986).

The ethnohistoric village of Millejo is recorded less than a mile (1.4 km) to the east of the project area. Portions of Millejo are represented by two site numbers. CA-SDi-10, 669 (SDM-W-1140) was recorded by Shipek, based on historic and ethnographic data, rather than archaeological evidence. CA-SDi-10, 967 (SDM-W-2460) was also recorded as Millejo; however, the recorders referenced Shipek's site record for CA-SDi-10, 699 (SDM-W-1140). Apparently, they considered CA-SDi-10, 967 (SDM-W-2460) to be another part of the village.

Records searches were requested from the San Diego Museum of Man and the South Coastal Information Center at San Diego State University for the project area and a one-mile radius. Fifteen archaeological sites have been previously recorded within a one-mile radius of the property. These resources include: five lithic scatters consisting of debitage, cores, and tools; one site recorded as a quarry; five sites or scatters of shell, cores, and debitage; one deep shell midden; one contact era Kumeyaay village site, called Millejo; and one historic building site with a cobble and cement wall and foundation and associated purple glass, ceramics and metal (see Appendix M, Table 1).

Few, if any, temporally diagnostic artifacts have been found, and little material suitable for radiometric dating has been recovered. The nearby village of Millejo was occupied by the Kumeyaay during Late Prehistoric times and after the arrival of the Spanish, until at least 1850 (site record for CA-SDi-10, 699, on file at South Coastal Information Center). Roeder recorded a portion of the village (CA-SDi-10, 967) as "Possibly La Jollan?" (site record for CA-SDi-10, 967, on file at South Coastal Information Center). Carter recorded an isolated boulder core as being "of quite great age--perhaps belonging to the 130,000 year terrace" (site record for CA-SDi-10, 966, on file at South Coastal Information Center). Many archaeologists remain skeptical of Carter's Pleistocene artifacts, and this site (CA-SDi-10, 966) has already been destroyed, so there is no way to substantiate its antiquity.

Of the 15 archaeological sites recorded within a one-mile radius of the project area, no suggestion as to temporal period was made for eight of the sites. Two sites were recorded as "possibly associated with San Dieguito"; another two sites were recorded as possibly San Dieguito or La Jollan. One site was suggested to be possibly La Jollan or late prehistoric (Kumeyaay) and the remaining two sites were assigned to historic/contact provenance.

Two prehistoric sites were identified during a survey of the Model Project site. These sites have been temporarily designated Site 1 (Oneonta Slough) and Site 2 (20-acre marsh), until permanent trinomials are assigned by the South Coastal Information Center.

Site 1 is located on a point of land extending out into the channel. Artifacts were found at the interface between compact silt stones (which contained shell in growth position) and overlying consolidated sands. Cultural materials observed were shell, flaked lithic debitage and fire-altered rock. Cultural remains formed a lag deposit that also included more recent artifacts related to recreational use of the area. Examples of this type of material included shell casings, glass, nails, and brick.

The 20-acre marsh, Site 2, occurs in a similar geomorphological setting. Artifacts were eroding from a silty matrix and included a fine-grained metavolcanic core and three flakes. A variety of shell, notably chione *(Chione sp.)*, was also present. Concentrations of charcoal were noted, but were most likely of recent origin. Modern recreational waste, including glass bottles and plastic, was evident. No diagnostic artifacts were found at either site.

Historic foundations associated with U.S. Naval housing also were noted on the Wetland Restoration parcel.

## 3.6.2 IMPACTS AND MITIGATION

### 3.6.2.1 Impacts of Model Project

The sites identified within the project area are potentially significant and further testing will be required to assess their importance and the significance of potential impacts. Construction staging areas as well as actual amounts of acreage necessary for project implementation have not yet been identified for the Model Project. Use of such staging areas or expansion of the project beyond the area addressed in this report could result in potentially significant archaeological impacts. Additional survey and testing would be required to assess potential impacts outside the parcels specifically studied (see Appendix M).

#### 3.6.2.2 Impacts of 495-Acre Restoration Project

Based on the density of cultural resource sites in the area, there is a relatively high potential for other, previously unrecorded archaeological sites within the project area. While some of these sites may yield little scientific information and may not be considered important, others may be significant archaeological resources. The significance of impacts to cultural resources will need to be addressed in a supplemental environmental document once onsite information becomes available.

#### 3.6.2.3 Mitigation

**Model Project.** The significance of archaeological impacts from the Model Project cannot be determined at this time. If the archaeological resources potentially subject to impacts from project implementation are determined to be significant, appropriate mitigation measures shall be developed to avoid or reduce the impacts to below a level of significance.

**495-Acre Restoration Project.** A complete cultural resources survey of the project area will be performed prior to permitting the 495-acre Restoration Project. If the archaeological resources potentially subject to impacts from project implementation are determined to be significant, appropriate mitigation measures shall be developed to avoid or reduce the impacts to below a level of significance.

## 3.7 LAND USE

### 3.7.1 ENVIRONMENTAL SETTING

#### 3.7.1.1 Historic Setting

The Tijuana River National Estuarine Sanctuary was established in 1982 in accordance with Section 315 of the Coastal Zone Management Act of 1972. Designation of the Sanctuary brought together 2,531 acres of land under various ownership (federal-state-local and private) into a coordinated and cooperative management framework. In 1986,

the National Estuarine Sanctuary Program was renamed the National Estuarine Research Reserve Program and the Tijuana Sanctuary became the Tijuana River National Estuarine Research Reserve.

The 2,531-acre Tijuana River National Estuarine Research Reserve contains tidally-flushed wetlands, riparian and uplands habitat. Within the Reserve there is a federal National Wildlife Refuge and Endangered Species Reserve, a State Park, and various local public agency and privately owned properties.

National Estuarine Research Reserves are areas set aside for long-term research, education and interpretation through a cooperative federal/state effort. The primary goal of the joint program is to provide information that is useful for making management decisions regarding the development and/or protection of limited coastal zone resources.

The Reserve includes the Tijuana River Estuary. This area has been the subject of environmental and land use debate since the early 1970s. The goal of restoring tidal action and wetlands habitat has been the common objective of several separate study efforts. The current project is drawing upon the findings collected during this protracted period to identify a workable strategy to achieve the restoration goal. The present project area exhibits a nearly complete transformation from historic (1850s) tidal lands to current day (1990s) upland habitat. The result of this land conversion has been the severe reduction or elimination of tidal vegetation and wildlife dependent upon the tidal environment.

The Model Project will occur on land owned by the U.S. Fish and Wildlife Service (Connector Channel and Oneonta Slough sites) and the City of San Diego (experimental marsh). The 495-acre Restoration Project will occur on land owned by the U.S. Fish and Wildlife Service, California Department of Parks and Recreation, City of San Diego, County of San Diego, and private owners. Portions of eight parcels comprising 210 acres have been identified as necessary for acquisition for construction of this 495-acre Restoration Project. The purpose of this section is to examine the impacts that would occur to existing land use if the proposed project is implemented.

### 3.7.1.2 Plans and Policies

Several existing plans and policies guide activities within the Reserve area, as described in the following.

**Coastal Zone Management Act (CZMA)**

As previously stated, the Tijuana River National Estuarine Research Reserve was created in accordance with the CZMA. Federal implementing regulations require that a management plan be developed to guarantee that activities undertaken in the Reserve will conform to the intent of the program. The plan provides the basis for making coordinated decisions for the protection and careful development of the national estuarine research reserve. The Tijuana River National Estuarine Research Reserve Management Plan details general policies regarding resources and resource use to assist the Management Authority in meeting the goal of the national program. Specific projects and management actions are outlined for resource protection and restoration, research, interpretation, facility development and land acquisition.

The Tijuana Estuary Tidal Marsh Enhancement Project is authorized by Section 30233(a) of the CZMA which in part, permit the diking, filling and dredging of coastal wetlands and estuaries when such work is directed toward restoration and nature study. Section 30233(c) requires that the diking, dredging and filling in estuaries and wetlands maintain or enhance the functional capacity of the wetland or estuary. The Tijuana Estuary Tidal Marsh Enhancement Project is consistent with these criteria.

**City of San Diego Progress Guide and General Plan (PGGP)**

The project vicinity is classified as open space in the City's General Plan, with the primary categorization of "Resource Based Parks," and secondary designation for "Agricultural" use. The city uses the open space land uses as a planning tool to protect the quality of life through the preservation of natural resources. (PGGP, 1989). The open space system is based upon the natural features of the coastal plain, particularly the river valleys, as in the case of the project area.

A central goal of the city's major planning document is the preservation of environmental quality. The policies they have established to obtain this goal, include the following key elements:

- Conserve agricultural lands,
- Manage natural resources - floodplains, vegetation, aquifers, slopes, hillsides, canyons, coastal and waterfront areas,
- Preserve open space and vistas, and
- Reduce air, noise and water pollution.

Most of the project area is within the Tia Juana River Valley Planning Area, which has been designated for "Future Urbanizing - presently vacant land to be held as "urban reserve" for future development." In 1985, San Diego voters approved a ballot initiative which strengthens the "Future Urbanization" designation by imposing the condition that any change from this reserve category may be accomplished only by vote of a majority of the electorate.

The majority of the project area is within the 100-year floodplain; that is, the area can expect floodwater inundation when a 100-year storm occurs (probability of occurrence = 1 percent each year). As the area has progressively moved from its historic wetlands habitat to the present mixed uplands habitat, the 100-year flood contour has changed in direct proportion to the loss of permeable surface area and natural drainage channels. The City of San Diego seeks to control flooding through natural floodway and floodplain preservation to the extent that such measures do not endanger life or property.

**Tia Juana River Valley Plan (TJRVP).** The study area designated as the Tia Juana River Valley contains 5,450 acres, a small portion of the entire 1,700 square mile watershed of the Tijuana River, nearly 75 percent of which lies within Mexico.

The Tia Juana River Valley Land Use Plan produced by the City of San Diego has been approved by the California Coastal Commission. The plan designates the project site as resource management, a category that is compatible with the proposed project. The goal of the resource management designation is "to protect and preserve diminishing natural

coastal resources" (TJRVP, 1979). Preservation of the ecological system of the estuary and limitation of active recreation to the sandy beach and upland areas are identified as key objectives in the plan. The use of city-owned land for the experimental marsh is an important step in realizing the preservation goal inherent in the resource management designation.

The Border Highlands area of the Tia Juana River Valley planning area was excluded from the plan's approval. A separate study, which focuses on the extensive sand and gravel resources in this area, was completed by the City under direction of the Coastal Commission. The purpose of this precise plan was to stipulate the means through which sand and gravel operations could successfully coexist with other more passive land uses within the resource management area. Reclamation plans, to be implemented following extraction, will act to control erosion and sedimentation of the sensitive wetlands habitat.

**County of San Diego.** The entire Tijuana Estuary falls within San Diego County. Certain areas of the project site are within unincorporated county land and are under the jurisdiction of San Diego County. The county does not have a comprehensive General Plan, but rather works with a series of Community Plans that guide land use plans and policies. County policy for the Tijuana River Valley culminated in a major land acquisition program in the late 1980s upstream of the Reserve. To date, 737 acres have been acquired through the program and carried out by the County's Department of Park and Recreation. Plans for management of the new publicly-owned lands are varied but include, resource restoration, agriculture, active and passive recreation, and open space. The county's initiative in the Tijuana River Valley is complimentary to the tidal restoration project. Elements of the 495-acre Restoration Project are in conflict with current land use on newly-acquired County lands.

**Regional Government.** The San Diego Association of Governments (SANDAG) is a voluntary effort between local government agencies that is designed to facilitate coordinated planning. SANDAG has developed several plans of regional scope that impact the project area. Among the most comprehensive of these documents are the Regional Housing Inventory and the Regional Transportation Plan. The Regional Housing Inventory ranked all vacant and residentially zoned lands within the San Diego region that would be suitable for future housing development. Within the Tia Juana River planning area there were no such lands designated. Therefore, project implementation would not impact the regional housing plan.

**California Coastal Act.** The California Coastal Act of 1976 mandates that all designated coastal regions develop local Coastal Plans consistent with City and regional plans.

The goals established for the Tijuana Estuary and River Valley area by the California Coastal Plan (California Coastal Zone Conservation Commission [CCZCC], 1975) have not been significantly changed since the plan's initial publication fifteen years ago. The planning block identified as the Tijuana River Valley is designated as a special study area and carried a priority ranking for state acquisition and protection. The three principal objectives of plan implementation are paraphrased here:

(1) Preserve and protect resources and habitat values and agricultural lands.

(2) Prevent urban encroachment through acquisition of 380 acres by Parks and Recreation; such acquired lands to be improved in a manner consistent with estuarine preservation.

(3) Retain or restore estuary to regime of tidal action.

**Other Regulatory Influences.** The Local Agency Formation Commission (LAFCO) holds the responsibility for determining appropriate growth limits for existing cities and/or the establishment of new jurisdictional units. This duty is carried out through the means of Sphere of Influence studies which evaluate land use and demographic factors in relation to an area's service structure carrying capacity to assess growth potential. A Sphere of Influence study has not yet been completed for San Diego. As an interim measure, the city has designated prospective annexation areas to project the ultimate boundaries of the city. The strip of unincorporated county land bordering the coast, to the west of the project area, is included as a prospective annexation area. If this annexation occurred, the city would have jurisdiction over the major portion of the project area which could serve to simplify regulatory issues.

Existing land use at the project site includes agriculture and resource conservation (public lands). Land ownership includes the City of San Diego, County of San Diego, State of California (Border Field State Park), U.S. Fish and Wildlife Service (National Wildlife Refuge), and private property. Since approval of the Management Plan in 1986, the State Coastal Conservancy has provided $1.3 million in state and federal funds to the City of

San Diego for purchase of 317 acres of private lands for inclusion in the Reserve. The Conservancy has identified portions of seven additional parcels totaling 210 acres that are necessary for construction of the 495-acre Restoration Project. These include both private land devoted to sod farming and land owned by the County of San Diego and leased for sod production, as well as other private undeveloped lands.

## 3.7.2 IMPACTS AND MITIGATION

### 3.7.2.1 Impacts of Model Project

The Model Project will be consistent with the prevailing land uses prescribed for the Reserve. All the proposed actions will occur on public land. Therefore, the Model Project will not impact present land uses in the Reserve.

### 3.7.2.2 Impacts of 495-Acre Restoration Project

A land use impact of the project will be the conversion of private lands to public lands. A 20.34 acre parcel of private land is isolated within the Reserve and has no access. Development of the property for housing, residential, or agricultural use likely would not be permitted under the current regulatory environment. The parcel meets the technical definition of a Section 404 wetland and would, therefore, be under the jurisdiction of the Corps of Engineers pursuant to its authority under Section 404 of the Clean Water Act. Development of the property also would not be in compliance with existing land use designations and would require an amendment to the existing land use plan through the California Coastal Commission.

The project also will result in impacts to private and publicly-owned land currently in agricultural production outside of the present Reserve boundary. These lands would be converted to resource conservation uses. This change in land use resulting from the project conflicts, to a degree, with policies of the Coastal Commission, the Coastal Conservancy, the City of San Diego, and the County of San Diego that encourage the preservation of coastal agriculture. Therefore, the purchase and restoration of

agricultural land for resource conservation purposes will potentially result in significant adverse land use impacts.

#### 3.7.2.3 Mitigation

**Model Project.** The model project will not result in any significant land use impacts. Therefore, no mitigation measures are proposed.

**495-Acre Restoration Project.** The project may result in significant land use impacts by eliminating existing agricultural production. Supplemental environmental documents should investigate the feasibility of an agriculture relocation program upstream of the project area. Where land use conflicts exist and land acquisition and change of use is unavoidable, the agricultural relocation program would ensure the protection of a sustainable agricultural community in the valley compatible with resource restoration objectives. The County's current land acquisition program upstream of the Reserve has a significant land management component wherein productive agricultural tracts are purchased and leased for continued production. Other approaches may also be possible. The agencies concerned with restoration projects have a long-standing interest in maintaining the valley's agricultural heritage and support a program to mitigate impacts to agricultural land uses so their effects are not significant.

## 3.8 TRANSPORTATION AND CIRCULATION

### 3.8.1 ENVIRONMENTAL SETTING

This section focuses on those roadways that are potential transportation routes for the heavy equipment moving to and from the construction sites, including the trucks hauling away the dredged or excavated material. The connector channel site is accessible through the interpretative center, off of Caspian Way. Caspian Way is a one-way narrow residential street that dead-ends with Third Street which intersects Imperial Beach Boulevard, one of the main east-west routes through Imperial Beach. Another potential access point could be constructed near the intersection of Third Street and Caspian Way.

Access to the construction site for widening of Oneonta Slough will likely be at the western end of Iris Avenue, west of its intersection with Fifth Street. Both streets run through residential areas and Fifth Street dead-ends with Imperial Beach Boulevard to the north.

Access to the restoration site in the south arm of the Reserve will be on Monument Road via Hollister Street. Hollister Street runs north from Monument and intersects Imperial Beach Boulevard. The southern part of Hollister Street runs through agricultural lands while the northern end runs through residential areas. Southwestern High School is located on the east side of Hollister Street near Imperial Beach Boulevard. Temporary access roads will need to be constructed to reach the construction site from Monument Road.

## 3.8.2 IMPACTS AND MITIGATION

### 3.8.2.1 Impacts of Model Project

Construction of the connector channel would result in approximately 270 truck trips during the duration of construction (assuming 4000 cubic yards of material and 15 cubic yards/truck). This increased truck traffic could have a significant short term impact on traffic especially along Imperial Beach Boulevard during peak traffic hours. Trucks are slower in traffic and tend to increase congestion at intersections because they cannot accelerate and travel through an intersection as rapidly as automobiles. This impact will be short-term, occurring only during construction of the channel. There will be no long-term impacts.

Widening of Oneonta Slough would result in a total of about 1,730 truck trips for the duration of the project assuming construction in Area A only. Construction in Area B would add a total of about 470 truck trips for a total of about 2,200 truck trips for full widening of Oneonta Slough. This would result in a significant short-term impact on traffic, especially along Imperial Beach Boulevard during peak traffic hours. If construction of the connector channel and widening of Oneonta Slough occur simultaneously, the congestion along Imperial Beach Boulevard would be further

affected because of the potential doubling of truck traffic, at least during the period of time it takes to construct the connector channel.

Construction of the 20-acre marsh in the south arm would result in a total of nearly 11,000 truck trips along some portion of Monument Road and possibly Hollister Street. The number of trips outside the Reserve onto Hollister Street will depend on the amount of material disposed of onsite versus that disposed of through one of the offsite disposal options. The approach will be determined upon review of sediment analyses and permitting by the San Diego Regional Water Quality Control Board. Impacts to traffic during construction are potentially significant and will require consultation and preparation of a specific plan with traffic engineers from the City of Imperial Beach and the City of San Diego to avoid adverse impacts.

#### 3.8.2.2 Impacts of 495-Acre Restoration Project

The extent of impacts will depend on the disposal alternative for the materials removed from the site. If the materials are appropriate for use in constructing the river training berm, the impact to traffic will be restricted to the area of Monument Road near the construction site. During certain phases of constructing the river training berm, Monument Road probably will need to be temporarily rerouted. The result would be some congestion along Monument Road during construction but this impact would be short-term. Monument Road will be rebuilt in order to maintain access to Border Field State Park and to provide access to State Park and U.S. Border Patrol officials.

If the excavated material has to be hauled offsite, the impact to traffic along Hollister Street, especially near Imperial Beach Boulevard, could be significant. This impact would be compounded by the traffic generated by trucks bringing needed fill material to the site to construct the river training berm.

The extent of traffic impacts will need to be assessed in the supplemental environmental documents once the specific construction design and schedule is developed. Completion of the construction planning for the disposal options will occur once the sediment quality studies has been completed and the results appropriately analyzed.

### 3.8.2.3 Mitigation

**Model Project.** Truck travel routes and time of travel should be determined in consultation with the City of Imperial Beach and the City and County of San Diego in an attempt to reduce the magnitude of expected impacts. However, restricting truck traffic to offpeak hours would increase the duration of truck travel on the roads and could result in the need to increase onsite stockpiling so as not to delay the construction schedule. Development of mitigation measures will be determined after the extent and magnitude of the impacts are known.

**495-Acre Restoration Project.** Truck travel routes and time of travel should be determined in consultation with the City of Imperial Beach and the City and County of San Diego in an attempt to reduce the magnitude of expected impacts. However, restricting truck traffic to offpeak hours would increase the duration of truck travel on the roads and could result in the need to increase onsite stockpiling so as not to delay the construction schedule. Development of mitigation measures will be determined after the extent and magnitude of the impacts are known.

## 3.9 UTILITIES

### 3.9.1 ENVIRONMENTAL SETTING

**Electrical and Gas Service.** A San Diego Gas and Electric Company overhead electrical transmission line is sited along the north side of Monument Road in the project vicinity. The nearest gas main is located in the Monument Road right-of-way.

The Tijuana River Valley planning area has been studied for the feasibility of power plant siting. At one time, San Diego Gas and Electric Company proposed the area for siting of a nuclear power plant. The area is still under consideration for location of a power plant to meet the City's future needs. Coordination of long-range plans with City and utility representatives is imperative for the project to avoid land use conflicts.

**Water and Sewer.** Major mains servicing the Tijuana River Valley are located within the I-5 corridor; sublines extend from there. The California American Water Company

and the City of San Diego Utilities Company are responsible for regional water service. A 16-inch main, which extends along Hollister Street to Monument Road. Water service is provided to the PERL facilities and the overlook in Border Field State Park.

The existing sewer system serving the Tijuana Valley includes a 36-inch main line conveyance connecting north to the Pt. Loma treatment plant, a 30-inch extension connecting to the international border, and various feeder lines.

In summer 1991, the International Boundary and Water Commission (IBWC) constructed a Tijuana River diversion structure, pump, and tie-in to the 30-inch mainline extension to capture sewage flows in the Tijuana River channel for transport and treatment at the Pt. Loma treatment plant. This system and related works in the Border Highlands canyons, known as the "Interim Measures", are emergency works undertaken by the IBWC to address renegade sewage flows into the Tijuana River Valley. The system has a capacity of 13.5 million gallons per day (mgd) and is expected to be fully functional in fall 1991. It is believed to be adequate to address dry season sewage flows in the river channel until completion of an international wastewater treatment plant proposed for construction east of Dairy Mart Road between the river channel and the border.

IBWC Interim Measures facilities will not be affected by the restoration project. Small feeder sewer lines and switchbacks in the project area could be damaged by the planned excavation work. It will be necessary for the construction plans to be accurately developed and presented to City Engineering prior to on-site excavation. This prudent measure can eliminate any adverse impact. Should relocation(s) of feeder lines be necessary, this work can be accomplished during project construction (with City supervision) at a reasonable cost.

**Telephone.** Telephone service is currently provided for the PERL facilities. No impacts are expected from the project.

### 3.9.2 IMPACTS AND MITIGATION

#### 3.9.2.1 Impacts of Model Project

The Model Project will not impact utilities in the Reserve.

#### 3.9.2.2 Impacts of 495-Acre Restoration Project

The only expected impact will occur during construction of the river training structure. Monument Road will need to be reconstructed to pass over the structure and the water and electrical lines that supply Border Field State Park will have to be relocated. The resulting impact would be short-term but not significant.

There would be no long-term cumulative impacts to utilities as a result of the project.

#### 3.9.2.3 Mitigation

No mitigation measures are planned to offset the short-term impacts caused by project construction.

## 3.10 HUMAN HEALTH

### 3.10.1 ENVIRONMENTAL SETTING

One of the major problems in the Reserve is the flow of sewage from Mexico down the Tijuana River. Sewage contamination of the Tijuana River basin in the United States has been a chronic problem since the 1930s. The contamination has resulted from the rapid and constant population growth in Tijuana coupled with a lack of corresponding sewage infrastructure. Due to the physiographic setting and relationship of the city of Tijuana to the United States, sewage that is not captured and treated flows into the United States in the Tijuana River or through north-draining canyons and gullies. This raw waste stream contaminates ground and surface waters and nearshore ocean waters. Sources of

contamination include renegade flows from unsewered areas of the rapidly urbanizing Tijuana (55 percent of the city of Tijuana was estimated to be unsewered in 1987 [International Boundary and Water Commission, 1987]); overflow from inadequately sized treatment and conveyance facilities; or discharges from spills during malfunctions of the existing infrastructure or recurring high river flows during storm events.

Since 1980 there have been several episodes of major sewage flows into the Reserve and today the flow is continual. In January, 1980, heavy rains damaged the Tijuana pipelines and washed out the emergency bypass sewer; all 22 MGD of Tijuana's raw sewage was discharged to the Tijuana River in the United States. Repairs to the line could not be completed for three months, and the County quarantined four miles of beaches through July. Again, two years later, heavy rains caused failure of the force main between Smuggler Gulch and Goat Canyon with 4.5 MGD spills of raw sewage into the Tijuana River basin. Five wells were contaminated and a mile of beach was quarantined.

In 1983 heavy rains flooded a new pump station in Mexico that had not been completed, damaged collectors and the force main, and washed out the canal in a number of locations. The Playas de Tijuana treatment plant serving the coastal community of Tijuana was also damaged. Due to the rains, impounded water was released form reservoirs in Mexico and the United States which maintained flows in the Tijuana River through the summer. Sewage was collected by these flows and contaminated nearshore waters up to the Silver Strand State Park through August.

Currently, up to 12 MGD of renegade sewage flows down the Tijuana River and poses a health hazard in the Reserve. The contamination affects potential harvesting of resources that use the estuary (such as fish) and contact recreation (swimming) in the estuary and nearby beaches along the ocean. This sewage also adversely affects the beneficial uses defined for the coastal waters in the Reserve. A major sewage treatment plant is planned for construction by the International Boundary and Water Commission (IBWC) on the United States side of the border upstream of the Reserve. The facility, to be located near Dairy Mart and Monument Roads is intended to eliminate sewage flows in the river. It is scheduled for completion in 1995.

The tidal restoration program is expected to compliment the IBWC initiative. A significant increase in the exchange of ocean and estuarine waters will occur with each

tidal cycle as a result of the restoration project. The increase in tidal prism is expected to improve water quality in the estuary and lower river.

Another related health issue is the presence of disease vectors in the water in the Reserve (Refer to Water Quality, Section 3.3). The water in the Tijuana River supports mosquito larvae. The poor water quality apparently reduces the effectiveness of chemical controls and prevents the establishment of a viable population of mosquito fish. The lack of easy access to much of the potential mosquito breeding areas makes it difficult to develop an effective vector control program. The tidal restoration program is expected to compliment the IBWC initiative. A significant increase in the exchange of ocean and estuarine waters will occur with each tidal cycle as a result of the restoration project. The increase in tidal prism is expected to improve water quality in the estuary and lower river.

Air emissions associated with construction would be temporary and are not expected to pose a human health risk (Refer to Air Quality, Section 3.4). Methods to minimize air pollution will be identified in a permit with the San Diego Air Pollution Control District. The quality of sediments to be excavated is not now known. A detailed sediment analysis will be performed to determine disposal of sediments. The plan, to be prepared for the San Diego Regional Water Quality Control Board and coordinated with other state and federal regulatory agencies, will determine if disposal poses any risk to human health, and will identify necessary procedures to be taken to assure that any hazardous human exposure, either directly or indirectly though secondary water quality effects, are avoided.

### 3.10.2 IMPACTS AND MITIGATION

#### 3.10.2.1 Impacts of Model Project

Adherence to regulatory procedures described above will assure that the Model Project will not increase any human health risk.

#### 3.10.2.2 Impacts of 495-Acre Restoration Project

Adherence to regulatory procedures described above will assure that the project will not result in any human health risk. The project will increase tidal flushing which will be beneficial as a means of diluting and improving the quality of water entering the estuary from the river. The cycles of tidal flushing also will prevent development of large areas of standing water that could serve as development areas for mosquitos.

#### 3.10.2.3 Mitigation

No mitigation measures are necessary since there will be no adverse impacts to human health as a result of the project.

## 3.11 AESTHETICS

### 3.11.1 ENVIRONMENTAL SETTING

As one of the few remaining tidal wetland systems in southern California, the Tijuana River Estuary is an important feature of the landscape. The 2,531-acre Reserve and the largely agricultural and lightly-developed lands of the Tijuana River Valley upstream of the Reserve represent a significant open space for the intensely urban region. Of particular note is that the Tijuana Estuary is not crossed by major highways or railroads. The broad expanse of wetlands found at the Reserve is a pleasing visual and aesthetic resource which is now unique in southern California. The proximity of the U.S. Navy Outlying Field and residential development in the City of Imperial Beach serve to underscore the aesthetic value of the Reserve. Noise associated with helicopter use of the U.S. Navy Outlying Field is a negative aesthetic feature common at the Reserve.

Sedimentation of the estuary in recent years has resulted in a severe decrease in tidal circulation and areas of oxygen-deficient channel substrate. These conditions have resulted in localized areas of offensive strong odors. The tidal restoration project is expected to significantly improve this condition.

## 3.11.2 IMPACTS AND MITIGATION

### 3.11.2.1 Impacts of Model Project

The Model Project will involve temporary construction-related disturbances that would affect the aesthetic value of the estuary but the completed project, once revegetation has been successfully completed will result in an aesthetically-enhanced environment. This will be especially true with the connector channel which will be in full view of the Visitor's Center. The experimental berm in the south arm will be a temporary feature of the landscape and will eventually be removed when the 495-acre Restoration Project is built.

### 3.11.2.2 Impacts of 495-Acre Restoration Project

The project will involve temporary construction-related disturbances that would affect the aesthetic value of the estuary but the ultimate buildout will result in an aesthetically-enhanced environment. The restored tidal marsh in the south arm would ultimately contain more abundant vegetation intermixed with tidal channels. The circulation within the estuary will improve, thus enhancing tidal flushing, water quality, and the long-term vitality of the vegetation.

Stockpiling of materials will create an isolated hill in an otherwise level area. Initially, this hill would be devoid of vegetation and detract from the visual aesthetics. This impact will be short-term and not significant since the stockpiles will be removed by the end of construction. The river training structure will become a permanent feature of the landscape. The topographic relief will be a strong visual element in the landscape, a form which will appear as a semi-natural outgrowth of the Border Highlands. The introduction of coastal sage scrub vegetation through the berm revegetation program will add to the landscape diversity in terms of color and texture. The topographic relief will obscure views up and down the valley from locations immediately east and west of the berm. However, enhanced views will result from the structure itself, as well as from the new raised roadbed proposed for Monument Road west of the river training structure.

#### 3.11.2.3 Mitigation

**Model Project.** The height of the experimental berm will be kept to a minimum. The slopes will be vegetated with native upland plants as part of the experimental program. The experimental berm will be removed once construction of the larger project begins.

**495-Acre Restoration Project.** The river training structure will be vegetated with coastal sage scrub species so that the visible slopes of the berm are similar in color and texture to the hills to the south. Along the eastern area of the berm on the floor of the reserve, riparian vegetation will be transplanted. The emphasis will be on establishment of native species, such as cottonwoods, sycamore, and some willows, that will grow tall and provide a visual screen to the eastern side of the berm. These measures will assure that no adverse aesthetic impacts result from the project.

## 3.12 RECREATION

### 3.12.1 ENVIRONMENTAL SETTING

Recreational use of the Reserve is permitted in specific areas where it is compatible with protection of sensitive resources. Recreational uses of the Reserve includes hiking, canoeing, picnicking, nature study and birdwatching, beach use, bicycling, horseback riding, and photography. Private and commercial stables operate in the valley upstream of the Reserve. Equestrian trails traverse eastern and southern areas of the Reserve. However, they are restricted from the central estuary, the northern reaches around Oneonta Slough and the Tidal Ponds, and along the barrier dunes because of their impact on sensitive resources. Other recreational uses are allowed only in designated areas in the Reserve. Water recreation is generally prohibited in the Reserve though special use permits for canoeing have been issued during the winter months.

The Visitor's Center provides a destination for those seeking to learn more about the resources of the Reserve and provides a starting point for hiking, nature study and birdwatching, and photography. Border Field State Park facilities at the southwestern end of the Reserve provides facilities for picnicking as well as an access point to the beach for equestrian and other beach uses.

## 3.12.2 IMPACTS AND MITIGATION

### 3.12.2.1 Impacts of Model Project

The Model Project will not impact recreation in the Reserve.

### 3.12.2.2 Impacts of 495-Acre Restoration Project

Development of the tidal marsh in the south arm will eliminate use of a major portion of the south arm for horseback riding. Horse traffic will be affected by the river training berm as it becomes connected to the adjacent bluff. It will be necessary to plan for new trail routes in advance of berm completion, so that fencing and signs can direct recreational users along appropriate paths.

Construction of the tidal marshes in the south arm may result in a beneficial impact to other recreational pursuits such as nature study and birdwatching, photography, and hiking.

### 3.12.2.3 Mitigation

**Model Project.** No significant impacts to recreation will result from the Model Project therefore no mitigation measures are identified.

**495-Acre Restoration Project.** Necessary rerouting of equestrian and other public access trails will be identified and developed as construction plans for the project are prepared. The planning and development of equestrian and hiking trails will endeavor to maintain the greatest degree of public access possible while protecting the sensitive areas of the Reserve. Specifically, access will be maintained to the beach to accommodate travel by horseback riders and hikers originating in the Tijuana River Valley, upstream of the Reserve.

## 3.13 CUMULATIVE IMPACT ASSESSMENT

### 3.13.1 INTRODUCTION

There are several projects that have been proposed for the Tijuana River Valley including the City of San Diego's Clean Water Program, Cal Mat sand and gravel quarry operation, expansion of the County of San Diego's park system, San Diego County Emergency Mosquito Abatement Program, and the International Wastewater Treatment Plant and Outfall Facilities. It is likely that if these projects are constructed that they will contribute both individual and cumulative impacts to the resources of the Tijuana River Valley. Some of these impacts will be beneficial and some of them will be adverse and require mitigation.

#### 3.13.1.1 City of San Diego's Clean Water Program

The City of San Diego, in complying with an EPA order requiring secondary treatment of present and future wastewaters generated in the San Diego Metropolitan Sewerage System Service Area, is proposing to construct a number of facilities in and around its service area including the construction of a treatment facility in the Tijuana River Valley. Presently, the preferred location for the Tijuana River Valley facility is adjacent to a proposed IBWC facility east of Dairy Mart Road between the river channel and the international border with Mexico. Construction and operation of the treatment plant would likely result in impacts to air quality, cultural resources, biological resources, aesthetics, and traffic and circulation. Environmental documentation was prepared for the project in 1990; however, it has not been certified.

#### 3.13.1.2 Cal Mat Sand and Gravel Quarry Operation

Cal Mat has applied to the City of San Diego for a Conditional Use and Reclamation Permit for the long-term extraction and processing of sand and gravel on 388 acres owned by the company. The Cal Mat property is designated for long-term sand and gravel extraction and processing in the Border Highlands Local Coastal Program Land Use Plan and part of the Tijuana River Plan. Operation of the quarry would result in

impacts to biological resources, aesthetics, topography, traffic and circulation, and possibly cultural resources. Environmental documentation has been initiated.

### 3.13.1.3 San Diego County Park Expansion Plan

San Diego County Department of Parks and Recreation is currently acquiring property in the Tijuana River Valley for inclusion in the planned Tijuana Valley Regional Park. The area of focus for the proposed park lies west of Interstate 5, east Borderfield State Park and Tijuana River National Estuarine Research Reserve, and south of Imperial Beach. To date, 737 acres have been purchased by the County. The primary goal of the program is preservation of the valley's wildlife resources and agricultural heritage and development of recreational opportunities compatible with these objectives. Lands that provide valuable habitat for birds are a top priority for purchase along with productive agricultural lands. A lease program has been developed to maintain lands in agricultural production. As a part of its long-term planning, County staff has expressed a commitment to working with other agencies to reconcile any conflicts between agricultural use and wildlife protection. Lands that have marginal biological or agricultural values will be designated for more active recreational use. Development of this park system will provide a beneficial impact by assuring the long term protection of sensitive biological resources.

### 3.13.1.4 San Diego County Emergency Mosquito Abatement Program

The Tijuana River Valley is considered by the San Diego County Vector Surveillance and Control Division to be one of the most severe mosquito breeding areas in San Diego County. To combat the mosquito problem in the valley, the County was granted a Clean Water Act Section 404 permit from the Corps of Engineers to implement an emergency mosquito abatement program. The project was undertaken in late summer 1991.

The program was necessitated by the persistent sewage flows in the constricted channels of the Tijuana River resulting in excessive breeding of the Anophles mosquito. Channel constriction was caused by accumulation of trash and exotic vegetation in and adjacent to the river channel. The County abatement project consisted of source control, biological control, and chemical control. Debris and exotic vegetation (primarily giant reed grass,

*Arundo donax*), was removed from the river channel with an instream dredger. The work was carried out in three areas: the reach of the river between the 19th Street Bridge and the Hollister Road Bridge, the reach immediately downstream of the Hollister Road Bridge, and in the channel connecting Smuggler's Gulch with the river. The work was carefully coordinated with the U.S. Fish and Wildlife Service, California Department of Fish and Game, and other concerned agencies to avoid impact to the endangered least Bell's vireo and other valuable resources of the riparian corridor.

The emergency program undertaken in the summer of 1991 took place upstream of the Reserve boundary. Routine mosquito abatement activity occurs within the Reserve under a program carried out by the San Diego County Vector Surveillance and Control Division. This program is based upon the "Treatment Criteria for Mosquito Control" formulated in the 1986 management plan for the Reserve and is carried out in close coordination with the U.S. Fish and Wildlife Service and Department of Parks and Recreation. The preferred method of mosquito control is through maintenance of predator species, Mosquitofish (*Gambusia*) or California killifish (*Fundulus parvipinnis*). These species do not exist in the estuary in adequate numbers for mosquito control. The County's control program in the Reserve is generally initiated in warmer periods of the year when an increase in water temperature coincides with higher tides to create ideal mosquito breeding conditions. The principle treatment method involves use of *Bacillus thuringiensis israelensis*, an organic pesticide derived from a bacteria. A detailed field evaluation aimed at determining the optimum protocol for use of the product under various field conditions was initiated in 1991. Recommendations are expected to result in refinement of the program for the 1992 season.

### 3.13.1.5 The International Wastewater Treatment Plant and Outfall Facilities

A draft environmental impact statement was released in May 1991 by the International Boundary and Water Commission for a proposed international wastewater treatment plant and associated facilities. This project consists of a 25-mgd treatment plant with an ocean outfall. A 12-foot diameter pipeline would deliver treated effluent to the ocean outfall. A second City of San Diego wastewater treatment plant has been proposed for siting adjacent to the preferred site for the IBWC facility. This plant would share the ocean outfall conveyance system (Section 3.13.1.1).

The IBWC project consists of: (1) the International Wastewater Treatment Plant; (2) the South Bay Land Outfall; (3) collection and pumping facilities for capturing renegade wastewater flows from canyons and from the Tijuana River; (4) a land outfall extension; (5) an ocean outfall; and (6) an International Boundary and Water Commission field office. This project will have a number of potentially significant impacts, including impacts to hydrology, aesthetics, noise, air quality, biological resources, cultural resources, and land use. Environmental documentation for the project has not been certified.

### 3.13.2 CUMULATIVE IMPACTS OF THE MODEL PROJECT

The Model Project will have significant beneficial impacts by: (1) maintaining local and regional biodiversity; (2) contributing to an overall goal of the state and federal Endangered Species Act of increasing habitat for threatened or endangered species; (3) contributing to the national goal of "no net loss of wetlands"; and (4) contributing to the goal of the State of California of increasing wetland habitat by 50 percent by the year 2000. Depending on the timing of construction of the Model Project and other construction projects identified for the Tijuana River Valley, there could be a significant, albeit short-term, impact to traffic and circulation and air quality in and about Imperial Beach and San Diego. These impacts can be mitigated through coordination with other project proponents and responsible public agencies concerning the timing of work undertaken, traffic routing, and dust control measures. Once the projects are completed, this impact would no longer be present.

Depending on the significance of cultural resources affected by each of the construction projects, there could be a significant cumulative adverse impact to cultural resources of the Tijuana River Valley. These impacts can be avoided through careful construction planning which incorporates site-specific cultural resource investigations.

The preferred option for disposal of excavated material from the Model Project is to use dredged materials for construction of a new alignment of Monument Road at a diagonal across the mouth of Goat Canyon to a point just below the Border Field bluff. Construction of this roadbed/sediment control structure would occur after construction of the pipeline corridor connecting the IBWC's treatment plant with the ocean outfall ("the Land Outfall Extension") along the same alignment. Impacts of the initial construction in

the disturbed and baccharis/mule fat habitats were evaluated in the IBWC Treatment Plant EIS (May 1991). Coordination of the two projects should assure that no adverse cumulative impacts result. Significant benefits are anticipated in terms of controlling sediment flow from Goat Canyon to the restored south arm marsh and creation of an area for riparian restoration.

### 3.13.3 CUMULATIVE IMPACTS OF THE 495-ACRE RESTORATION PROJECT

The 495-acre Project will have significant beneficial impacts by: (1) maintaining local and regional biodiversity; (2) contributing to an overall goal of the state and federal Endangered Species Act of increasing habitat for threatened or endangered species; (3) contributing to the national goal of "no net loss of wetlands"; and (4) contributing to the goal of the State of California of increasing wetland habitat by 50 percent by the year 2000. Depending on the timing of construction of the 495-Acre Project and other construction projects identified for the Tijuana River Valley, there could be a significant, albeit short-term, impact to traffic and circulation and air quality in and about Imperial Beach and San Diego. These impacts can be mitigated through coordination with other project proponents and responsible public agencies concerning the timing of work undertaken, traffic routing, and dust control measures. Once the projects are completed, this impact would no longer be present.

Depending on the significance of cultural resources affected by each of the construction projects, there could be a significant cumulative adverse impact to cultural resources of the Tijuana River Valley. These impacts can be avoided through careful construction planning which incorporates site-specific cultural resource investigations.

The cumulative impact of the 495-Acre Restoration Project and other projects in the area may result in a potentially significant adverse impact to water quality and biological resources in the riparian corridor just upstream of the estuary. The increased tidal volume resulting from the restoration project may result in higher surface and groundwater salinity further upstream in the Tijuana River possibly affecting riparian vegetation. The anticipated elimination of current flows in the river by the International Wastewater Treatment Plant may accentuate upstream salinity intrusion leading to adverse impacts to willow-dominated riparian habitat that is potential habitat for the endangered least Bell's vireo. The potential significance of this cumulative impact

should be addressed in a supplemental environmental impact report/statement after the development of a surface and groundwater model of the Tijuana River Valley. The assessment should determine the level of impact anticipated and, if needed, develop alternatives for providing flows necessary for sustaining the existing and proposed riparian habitat areas.

# 4.0 RELATIONSHIP BETWEEN SHORT-TERM USES OF ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The Tijuana Estuary currently provides habitat for a number of species, including several that are either listed as endangered or threatened species by the federal and state government, are candidate species for listing, or are otherwise considered to be sensitive. However, in recent years the quality of the habitat has been threatened by the deterioration of water quality and reduction in the tidal prism. The estuary also is important in maintaining regional biodiversity because of the number of species that are dependent upon the estuary as a habitat.

In addition to its value as a habitat, the Tijuana Estuary is a significant element of the local and regional landscape because it represents one of the few remaining coastal wetland systems. It provides us with a window to how these types of systems functioned prior to the influences of man.

The long-term productivity of the Tijuana Estuary will be enhanced by implementation of this project. In fact, based on the analyses prepared in support of this project, the very survival of the Tijuana Estuary as we know it today depends on this project. There will be short-term adverse impacts to resources of the estuary as a result of implementation of the project, but after completion of the project there will be opportunities for affected resources to recover resulting in a long-term beneficial impact. This project seeks to reverse the present deterioration of the estuary. Through the adaptive management approach, the project will balance project goals with the protection of the present resource values.

The program design has benefited from past and ongoing research of resource values in the Reserve. The adaptive management and modular construction approach being proposed will capitalize on knowledge about how well procedures work, what problems develop, and what unforeseen benefits might be realized. It will not be possible to avoid some damage to the ecosystem as the work progresses. The adaptive management approach and the careful construction measures outlined will make it possible to avoid jeopardizing the very species which this project is designed to benefit.

# 5.0
# GROWTH-INDUCING IMPACTS

The Tijuana Estuary Tidal Restoration Program does not contain any elements that will increase development in the region. Any future development within the boundaries of the Reserve will be of an extremely limited nature. The Reserve is an impetus to additional public land acquisition adjacent to its boundaries for open space and parklands uses.

# 6.0
# IRREVERSIBLE AND IRRETRIEVABLE IMPACTS

The commitment of general resources to the project is irreversible. The capital expended to purchase the land and fund the studies is lost to other potential investments. Additional commitment of funds for implementing the project also represents irreversible loss once project implementation is undertaken. An irretrievable loss will be the loss of energy associated with the fuel used to run the construction equipment and human energy to perform the latter tasks. Construction of the river training structure will result in a long-term loss of lands, but the impact will neither be irreversible or irretrievable. The estuary is a dynamic environment. The changes that will occur as a result of the project will serve to foster other changes in the system. However, the estuary is a depositional environment and over time sedimentation in the estuary could again become a dominant factor, especially if the river training structure is allowed to degrade.

# 7.0
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Research and development of this project was initiated in 1985 by the Pacific Estuarine Research Laboratory (PERL) and Philip Williams & Associates, Ltd. (PWA) under contract with the State Coastal Conservancy. Leadership in technical research and design were provided by Dr. Joy Zedler (PERL) and Dr. Philip Williams (PWA).

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Atkins, M.D. 1978. Insects in Perspective. MacMillan Publishing Co., New York. pp. 513.

Baharav, D. 1975. Movement of the Horned Lizard *Prynosoma solare*. Copeia 4:649-657.

Bingham, J. 1978. Archaeological Test Excavations Within Border Field State Park, San Diego County. California Archaeological Reports 16, State of California Department of Parks and Recreation, Sacramento, California.

Browning, B. M. and J. W. Speth. 1973. The Natural Resources of San Diego Bay, Their Status and Future. State of California, Department of Fish and Game. Coastal Wetland Series No. 5. 105 pp. + app.

Bull, C. S. 1983. Shaking the Foundations: The Evidence for San Diego Prehistory. Cultural Resource Management Center, San Diego State University, San Diego, California. Casual Papers: Cultural Resource Management 1(3):16-64.

Bull, C.S. 1987. A New Proposal: Some Suggestions for San Diego Prehistory. In: San Dieguito-La Jolla: Chronology and Controversy, edited by Dennis Gallegos. San Diego county Archaeological Society, Research Paper 1. pp. 35-42.

Burger, J. 1984. Abiotic Factors Affecting Migrant Shorebirds. In: Burger, J. and B.L. Olla (eds.) 1984. Behavior of Marine Animals, Vol. 6. Shorebirds - Migration and foraging behavior. Plenum, New York, N.Y. pp. 1-67.

Carrico, R. L. 1987. Sixty-Five Years of San Diego County Archaeology. In: San Dieguito-La Jolla: Chronology and Controversy, edited by Dennis Gallegos. San Diego County Archaeological Society, Research Paper 1. pp. 1-14.

Carter, G. F. 1957. Pleistocene Man at San Diego. John Hopkins Press, Baltimore, Maryland.

Carter, G. F. 1978. An American Lower Paleolithic. Anthropological Journal of Canada. 16:2-38.

Carter, G. F. 1980. Earlier Than You Think: A Personal View of Man in America. College Station: Texas A&M University Press.

Chambers Group, Inc. 1991. Least Bell's Vireo Habitat Delineation for the Tijuana River Valley. Report prepared for the Department of the Army, Los Angeles, District, Corps of Engineers.

Conway, J. B., H. F. Salgado, C. L. Sandall, E. A. Kobisher and L. R. Nuno. 1985. An Investigation of Water Quality in the Tijuana River. United States-Mexican Border Health Association 1(2): 24-25.

Conway, J. B., J. A. Lopez, and H. F. Salgado. 1987. Tijuana and Tecate Border Monitoring Program in the Tijuana River Drainage Basin. Draft document.

Cox, G. W. and J. B. Zedler. 1986. The Influence of Mima Mounds on Vegetation Patterns in the Tijuana Estuary Salt Marsh, San Diego County, California. Bull. Southern California Acad. Sci. 85(3):158-172.

Dahl, T. E. 1990. Wetlands Losses in the United States -- 1780s to 1980s. U.S. Dept. of the Interior, Fish and Wildlife Service, Washington, D.C. pp. 21.

DiGiorgio, C. L. 1989. Invertebrates of the Tijuana Estuary. Report prepared for Pacific Estuarine Research Laboratory for the Tijuana Estuary Tidal Marsh Enhancement Plan.

Emmel, T. C. and J. F. Emmel. 1973. The Butterflies of Southern California. Natural History Museum of Los Angeles County, Los Angeles. pp. 148.

Engineering Science. 1988. Tijuana Oceanographic Engineering Study. Prepared for City of San Diego, San Diego, California.

Espinosa, R. 1989. Herpetofauna. Report Prepared for Pacific Estuarine Research Laboratory for the Tijuana Estuary Tidal Marsh Enhancement Plan.

Florsheim, J., P. B. Williams, L. Fishbain, and P. Goodwin. 1990. Hydrologic and Geomorphic Analysis of the Tijuana Estuary: Technical Appendix. Report Prepared for the San Diego State University Foundation with funding from the San Diego State University Foundation and the California Coastal Conservancy. pp. 60.

Fong, P. 1986. Monitoring and Manipulation of Phytoplankton Dynamics in a Southern California Estuary. M.S. Thesis, San Diego State University, San Diego. pp. 93.

Gallegos, D. 1987. A Review and Synthesis of Environmental and Cultural Material for the Batiquitos Lagoon Region. In San Dieguito-La Jolla: Chronology and Controversy, edited by Dennis Gallegos. San Diego County Archaeological Society, Research 1. pp. 23-24.

Gersberg, R., F. Trinidade, and C. Nordby. 1989. Heavy Metals in Sediments at Tijuana Estuary. Border Health V:5-15.

Gosselink, J. G. and L. C. Lee. 1987. Cumulative Impact Assessment in Bottomland Hardwood Forests. Center for Wetland Resources, Louisiana State University, Baton Rouge. LSU-CEI-86-09. pp. 113.

Harris, L. D. 1984. The Fragmented Forest. University of Chicago Press, Chicago. pp. 199.

Homziak, J. 1977. Substrate Relationships and Competition Among Three Species of Callianassid Shrimp. M.A. Thesis (M.A., Biology) Presented to the Faculty of San Diego State University, San Diego. pp. 160.

Hosmer, S. C. 1977. Pelecypod-sediment Relationships at Tijuana Estuary. A Thesis Presented to the Faculty of San Diego State University. pp. 115.

James Dobbin Associates Incorporated. 1986. Tijuana River National Estuarine Sanctuary Management Plan. Prepared for the State of California Coastal Commission, U.S. Department of Commerce National Oceanic and Atmospheric Administration Sanctuary Programs Division and the Tijuana River National Estuarine Sanctuary Management Authority. pp. 183.

Kennedy, M. P. and S. S. Tan. 1975. Map Showing Character and Recency of Faulting in the San Diego Area, California. State of California Resources Agency, Division of Mines and Geology.

Kramer, N. 1989. Heavy Metal Analysis of Fish, Water and Sediment From the Vicinity of the U.S.-Mexico Border. Unpublished manuscript. pp. 3.

Kus, B. E., and P. Ashfield. 1989. Bird Use of the Tijuana River Estuary. Final Report to Pacific Estuarine Research Laboratory, San Diego State University, San Diego, California.

Langis, R., T. Griswold, and J. Zedler. 1991. Assessing the Sources and Loadings of Pollutants Affecting Tijuana Estuary. NOAA Technical Memorandum. NOS MEMD, Washington, D.C.

Lincoln, P. G. 1985. Pollinator Effectiveness and Ecology of Seed Set in *Cordylanthus maritimus* subsp. *maritimus* at Point Mugu, California. Final Report to U.S. Fish & Wildlife Service, Endangered Species Office, Sacramento, California. pp. 31.

Marcus, L. 1989. The Coastal Wetlands of San Diego County. Calif. State Coastal Conservancy, Oakland. pp. 64.

Masters, P. 1988. Paleo-Environmental Reconstruction of San Diego Bay, 10,000 Years B.P. to Present. In: Five Thousand Years of Maritime Subsistence at Ballast Point Prehistoric Site SDi-48 (W-164) San Diego, California. Denis Gallegos and Carolyn Kyle, ed. WESTEC Services, San Diego. pp. 4-1 to 4-22.

Miller, C. M. 1944. Ecological Relations and Adaptations of the Limbless Lizards of the Genus *Anniella*. Ecol. Monogr. 14(3): 272-289.

Minshall, H. L. 1976. The Broken Stones. Copley Books, San Diego, California.

Nagano, C. D. 1982. The Population Status of Seven Species of Insects inhabiting Tijuana Estuary National Wildlife Refuge, San Diego County, California. Report to the Office of Endangered Species.

National Wetlands Policy Forum. 1988. Protecting America's Wetlands: An Action Agenda. Final Report. Conservation Foundation, Washington, D.C. pp. 69.

Neuenschwander, L. F., T. H. Thorsted, Jr., and R. J. Vogel. 1979. The Salt Marsh and Transition Vegetation of Bahia de San Quintin. Bull. Southern California Acad. Sci., 78(3):163-182.

Nordby, C. 1982. The Comparative Ecology of Ichthyoplankton Within Tijuana Estuary and in Adjacent Nearshore Waters. M.S. Thesis, San Diego State University. pp. 101.

Nordby, C. S. 1987. Response of Channel Organisms to Estuarine Closure and Substrate Disturbance. In: Proceedings of the Society of Wetland Scientists; Eighth Annual Meeting, May 26-29, 1987, Seattle, Washington. pp. 318-321.

Nordby, C. S. and J. B. Zedler. 1991. Responses of Fish and Macrobenthic Invertebrate Assemblages to Hydrologic Disturbances in Tijuana Estuary and Los Penasquitos Lagoon, California. Estuaries, 14(1):80-93.

Orme, A.R. 1973. Barrier Lagoon Systems. In: D.R. Coates (ed.), Coastal Geomorphology. Proceedings of the Third Annual Geomorphology Symposia Series Pub. in Geomorphology, S.U.N.Y. Bingamton, N.Y.

Pacific Estuarine Research Laboratory (PERL). 1990. A Manual for Assessing Restored and Natural Coastal Wetlands With Examples From Southern California. California Sea Grant Report No. T-CSGCP-021. La Jolla, California.

Park, R. A., M. S. Trehan, P. W. Mausel and R. C. Howe. 1988. The Effects of Sea Level Rise on U.S. Coastal Wetlands. Holcomb Research Institute Report No. 42, Holcomb Research Institute, Butler University, Indianapolis, Indiana. pp. 60.

Pearson, T. H. and R. Rosenberg. 1978. Macrobenthic Succession in Relation To Organic Enrichment and Pollution of the Marine Environment. In H. Barnes (ed.) Oceanography and Marine Biology: An Annual Review. 16: 229-311.

Peterson, C. H. 1982. The Importance of Predation and Intra- and Interspecific Competition in the Population Biology of Two Infaunal Suspension-Feeding Bivalves, Protothaca staminea and Chione undatella. Ecol. Monogr. 52: 437-475.

Preston, E. M. and B. L. Bedford. 1988. Evaluating Cumulative Effects on Wetland Functions: A Conceptual Overview and Generic Framework. Environmental Management 12 (5): 565-583.

Purer, E. 1942. Plant Ecology of the Coastal Salt Marshlands of San Diego County. Ecol. Monogr. 12:82-111.

Quammen, M. L.. 1982. Influence of Subtle Substrate Differences on Feeding by Shorebirds on Intertidal Mudflats. Mar. Biol. 71: 339-343.

Rea, A. M. and K. L. Weaver. 1990. The Taxonomy, Distribution, and Status of Coastal California Cactus Wrens. Western Birds 21(3):81-126.

Robbins-Wade, M., G. T. Gross, and D. S. Cardenas. 1987. Cultural Resources Inventory and Assessment: California Terraces. RBR and Associates, San Diego, California.

Rogers, M. J. 1966. Ancient Hunters of the Far West. Union-Tribune Publishing Company, San Diego, California.

Rudnicki, R. 1986. Dynamics of Macroalgae in Tijuana Estuary: Response to Simulated Wastewater Addition. M.S. Thesis, San Diego State University, San Diego. pp. 82.

Rutherford, S. E. 1989. Detritus Production and Epibenthic Communities of Natural Versus Constructed Salt Marshes. M.S. Thesis, San Diego State University, San Diego, California. pp. 78.

San Diego Association of Geologists. 1982. Geologic Studies in San Diego County. (P.L. Abbott ed.) pp. 160.

San Diego, City of. 1989. Progress Guide and General Plan. San Diego Planning Commission, San Diego, California.

Seamans, P. 1988. Wastewater Creates a Border Problem. J. Water Pollution Control Federation. 60: 1789-1804.

Smith, B. F. 1987. A Reinterpretation of the Transitional Phase. In: San Dieguito-La Jolla: Chronology and Controversy. Dennis Gallegos, ed. San Diego County Archaeological Society, Research Paper 1. pp. 61-71.

Smith, S. H. 1974. The Growth and Mortality of the Littleneck Clam, *Protothaca staminea*, in Tia Juana Slough, California. M.S. Thesis, San Diego State University, San Diego. pp. 116.

Speth, J. 1969. Status Report on the Coastal Wetlands of Southern California. California Department of Fish and Game Report. pp. 29.

Swift, K. 1988. Salt Marsh Restoration: Assessing a Southern California Example. M.S. Thesis, San Diego State University, San Diego, California. pp. 84.

Taylor, E. W. and J. Tiszler. 1989. The Mammals of the Tijuana Estuary. Report prepared for Pacific Estuarine Research Laboratory for the Tijuana Estuary Tidal Marsh Enhancement Plan.

United States Department of Agriculture. 1973. Soil Survey for San Diego Area, California. United States Soil Conservation Service and Forest Service, U.S. Government Printing Office, Washington, D.C. pp. 104 + app.

United States Department of Interior, Fish and Wildlife Service. Undated. Endangered Environments, Southern California Estuaries and Coast Environments.

United States Department of Interior, Fish and Wildlife Service. 1979. Environmental Assessment: Proposed Land Acquisition, Tijuana Estuary, San Diego County, California.

Unitt, P. 1984. The Birds of San Diego County. San Diego Society of Natural History. Luster Industries, San Diego County. pp. 276.

Wade, S. A. 1986. Archaeological Testing Program at SDi-10, 185, Loci A-C, and SDi-10, 186, Otay Mesa, City of San Diego, California. RECON, San Diego, California.

Walters, C. 1986. Adaptive Management of Renewable Resources. Macmillan Publ. Co. New York. pp. 374.

Warnock, N., S. Griffin and L. E. Stenzel. 1989. Results of the 22-23 April 1989 Shorebird Census in Coastal Wetlands of San Diego County and Northern Baja California. Contribution No. 408 of the Point Reyes Bird Observatory.

Warren, C. N. 1967. The San Dieguito Complex: A Review and Hypothesis. American Antiquity 32:168-185.

Warren, C. N. 1985. Garbage About the Foundations: A Comment on Bull's Assertions. Casual Papers: Cultural Resource Management. Cultural Resource Management Center, San Diego State University, San Diego, California. 2(1):82-90.

Warren C. N. 1987. The San Dieguito and La Jolla: Some Comments. In: San Dieguito-La Jolla: Chronology and Controversy. Dennis Gallegos, ed. San Diego County Archaeological Society, Research Paper 1. pp. 73-85.

Wilbur, S. R. and R. E. Tomlinson. 1976. The Literature of Western Clapper Rails. Special Scientific report to the U.S. Fish & Wildlife Service, No. 194: 1-31.

Williams, K. S., M. Busnardo, D. W. Gibson, K. M. Johnson and S. A. Snover. 1989. Terrestrial Arthropods of Tijuana Estuary. Report Prepared for Pacific Estuarine Research Laboratory for the Tijuana Estuary Tidal Marsh Enhancement Plan.

Williams, P. B. and M. L. Swanson. 1987. Tijuana Estuary Enhancement: Hydrologic Analysis. Prepared for the San Diego State University Foundation with funding from the California State Coastal Conservancy, June 12, 1987. pp. 50.

Zedler, J., C. Nordby and T. Griswold. 1990. Linkages: Among Estuarine Habitats and With the Watershed. NOAA Technical Memorandum. NOS MEMD, Washington, D.C.

Zedler, J. B. and C. S. Nordby. 1986. The Ecology of Tijuana Estuary: An Estuarine Profile. U.S. Fish Wildl. Serv. Biol. Rep. 85 (7.5). pp. 104.

Zedler, J. B. 1977. Salt Marsh Community Structure in the Tijuana Estuary, California. Est. Coast. Mar. Sci. 5:39-54.

Zedler, J. B. 1982. The Ecology of Southern California Coastal Salt Marshes: A Community Profile. U.S. Fish and Wildlife Service, Biological Services Program, FWS/OBS-81/54. pp. 110.

Zedler, J. B. 1984. Salt Marsh Restoration: A Guidebook for Southern California. Calif. Sea Grant Coll. Program. Rep. No. 7-CSGCP-009. 46 pp.

Zedler, J. B. and C. S. Nordby. 1986. The Ecology of the Tijuana Estuary, California: An Estuarine Profile. U.S. Fish and Wildlife Service, Biological Report 85(7.5). pp. 104.

Zedler, J. B., R. Langis, J. Cantilli, M. Zalejko and S. Rutherford. 1990. Assessing the Successful Functioning of Constructed Salt Marshes. Presented at the Society for Ecological Restoration and Management Annual Meeting, January 16-20, 1989, Oakland, California.

Zembal, R. K. Kramer, R. Bransfield and N. Gilbert. 1988. A Survey of Belding's Savannah Sparrows in California. Amer. Birds 42(5): 1233-36.

Zembal, R., B. W. Massey and J. M. Fancher. 1989. Movements and Activity Patterns of the Light-footed Clapper Rail. J. Wildl. Manage. 53(1):39-42.

**Personal Communications**

Copper, E. 1989. Personal Communication. Private Consultant, San Diego, California.

Espinoza, R. 1989. Personal Communication. Research Assistant, Department of Biology, San Diego State University, San Diego, California.

Fink, B. 1990. Personal Communication. Research Associate, Pacific Estuarine Research Laboratory, Department of Biology, San Diego State University, San Diego, California.

Jorgensen, P. 1989. Personal Communication. Manager, Tijuana River National Estuarine Research Reserve. California Department of Parks & Recreation. San Diego, California.

Kenney, M. 1989. Personal Communication. Fish & Wildlife Biologist. Ecological Services, U.S. Fish & Wildlife Service, Laguna Niguel, California.

McGill, M. 1989. Personal Communication. U.S. Fish & Wildlife Service, San Diego, Tijuana Slough National Wildlife Refuge, San Diego, California.

Ryno, R. 1991. Personal Communication. Assistant Refuge Manager, Tijuana Slough National Wildlife Refuge. U.S. Fish & Wildlife Service, San Diego, California.

Taylor, E. 1989. Personal Communication. Research Assistant, Department of Biology, San Diego State University, San Diego, California.

Weitzel, M. 1990. Personal Communication. Manager, Tijuana Slough National Wildlife Refuge. U.S. Fish & Wildlife Service, San Diego, California.