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MOSS LANDING SOUTH HARBOR WETLANDS RESTORATION PROJECT MONITORING

THIRD ANNUAL REPORT

Submitted to:

Moss Landing Harbor District
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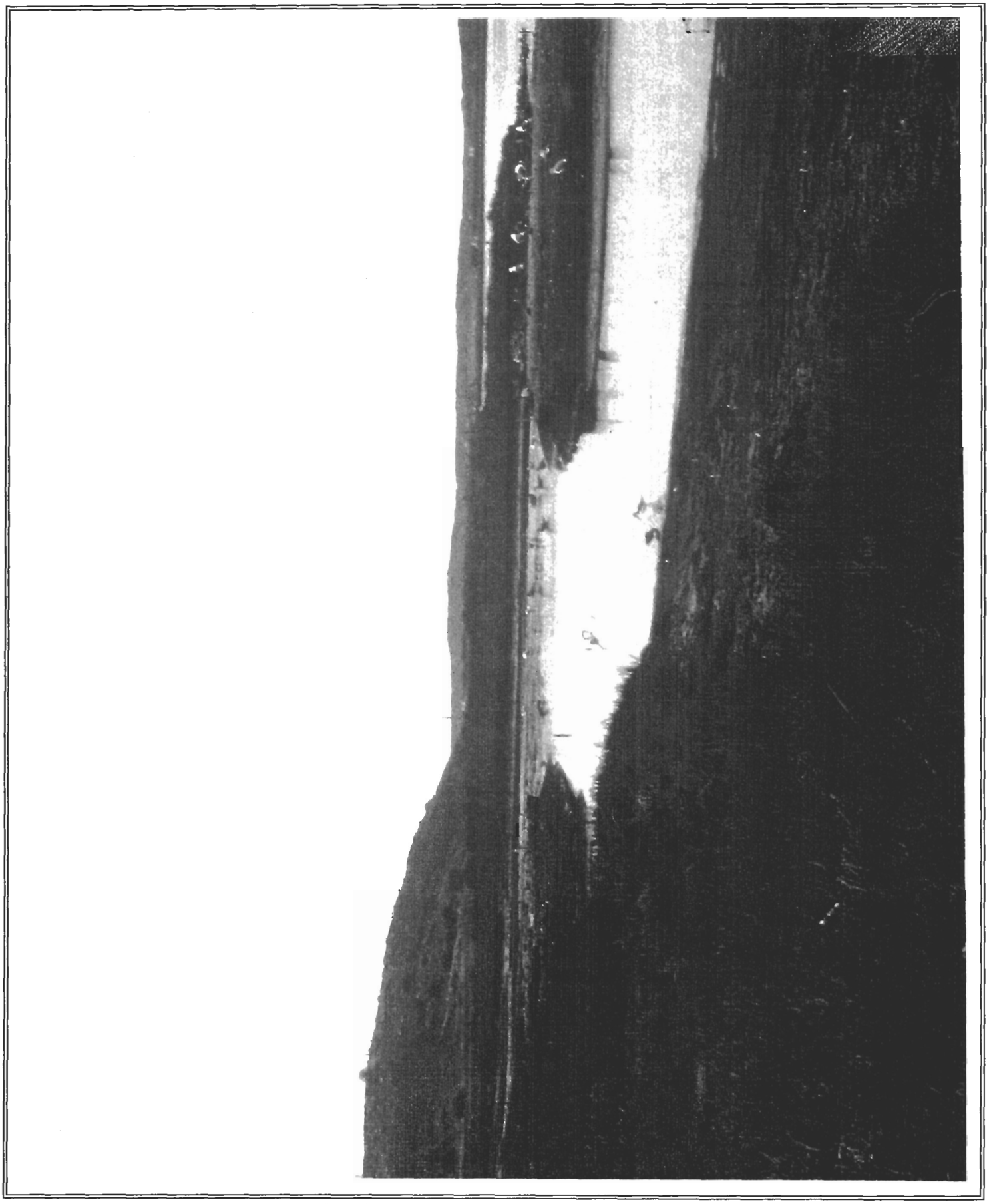
December 18, 1995



MOSS LANDING SOUTH HARBOR RESTORATION PROJECT: PANORAMIC VIEW OF THE PROJECT SITE, MARCH 1995

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II. INTRODUCTION

This report synthesizes and analyzes the results of three years of monitoring on vegetation, wildlife (birds) and erosion/sedimentation processes on the South Harbor Wetland Restoration Project in Moss Landing, California. The primary goals of this study are to:

(a) evaluate whether the restored habitats are progressing adequately toward meeting the mitigation objectives established for the project.
(b) measure the success of the restoration project with respect to the performance standards set forth for the project.
(c) determine additional needs or inputs such as replanting, regrading, and other maintenance and repair activities that may be required.

III. BACKGROUND

In June of 1988, the Moss Landing Harbor District (District) regraded approximately 1.4 acres of jurisdictional wetland to create a generally flat topography. In July of 1988, the U.S. Army Corps of Engineers (Corps) informed the Harbor District that the grading was unauthorized because it had involved the filling of a jurisdictional wetland as defined under Section 404 of the Clean Water Act. In addition, the California Coastal Commission issued a "stop work" order for the unauthorized activity.

Meanwhile, the District had applied for a coastal development permit to construct a 1,300 foot-long bulkhead along the west bank of the South Harbor, near Sandholdt Road. The District was required to mitigate for the loss of 0.35 acre of mudflat habitat as a result of this bulkhead project, otherwise known as the Shoreline Stabilization Project.

Subsequent to the unauthorized activity mentioned above, all activities related to the bulkhead project were suspended. To resolve the issue and proceed with the shoreline stabilization project, the District agreed to mitigate for the unauthorized activity by fully restoring the impacted wetland habitat.

The District retained Jones & Stokes Associates, Inc., of Sacramento, California to prepare the restoration plan for the project. During the development of the plan the District and its consultant made a strong case to combine the two projects - the restoration project for the unauthorized fill and the mitigation project for the bulkhead project - with the argument that combining the two different habitats (mudflat and wetland) at the same location would provide a more complete and diverse ecosystem, and would provide higher habitat qualities than would otherwise be obtained by implementing two separate projects. Separate restoration of the two impact areas at different locations was considered to be less beneficial to the ecosystem than a combined project (JSA, 1989.) In February 1989, Jones & Stokes developed the Moss Landing South Harbor Wetland Mitigation/Restoration Plan (JSA, 1989.) Thus, mitigation for both impacts, the unauthorized fill and the bulkhead project, were allowed to take place at the SHRS. In February 1990, the HRG was retained by the District to implement the Moss Landing South

South Harbor Wetland Mitigation/Restoration Plan (JSA, 1989.) Thus, mitigation for both impacts, the unauthorized fill and the bulkhead project, were allowed to take place at the SHRS. In February 1990, the HRG was retained by the District to implement the Moss Landing South Harbor Wetland Mitigation/Restoration Plan, and to develop a revegetation and monitoring program. In March 1990, the grading and revegetation work at the SHRS was initiated. In August 1990, the implementation phase of the project was completed. In September 1990, the HRG prepared a report - Revegetation and Monitoring Program for the Moss Landing South Harbor Restoration Project - outlining the revegetation, maintenance and monitoring activities that were already underway. In this report, early monitoring results were documented.

The First and Second Annual Monitoring Reports were prepared by HRG in July 1991 and October 1992, respectively. Monitoring of the site was interrupted between January 1992 and September 1994, at which time Assegued & Associates was contracted by the District to implement the remaining three years of the monitoring program.

IV. PROJECT LOCATION

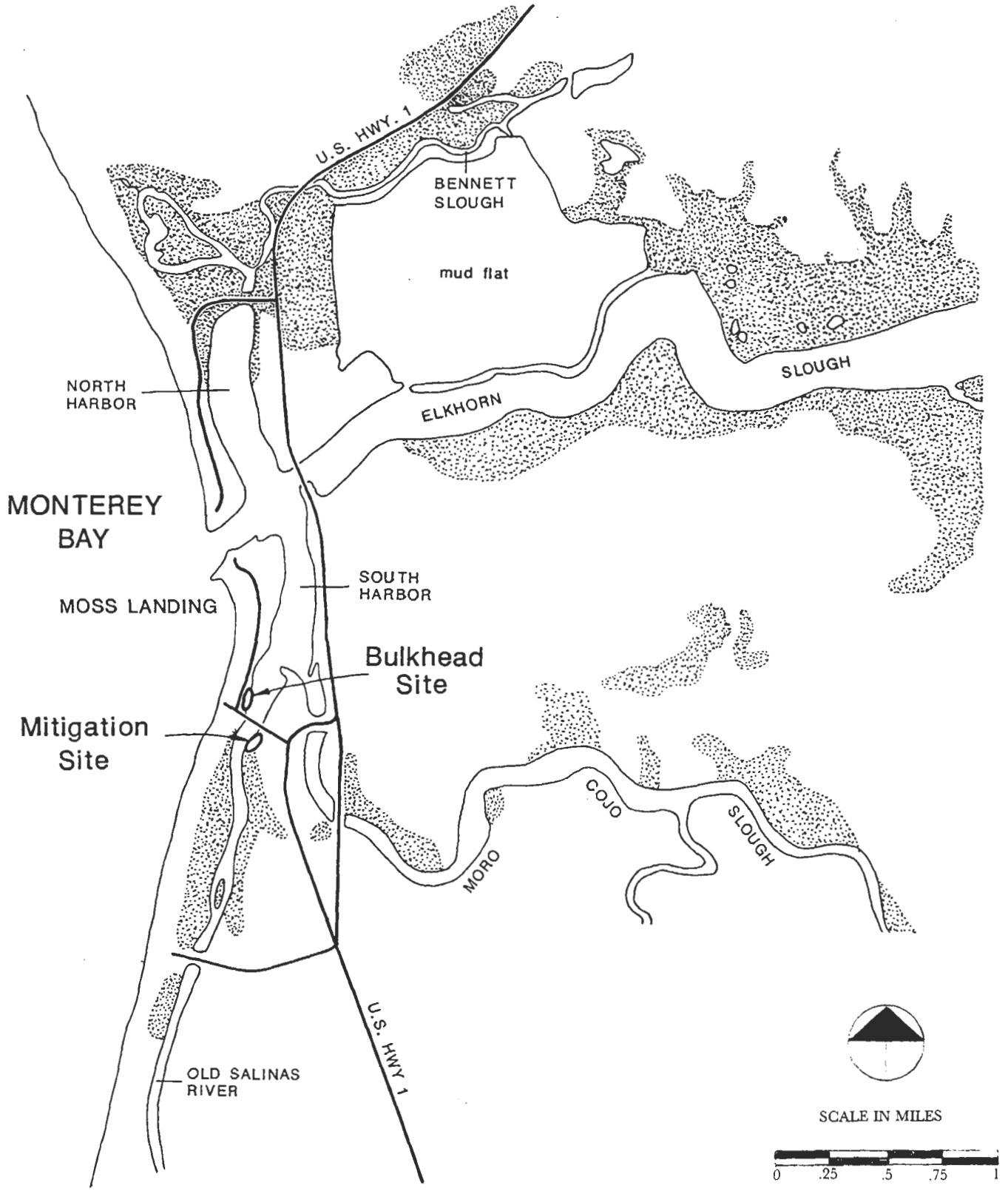
The project area is located just south of Sandholdt Road on the east bank of the Old Salinas River Channel in Moss Landing Harbor, Moss Landing, California, **Figure 1**. Both the west and east banks of the Old Salinas River Channel, between Potrero Road to the south and Sandholdt Road to the north, contain extensive mudflat and salt marsh habitat areas. The SHRS encompasses approximately 3.40 acres, which was designed to support four habitat types including: mudflats (1.10 acres), pickleweed salt marsh (1.42 acres), saltgrass (0.24 acre) and upland (0.64 acre.)

V. SETTING AT THE STUDY SITE

Historically, the SHRS was part of a longitudinal band of a marsh system that bordered the lower Salinas River as it flowed north to its former mouth, approximately 1.5 miles north of the Harbor entrance, **Figure 2.** Following a series of winter storms in 1909-1910 which damaged agricultural lands, the Salinas River was permanently diverted (diked) through the sand dunes near Mulligan Hill, located approximately 5 miles south of the SHRS. Thus, the "Old Salinas River Channel" was created north of the new dike system. Undoubtedly, this event reduced freshwater inflow into the Old Salinas River Channel, leading to a significant redistribution of habitat types - from freshwater marsh to salt marsh.

A. PRIOR TO RESTORATION CONSTRUCTION

Prior to the disturbance of the unauthorized fill and grading discussed above, the SHRS contained a deteriorated levee and berms enclosing two small settling ponds, relatively undisturbed tidal salt marsh and disturbed marsh and upland areas, **Figure 3**. The deteriorated levee, which extends along the eastern margin of the Old Salinas River Channel was built as a railroad dike in the late 1880's. It contained a few native plant species including *Spergularia macrotheca* (large-flower sand spurry), *Baccharis pilularis* ssp. *consangunea* (coyote brush) and *Grindelia*



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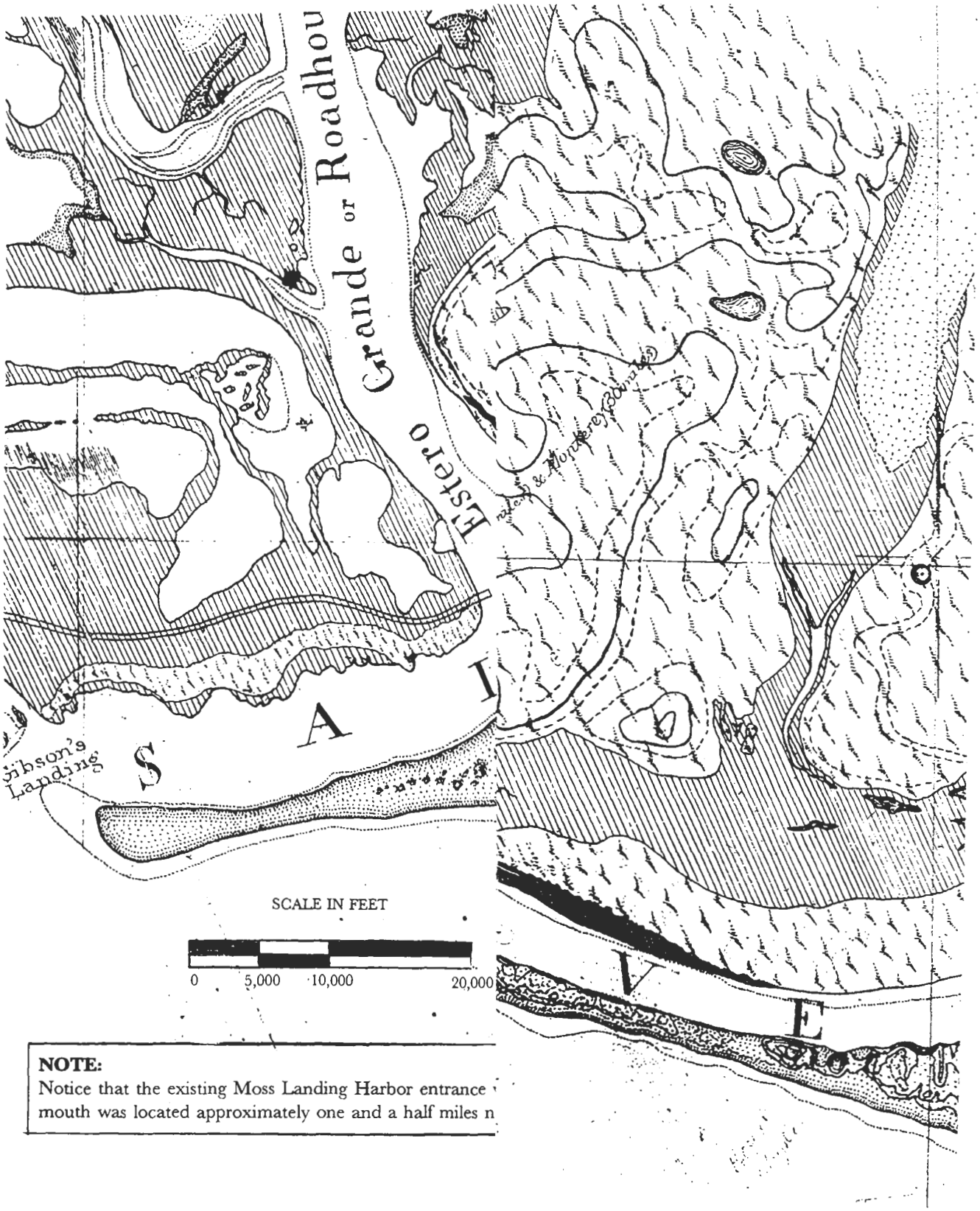
Moss Landing South Harbor
Restoration Project
Location Map

FIGURE 1



NOTE:
Notice that the existing Moss Landing Harbor entrance
mouth was located approximately one and a half miles n

MOSS ng South Harbor
HARE ation Project
P.O. BOX 1 ast of California, 1854
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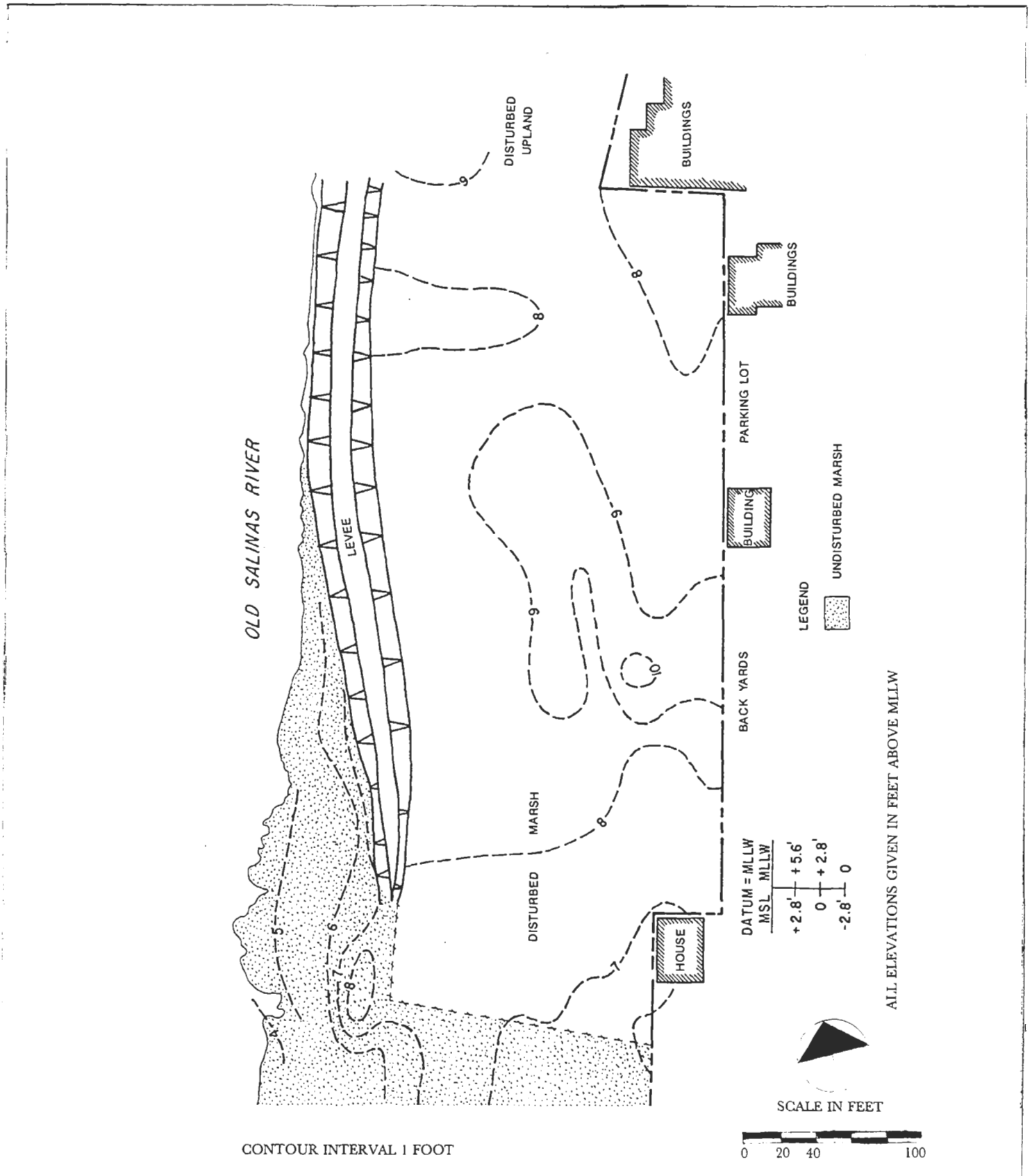
FIGURE 2



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Moss Landing South Harbor
Restoration Project
Site Topographic Prior
to Construction

FIGURE 3

latifolia (gum plant) scattered along the eastern face of the levee, and intermixed with other weedy, non-native vegetation.

A field survey conducted just before construction revealed that the levee face laying directly adjacent to the Old Salinas River Channel supported both low and high salt marsh vegetation of *Salicornia virginica* (pickleweed), *Frankenia grandifolia* (alkali heath) and *Jaumea carnosa* (fleshy jaumea.) Otherwise, most of the site was dominated by non-native grasses such as *Avena* sp., *Bromus diandrus*; and forbs such as *Raphanus* sp., and *Brassica* sp. Colonies of *Distichlis spicata* (saltgrass) provided the greatest proportion of native cover on the site. A few patches of *Elymus* spp. were also found in scattered populations throughout the mitigation site.

B. EXISTING CONDITIONS

Under current conditions the topographic features of the site consist of: (a) two broad branching slough channels; (b) an eroding central marsh plain; (c) a slope between the marsh plain and the upland; and (d) a compacted low berm. The two sloughs have wide entrances (approximately 100 feet wide) at the river channel, which taper to rather narrow channels towards the center of the restoration site. The marsh plain was designed to be a relatively level area with gradual slopes eparated by the two tidal sloughs, **Figure 4**. Extensive areas of this marsh plain remain unvegetated and are currently undergoing rapid erosion, **Figure 5** and **Figure 6**.

1. Topography

The SHRS is bordered by a compacted berm along the northern and eastern portions of the site. The berm has 3:1 slopes which rise rather sharply from 6.5 feet above MLLW at its toe, to 10 feet above MLLW at the top of the berm. The two broad tidal slough channels were once separated by the marsh plain, or the central peninsula. The central peninsula extended in an east-west direction towards the Old Salinas River Channel. In recent years, this central peninsula has been severely eroded, and the two sloughs are now connected by a deeply incised channel. The sides of this incised channel continue to erode with large chunks of the marsh plain cleaving and slumping into the channel. The bottoms of the two slough channels have become more incised and narrower since the completion of the project.

Along the south slough, bank cleavage and slumping of the pickleweed marsh occurred during the first two years of the project, but appear to have become stabilized in recent years. The marsh plain no longer surrounds and separate the two sloughs as envisioned by the restoration design. In effect, the central marsh plain has been transformed by erosion to an island which remains completely submerged when tides are greater than 4.5 MLLW, and partially submerged at lower tidal conditions.

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Moss Landing South Harbor Restoration Project Grading Plan

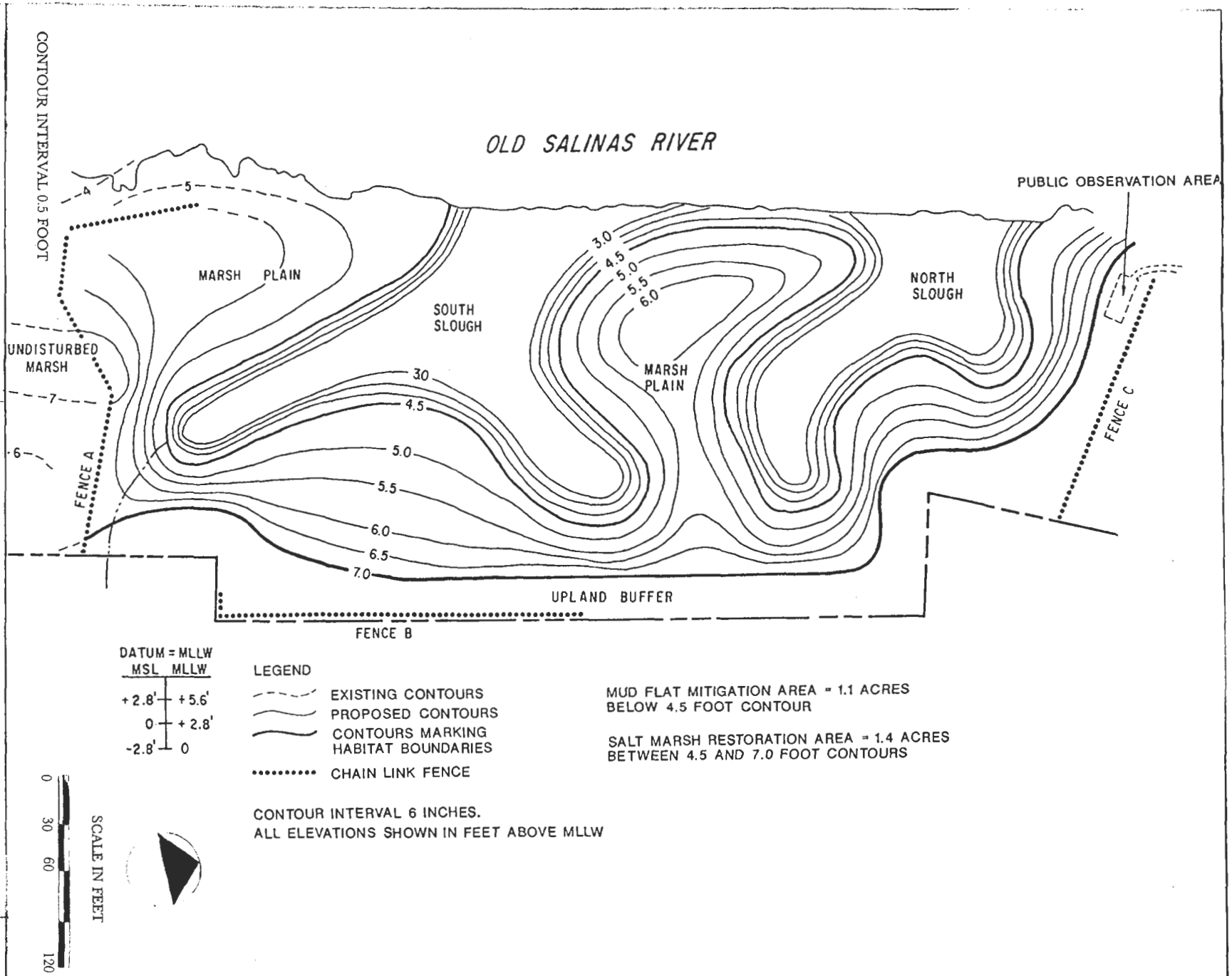
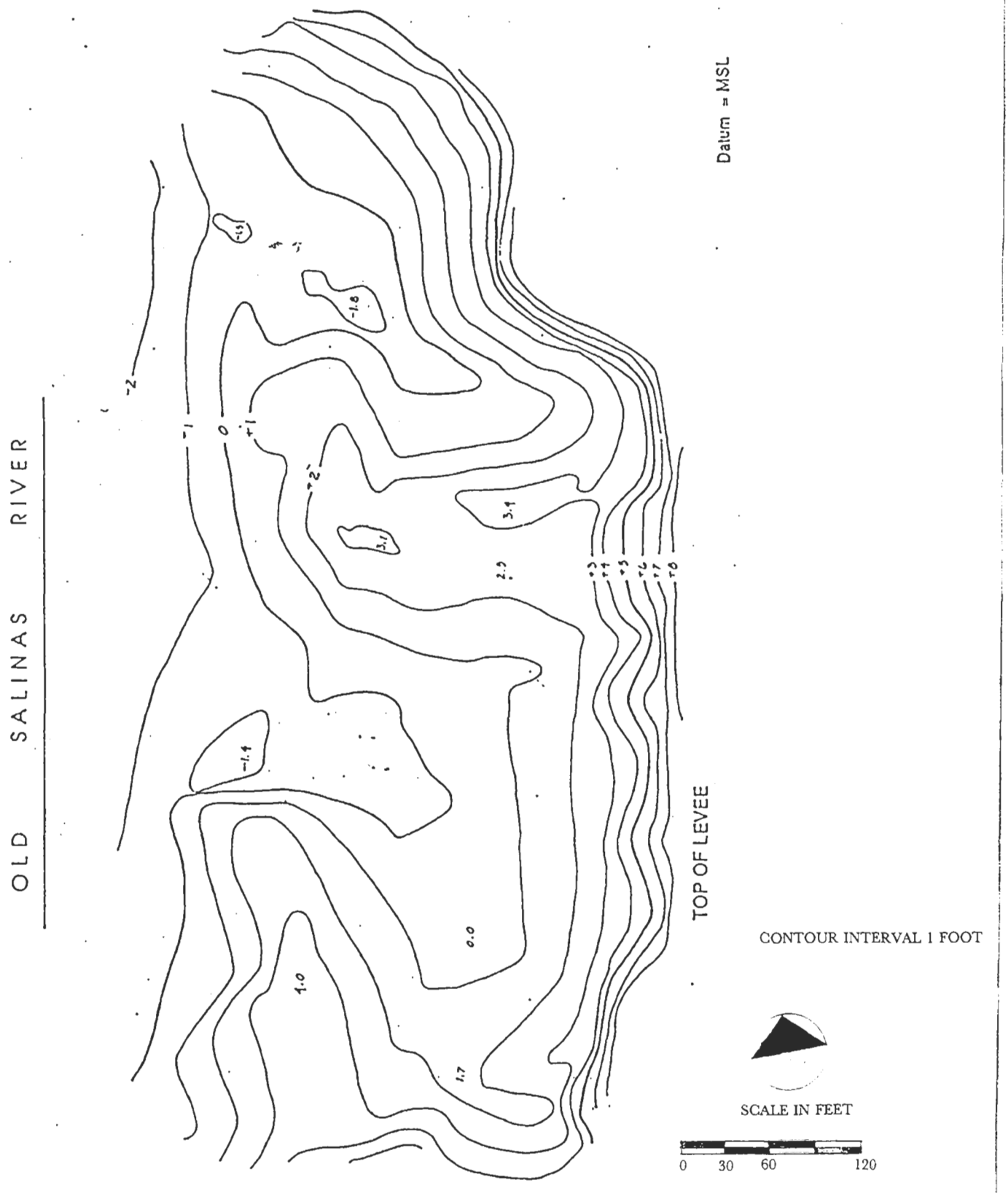


FIGURE 4



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Moss Landing South Harbor
Restoration Project
Site Topography in July 1991

FIGURE 5

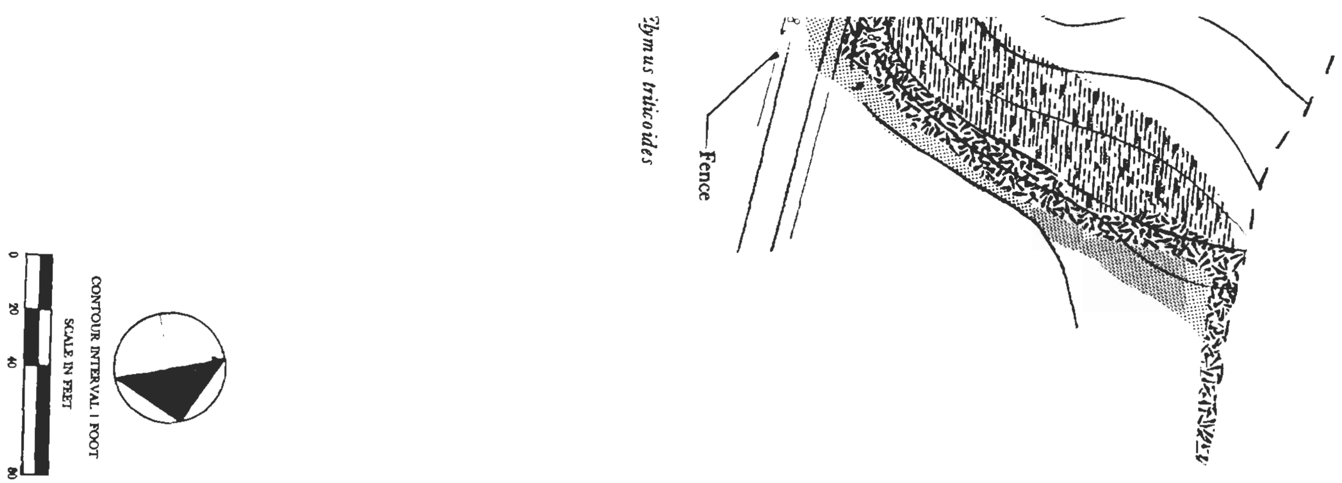


FIGURE 6	MOSS LANDING HARBOR DISTRICT P.O. BOX 10 MOSS LANDING, CA 95039	*Assegued & Associates* 1900 Smith Grade Santa Cruz, CA 95060 Tel/Fax: (408) 427-1135	Moss Landing South Harbor Restoration Project Vegetation and Topographic Map August 1995

2. Hydrology

The Old Salinas River Channel between the Potrero Road, south of the SHRS, and the Moss Landing Harbor entrance to the north is fully tidal. Upstream of the SHRS, flows into the Old Channel are conveyed via a series of culverts and flap gates located under Potrero Road Bridge. These features at the bridge effectively establish the limits of tidal influence within the Old Salinas River Channel system, and prevent saltwater from reaching upstream of Potrero Road. The Old Channel receives freshwater, albeit reduced during the summer months, via Tembladero Slough and the Monterey County's "Water Reclamation Ditch" located to the south/southeast of the SHRS. During winter storms, fresh and saltwater mixing occurs throughout the Old Channel system.

Drainage of upland areas of the SHRS and the adjacent areas to the east is facilitated by a shallow swale located along the toe course of the compacted berm (east-facing slope.) In general, the site slopes slightly to the south, and drainage from the upland areas generally occur in a north-south direction. No ponding from precipitation or at low tide conditions has been observed within the SHRS.

3. Soils

Surface soils at the SHRS consist of dredge spoil and other non-native fill material. Near sub-surface soils consist of hydric, aeolian and alluvial deposits of sand, silt, clay and some gravel. Marsh peat and organic rich clays are also present within the Old Salinas River Channel. Silt and clay sediments at the SHRS have their origin in watershed runoff and wind transport of sand. Re-suspension of these sediments probably occurs by tidal actions, infrequent high flows from the Old Salinas River Channel and Tembladero watersheds, and by occasional release of overflow from the Salinas Lagoon at the Salinas River mouth. Concerns have been raised regarding the presence of concentrations of toxic agricultural chemicals in the Old Salinas River Channel, and their eventual transport downstream into Monterey Bay. While toxic materials may occur in the Old Salinas River Channel, their presence on the site, transport mechanism through the Elkhorn Slough system and their effect on the area's biota are poorly understood (ABA Consultants, 1989.)

4. Vegetation

A compacted earthen berm extends along the eastern and northern edge of the site. The top of the berm and portions of the east-facing slope support weedy non-native plant species. The low lying areas along this east-facing slope support many native species including *Spergularia macrotheca* (sand-spurrey), *Atriplex* spp., and *Elymus triticoides* (ryegrass.) In addition, most of the *Salix lasiolepis* (arroyo willow) shrubs planted along the fence have been firmly established.

The west-facing slope, which is subject to tidal action at the lower elevations, supports a typical zonation of salt marsh vegetation. At the lowest elevation, pickleweed has fully colonized the regularly inundated zone just above the mudflats and extends up to the toe of the berm (4.5'-6.0'

MLLW.) This pickleweed marsh habitat area is followed by vigorously established *Distichlis spicata* (saltgrass) within the irregularly flooded zone (6.0'-7.0' MLLW.) The transition area, the area between the saltgrass and the top of the berm (7.0'-10.0' MLLW), supports various native species including ryegrass, *heliotropium* sp. (heliotrope) and *Grindelia latifolia* (gumplant), **Table 1.**

5. Wildlife

Bird species typically occurring within the SHRS include waterbirds such as various species of terns and gulls; shorebirds such as willet, least sandpiper, dunlin, dowitcher species, and killdeer; and wading birds including cormorants, egrets and great-blue herons.

Common mammalian species observed at the SHRS include *Microtus californicus* (California meadow vole), *Mus musculus* (house mouse), and *Peromyscus maniculatus* (California deer mouse.) Amphibians, reptiles and other small mammals may also be present at the site, although no observations were made[1].

6. Benthic Fauna

Samplings of the Old Salinas River Channel intertidal flats revealed that the benthic fauna within the project area is dominated by *Streblospio benedicti* and *Capitella capitata* (polychaetes), *Cumella vulgaris* (ostracod) and other species of ostracods, *Corophium* spp. and *Trasorchestia traskiana* (amphipods) and *Gemma gemma* (bivalve), (HRG, 1990.) These taxa are known to be well distributed throughout Moss Landing Harbor, the Elkhorn Slough system and the intertidal flats of Monterey Bay (Kinnetics, 1989.)

Other bottom dwelling and burrowing taxa such as *Macoma nasuta* (bent-nose clam), *Urechis caupo* (fat innkeeper) and *Hemigrapsuus oregonensis* (yellow shore crab) may be found within the general vicinity of the SHRS area (Kinnetics, 1989.)

VI. METHODS

The initial monitoring proposal was developed in 1989 (JSA, 1989.) It called for the coordinated quantitative and qualitative assessment of: (a) vegetation recovery and establishment; (b) benthic and invertebrate populations; (c) bird use; (d) soil erosion and sedimentation; (e) soil nutrient attributes; and (f) photo documentation.

During Year 1 and Year 2 the monitoring program followed this general approach with the following exceptions:

1. only one study of benthic/invertebrate fauna and one study of soil nutrient attributes were conducted during Year 1.

[1]No sampling of wildlife other than birds was conducted for this study.

TABLE 1.

Moss Landing South Harbor Restoration Project
Typical Plant List

SCIENTIFIC NAME	COMMON NAME
Ambrosia chamissonis	Beach-bur
Atriplex californica	
Atriplex lentiformis	Big Saltbush
Atriplex patula	Spear Oracle
Atriplex semibaccata	Australian Saltbush
Avena sp.	Wild Oat
Bromus diandrus	Ripgut Grass
Bromus hordeaceus	Brome
Carpobrotus chilensis	Sea Fig
Carpobrotus edulis	Iceplant
Conium maculatum	Poison Hemlock
Cuscuta salina	Dodder
Distichlis spicata	Saltgrass
Elymus triticoides	Creeping Wild Rye
Ericameria ericoides	Goldenbush
Eriophyllum staechadifolium	Seaside Woolly Sunflower
Frankenia grandifolia	Alkali Heath
Grindelia latifolia	Coastal Gumplant
Heliotropium sp.	Heliotrope
Hordeum leporinum	Barley
Jaumea carnosa	Fleshy Jaumea
Lavatera assurgentiflora	Tree Mallow
Lolium multiflorum	Italian Ryegrass
Malva sp.	Mallow
Medicago polymorpha	Bur Clover
Melilotus sp.	Sweetclover
Parapholis incurva	Sickle Grass
Plantago coronopus	Cut-leaved Plantain
Polypogon monspeliensis	Annual Beard Grass
Raphanus sativus	Wild Radish
Rumex crispus	Dock
Salicornia virginica	Pickleweed
Salix lasiolepis	Arroyo Willow
Senecio mikanioides	German Ivy
Sonchus sp.	Sow Thistle
Spergularia macrotheca	Sand-spurrey
Spergularia rubra	Sand-spurrey
Spergularia sp.	
Tetragonia tetragonioides	New Zealand Spinach
Vulpia bromoides	
Vulpia myuros	

2. no ground-level photographic documentation of the study site was undertaken during Year 2.

During the current monitoring year, Year 3, no benthic monitoring has been conducted. However, ground level photographs and slides were taken at each monitoring visit from permanent photo stations. To provide visual and historical perspective on the SHRS, a few ground level photographs from previous years are also included in this report.

Aerial photographs taken before and after construction of the SHRS are presented to document changes in habitat development within the study area. In addition, five soil samples were obtained and analyzed for soil nutrient contents from the same general location as previous years. In this report, the results of Year 1 and Year 3 soil results are compared and evaluated.

Historical and current data on vegetation and bird monitoring were synthesized so that they could be compared with each other by using the same analytical parameters. Because no reference site was provided for in Year 1 and Year 2, two vegetation monitoring transects were established at the same reference site as used for the bird monitoring. The reference site, RS, is located on the opposite (west) bank of the SHRS, **Figure 7**. The use of the same reference site for both vegetation and birds monitoring will serve as a permanent frame of reference for recording data throughout the remaining two monitoring years. Relating vegetation and birds data collection to the same reference site, allowed comparison and correlation of data for these two resources.[2]

A. VEGETATION

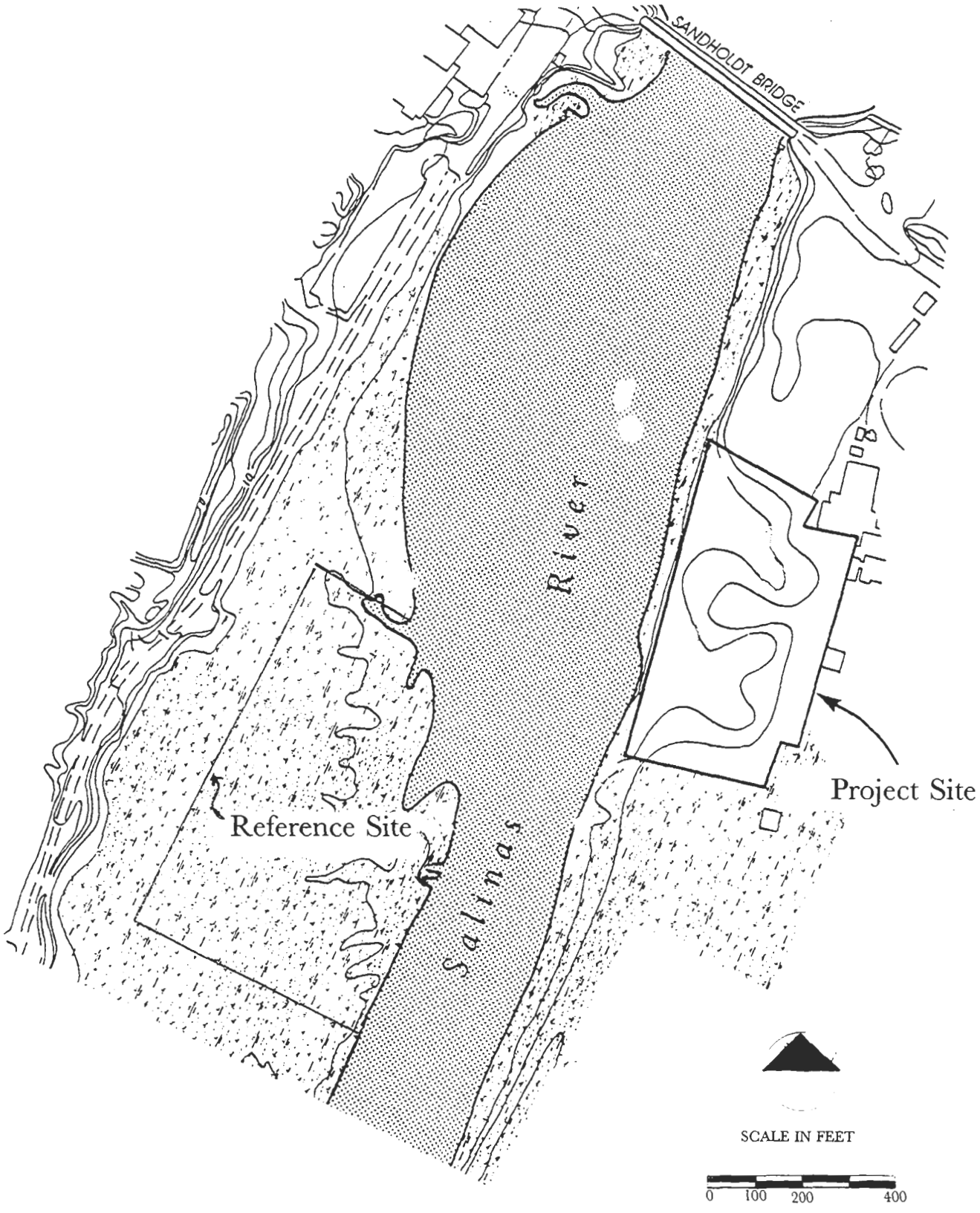
The objectives of the vegetation monitoring were to: (a) record plant species composition and percent cover of each species at the SHRS and RS; and (b) compare and relate the results obtained from Year 1, Year 2 and Year 3 to each other. Seasonal measurement of vegetation was conducted by recording species composition and by visually estimating percent cover of each species in one-meter-square quadrats placed along permanent transects.

The boundaries of mudflats, salt marsh and upland habitats were mapped, **Figure 6**. This map shows the location and extent of each habitat type. The annual extent of each habitat type was calculated using an electronic planimeter, **Table 2** and **Figure 8**.

B. WILDLIFE: BIRDS

Data on bird utilization of the SHRS and RS was obtained by walking along the top of the compacted berm and access road, respectively, **Table 3**. Bird counts were conducted from various observation points that were selected for their advantage in minimizing disturbance to birds. All birds were identified visually or by sound, during two 60 -minute census periods (30 minutes of observation at each location.) Two sampling periods, one morning and one evening

[2] The Reference Site was selected on the basis of its: (a) proximity to the Restoration Site; (b) similarities between the two sites with respect to the presence of specific stands of vegetation and wildlife habitats; and (c) similarities in existing hydrologic conditions.



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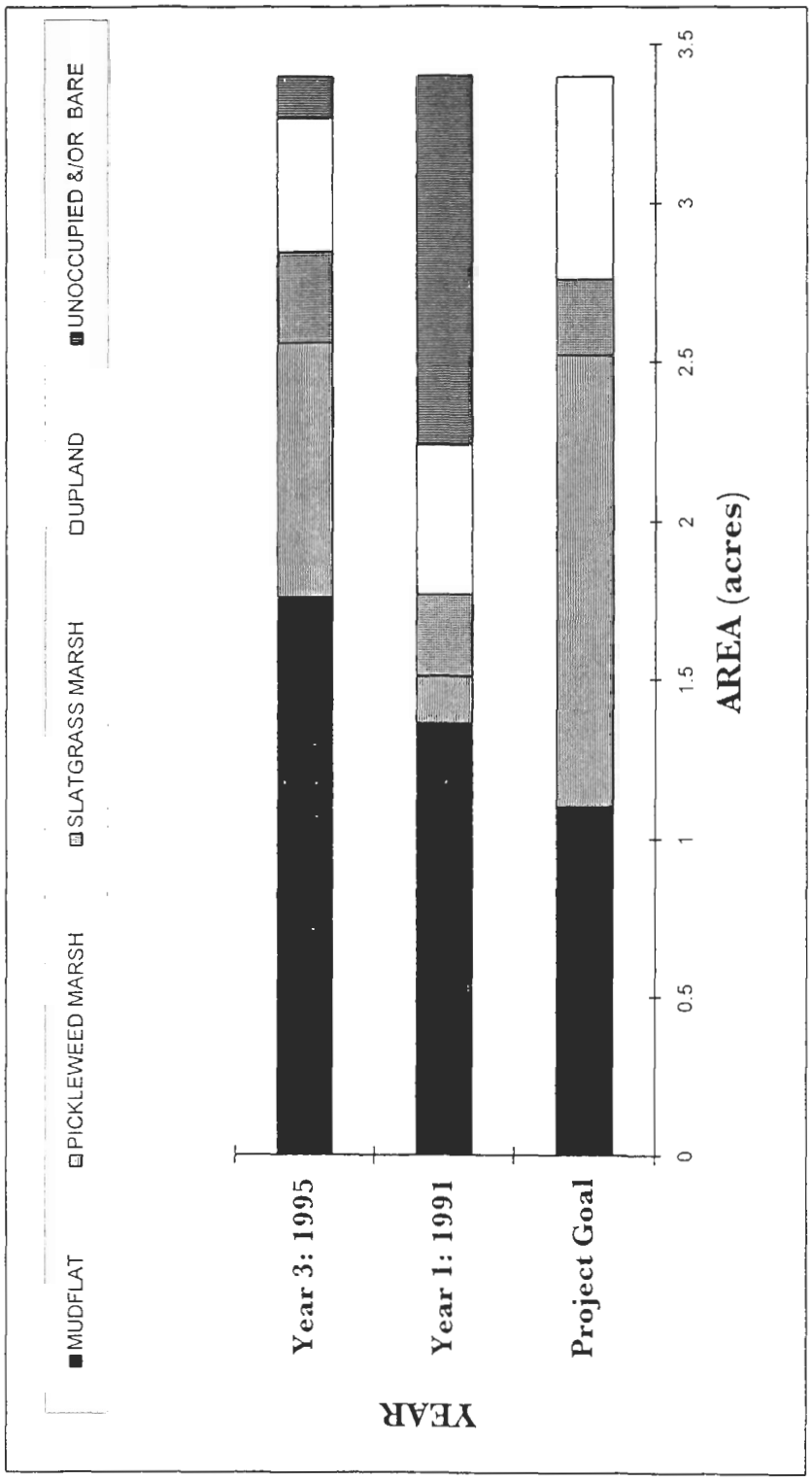
Moss Landing South Harbor
Restoration Project
Reference Site Location Map

FIGURE 7

TABLE 2.

Moss Landing South Harbor Restoration Project
Acreages of the Annual Extent of Habitat Areas

	HABITAT TYPE (acres)					
YEAR	**MUDFLAT**	**PICKLEWEED MARSH**	**SLATGRASS MARSH**	**UPLAND**	**UNOCCUPIED &/OR BARE**	**TOTAL**
Project Goal	1.10	1.42	0.24	0.64	0.00	3.40
Year 1: 1991	1.36	0.15	0.26	0.47	1.16	3.40
Year 3: 1995	1.76	0.80	0.29	0.42	0.13	3.40



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Moss Landing South Harbor Restoration Project Acreages of Annual Extent of Habitat Types

FIGURE 8

TABLE 3.

Moss Landing South Harbor Restoration Project
Typical Bird Species List

GROUP NAME	SCIENTIFIC NAME	COMMON NAME
Waders		
	Ardea herodias	Great Blue Heron
	Casmerodius albus	Great Egret
	Nycticorax nycticorax	Black-crowned Night Heron
	Egretta thula	Snowy Egret
	Phalacrocorax auritus	Double-crested Cormorant
Gull-Like		
	Sterna caspia	Caspian Tern
	Sterna elegans	Elegant Tern
	Sterna hirundo	Common Tern
	Sterna forsteri	Forster's Tern
	Larus argentatus	Herring Gull
	Larus californicus	California Gull
	Larus canus	Mew Gull
	Larus delawarensis	Ring-billed Gull
	Larus glaucescens	Glaucous-Winged Gull
	Larus thayeri	Thayer's Gull
		Western x glaucous-winged gull
	Larus occidentalis	Western Gull
	Larus heermanni	Heermann's Gull
	Larus philadelphia	Bonaparte's Gull
Duck-Like		
	Anas cyanoptera	Cinnamon Teal
	Pelecanus occidentalis	Brown Pelican
	Podiceps nigricollis	Eared grebe
	Branta bernicla	Brant
	Oxyura Jamaicensis	Ruddy Duck
	Fulica americana	American Coot
	Melanitta perspicillata	Surf Scoter
	Bucephala albeola	Bufflehead
	Bucephala calngula	Common Goldeneye
	Gavia stellata	Red-throated Loon
	Aechmophorus occidentalis	Western Grebe
	Aechmophorus clarkii	Clark's Grebe
	Anas platyrhynchos	Mallard

(Typical Bird Species List; continued from previous page)

GROUP NAME	SCIENTIFIC NAME	COMMON NAME
Shorebirds		
	Calidris minutilla	Least Sandpiper
	Calidris mauri	Western Sandpiper
	Catoptrophorus semipalmatus	Willet
	Pluvialus squatarola	Black-bellied Plover
	Actitis macularia	Spotted Sandpiper
	Arenaria interpres	Ruddy Turnstone
	Calidris melanotos	Pectoral Sandpiper
	Calidris bairdii	Baird's Sandpiper
	Calidris canutus	Red Knot
	Phalaropus lobatus	Red-necked Phalarope
	Numenius phaeopus	Whimbrel
	Charadrius semipalmatus	Semipalmated Plover
	Himantopus mexicanus	Black-necked Stilt
	Limnodromus spp.	Dowitchers
	Limosa fedoa	Marbled Godwit
	Numenius americanus	Long-billed Curlew
	Recurvirostra americana	American Avocet
	Tringa melanoleuca	Greater Yellowlegs
	Charadrius vociferus	Killdeer
	Calidris alba	Sanderling
	Calidris alpina	Dunlin
Songbirds		
	Agelaius phoeniceus	Red-winged Blackbird
	Sayornis nigricans	Black Phoebe

were completed at each location to ensure that most species present in the area were seen or heard. This level of sampling effort has been found to be sufficient for most studies and can be accomplished during a single day in the field (Mullen, 1993.)

The bird surveys during Year 1 and Year 2 are characterized by variations in the seasonal frequency, length of time spent at each station and total time included in each survey period. However, these variations are not considered to be important to the overall application of the data analysis technique, the Species Diversity Index (SDI), employed in this study. The SDI method allowed data to be directly comparable from survey to survey. The SDI method was used to compare and relate data collected at the SHRS and the RS from Year 1, Year 2 and Year 3.

C. EROSION/SEDIMENTATION

Standard survey level, rod and tape were used to determine elevation and topography at the SHRS. Data from this survey was used to assess the extent of erosion/sedimentation and changes in habitat types. Using the information from this topographic survey, a contour map showing approximate current conditions has been produced and compared to other topographic maps produced for the project. The extent of each habitat loss due to erosion was calculated using an electronic planimeter, **Table 2.**

VII. RESULTS AND DISCUSSION

A. VEGETATION MONITORING

A vegetation map was prepared for the SHRS in mid-summer of 1995, **Figure 6.** The map was used to quantify the extent of vegetation cover by habitat types. During each monitoring visit, qualitative data was obtained from nine transects and an average of 201 sampling quadrats at the SHRS; and 2 transects and 71 sampling quadrats at the RS. The samples were well distributed along longitudinal and elevational ranges found at the SHRS and RS.

1. Vegetation Communities

Three vegetation community types were created by the restoration project including: (a) pickleweed marsh; (b) saltgrass marsh; and (c) peripheral upland. The classification of these community types is briefly discussed below.

a. Pickleweed Marsh

In general, the pickleweed marsh plant community at the SHRS is found at lower elevations that range from about 4.5-6.0 feet above MLLW. At the lowest elevations, the pickleweed marsh is bound by mudflats that are less than 3 feet above MLLW. At the SHRS, this plant community is established on flats (level areas), slopes of the compacted berm and along the toe course of the

berm. These areas support dominant stands of pickleweed, which are usually flooded by tidal water, and are occasionally found parasitized by *Cascuta salina*.

At the higher elevations and middle ranges, which are characterized by less frequent flooding, the pickleweed marsh at the SHRS supports other salt marsh species such as alkali heath, fleshy jaumea, saltgrass, and *Atriplex* spp., albeit with less dominance than the pickleweed.

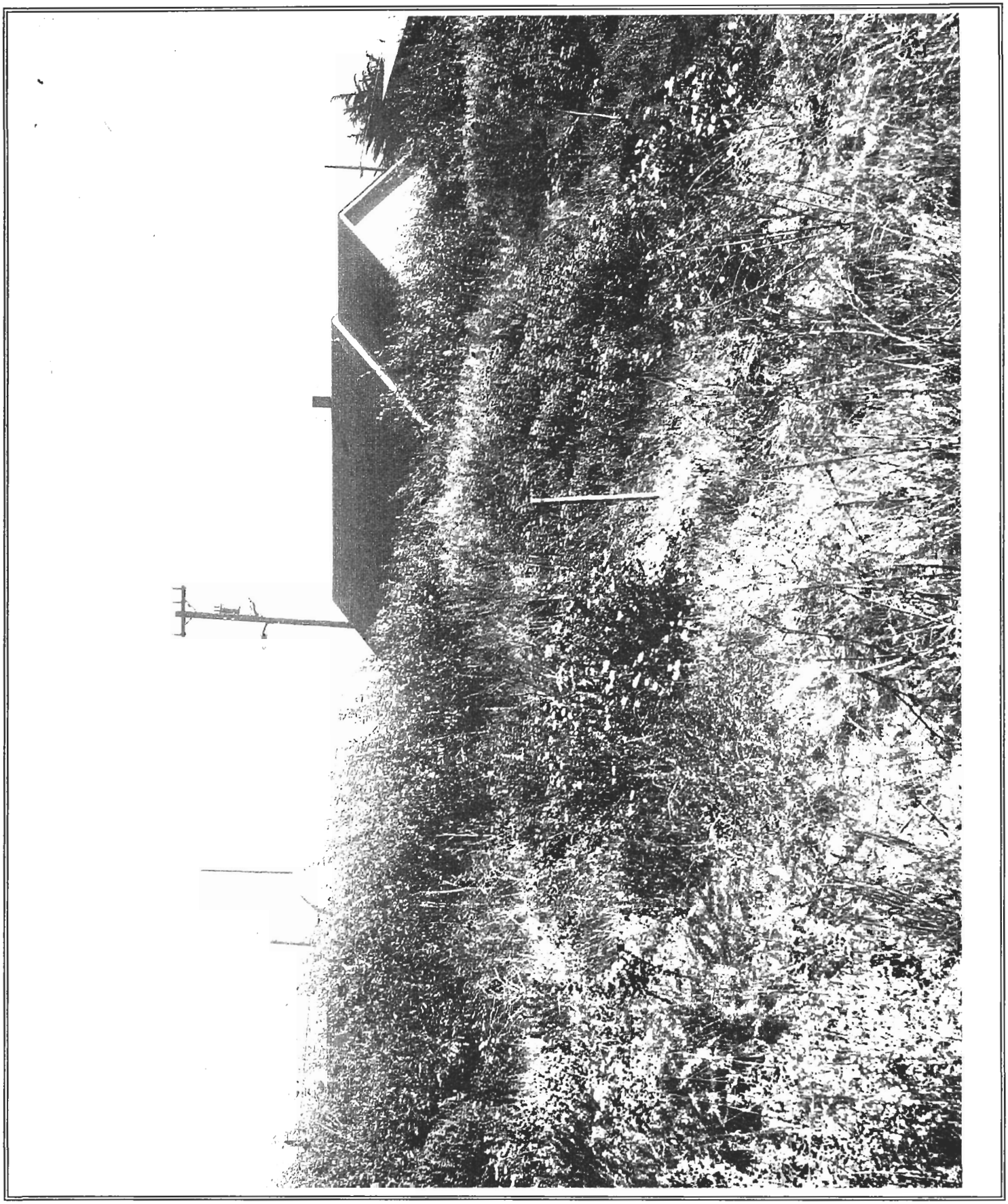
At the SHRS, vegetation changes appear to more or less follow along a topographic gradient, although somewhat gradual and with no evidence of clear demarkation into "zones of association" (Ferren, 1985.) At the RS, on the other hand, there is distinct and abrupt transition from wetland to upland species. The RS is characterized by an almost uniform stand of pickleweed at corresponding low elevations to the SHRS, and foredune plants such as *Camissonia cheiranthifolia* (beach primrose) at higher elevations.

The abrupt transition from wetland to upland observed at the RS is probably due to a road embankment that rises sharply along the western boundary of the RS. Of particular interest here is that the vegetated flats at the RS exhibit a marked decrease in diversity of vascular plants as compared to the SHRS. This decrease in diversity of plant life can be attributed to two ecological principles: (a) the RS is a relatively undisturbed, stable and homogeneous area, which tends to support just a few long-lived dominant species (pickleweed, in this case.) The SHRS, on the other hand, has undergone recent disturbances and now supports a mosaic of patches and heterogeneous elevations, which tend to increase species diversity (Barbour, 1970); and (b) the apparent increase in depth and frequency of flooding at the RS may have allowed almost complete dominance of the RS by pickleweed. Pickleweed, which is very tolerant of flooding (i.e. submersion), apparently remains dominant at the RS at the expense of other low marsh plants, which have lesser tolerance to flooding.

b. Saltgrass Marsh

In general, the saltgrass marsh occupies middle elevations along the slopes of the berm. It is dominated by saltgrass and ryegrass, and to a lesser extent by gumplant and alkali heath. The saltgrass marsh community is characterized by irregular-flooding by tidal water. It ranges in elevation from about 6.0-7.0 feet above MLLW. It generally occurs at the middle and high portions of the west-facing slope of the berm, between the pickleweed marsh and the upland. The largest population of saltgrass is located towards the northern portion of the SHRS, where it occupies a rather broad marsh plain along the margins of the north slough.

The west-facing slope of the compacted berm is subject to tidal actions. It supports a typical zonation of salt marsh vegetation along a topographic gradient ranging from the pickleweed marsh at the lowest, a vigorously established saltgrass marsh vegetation at the middle and upland vegetation at the highest. Within the transition area, 7.0'-9.0' MLLW, scattered colonies of *Heliotropium* sp. (Heliotrope) and *Parapholis incurva* (sickle grass) co-dominate along with saltgrass, gum plant and wild rye.



MOSS LANDING SOUTH HARBOR RESTORATION PROJECT: PANORAMIC VIEW OF THE PROJECT SITE SHOWING COASTAL GUMPLANT IN THE FOREGROUND AND ARROYO WILLOW IN THE BACKGROUND, MARCH 1995.

No significant saltgrass marsh community was found at the RS, except for a few patches scattered along the road embankment that border the western edge of the pickleweed marsh. Thus, the saltgrass vegetation community that is an important element of the habitat at the SHRS is not considered to be a significant contributor to the salt marsh vegetation at the RS.

c. Peripheral Upland

The compacted berm along the eastern and northern edges of the SHRS contained no vegetation after completion of the project in 1990. While both the east-face and west-face of the berm were revegetated, the top of the berm was not revegetated after grading because of its anticipated use as an access road for a future extension of the berm towards the south.

The upland areas at the SHRS continue to undergo successional changes of species association. Following completion of the grading activity, the top of the berm supported dense stands of decumbent or prostrate halophytes such as *Atriplex patula* (spear oracle), *A. semibaccata* (Australian saltbush), *Spergularia macrotheca* (sand spurry), *Cotula coronopifolia* (brass buttons), and a few scattered patches of pickleweed.

In the proceeding years, the more erect, naturalized ruderal species consisting of *Melilotus indicus* (sweet clover), *Bromus diandrus* (ripgut grass), *Polypogon monspeliensis* (annual beardgrass) *Malva parviflora* (malva), *Medicago polymorpha* (bur clover), and *Carpobrotus* spp. began to appear. In recent months, the more or less late successional species consisting of naturalized annuals such as *Avena* sp. (wild oat), *Bromus* spp. and *Lolium multiflorum* (Italian ryegrass); and forbs such as *Conium maculatum* (poison hemlock) and *Raphanus sativus* (wild radish) have become dominant. These findings are consistent with what Ferren has reported for the Carpenteria Salt Marsh in Santa Barbara, California (Ferren, 1985.)

The upland vegetation at the RS consists of typical dune (foredune) vegetation including *Ambrosia chamissonis*, *Cakile maritima* and *Camissonia cheiranthifolia* and other naturalized grass, ruderal and forb species described above.

2. Data Collection

Vegetation monitoring was conducted using the permanent quadrat method (Odum, 1959.) Standard surveying equipment was used to establish nine permanent sampling transects. The transects were established across the salt marsh and upland plains. A minimum of one quadrat per elevation of one foot was established along the transect lines. During Year 3 of monitoring, quadrat numbers in each transect were fixed since quadrat numbers varied in each monitoring year[3]. Quadrats were alternated from one side of the transect to the other to allow for a more representative sampling of the vegetation cover. Plant species cover was determined by visual estimates within each quadrat and recorded to the nearest 10 %.

[3]Data from Year 1 and Year 2 was sorted and organized such that all transects were compared to each other using the same number of quadrats in each transect.

3. Data Analysis

Data recorded during 7 monitoring visits over 3 years were analyzed and synthesized. Changes in species composition and species diversity between the SHRS and RS, and between the three monitoring periods were analyzed. Vegetation data was analyzed for percent absolute cover, average absolute cover and relative cover. Absolute cover, the amount of cover attributed to a given species, was calculated by totalling the percent cover observed in each quadrat and then dividing by the total number of quadrats where the species occurred. Relative cover, the percent of cover by a species in relation to the cover of all species, was also calculated. The percent relative cover value was used to: (a) evaluate vegetation establishment; and (b) compare annual cover measurements obtained in the SHRS and RS, **Table 4**.

a. Establishment of Vegetation Communities

The vegetation development and establishment of the SHRS are illustrated in **Figure 6.** A comparison of **Figure 6** (Year 3) with **Figures 5** and **Figure 6** in the Year 1 report shows an increase in the vegetation cover and extent of the SHRS. This is to be expected with initial colonization and expansion of vegetation across the barren soils of the newly constructed site.

i. Salt Marsh

The cover increased rather rapidly in the salt marsh beginning with the second year, as self recruited pickleweed and associated species expanded into the unvegetated areas. Saltgrass and pickleweed were the first well developed plants established[4]. Both species appeared in 6 out of 9 transects during Year 1 monitoring. Out of the 7 sampling periods analyzed for this study, saltgrass and pickleweed were recorded during an average of 6.22 and 6.00 samplings, respectively. Other salt marsh vegetation including alkali heath, gum plant and fleshy jaumea exhibited an overall annual increase of relative cover beginning in the second year and then began to level off or slow down; **Figures 9 - 17**.

During the 1990 revegetation work, eight plots with an average area of 300 square feet were treated with approximately 72 cubic yards of salvaged marsh soil (HRG, 1990.) At least 3 transects (#'s 1, 2, and 9) pass through portions of the project site that had received the salvaged marsh soil treatment. A comparison of the relative cover measurements of pickleweed in the treated and untreated areas showed average cover values of 52.52 % in the treated area, as compared to 21.58 % in the untreated areas; **Figures 11**, **12**, **13**, **14**, **15** and **16**.

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[4]It should be noted that the central marsh plain, which separated the north and south slough was not revegetated. The decision not to revegetate was made by the District consultant (HRG wildlife biologists) who suggested that the bare grounds at the mitigation site provided roosting area to certain birds. The basis for this decision is summarized in the First Annual Monitoring Report (HRG, 1991; Page 32) which states that "The large flock of roosting/resting gulls, terns, pelicans and other species was a unique feature of the Old Salinas River. These species prefer to roost on unvegetated ground, which was unavailable elsewhere on the Old Salinas River, except when extensive mudflat and mud bars are exposed during very low tides." Without revegetation, however, the establishment of marsh vegetation on the central plain was sufficiently delayed and restricted which undoubtedly contributed to the current problem of channel incision and rapid erosion of the central plain. This topic is discussed in more detail below.

TABLE 4.

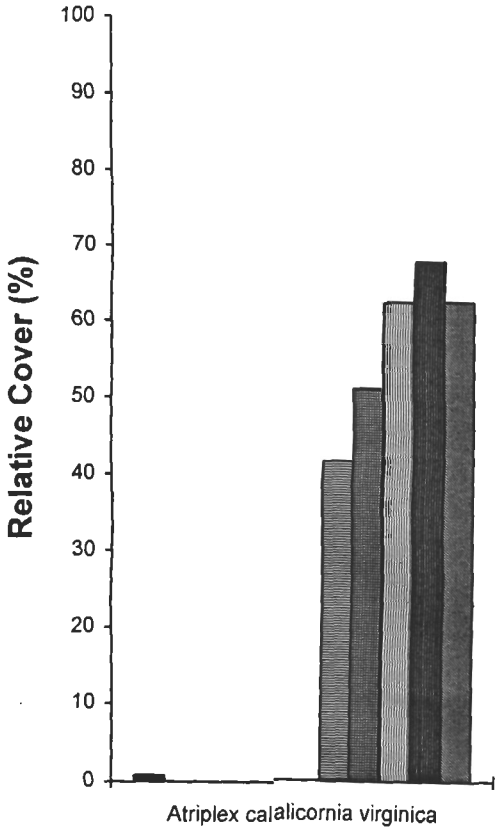
RELATIVE COVER {%} of Selected Plant Species: Calculated for each Transect
Moss landing South Harbor Restoration Project

TRANSECT NUMBER	SPECIES NAME	REFERENCE SITE	SUMMER 1990	SPRING 1991	FALL 1991	SPRING 1992	FALL 1992	FALL 1994	SPRING 1995
# 1	*Atriplex californica*	0.84							
	Distichlis spicata	6.97		74.47	22.68	15.85	24.31	21.46	24.31
	Elymus triticoides								
	Frankenia grandifolia	2.45			25.77	18.99	10.42	0.91	10.42
	Grindelia latifolia	3.97		10.00	5.15	1.9	3.47	1.37	3.47
	Jaumea carnosa	3.97		2.13				0.23	
	Salicornia virginica	81.81			41.24	50.63	61.81	67.12	61.81
	Salix lasiolepis								
	Bare								
		REFERENCE SITE	**SUMMER 1990**	**SPRING 1991**	**FALL 1991**	**SPRING 1992**	**FALL 1992**	**FALL 1994**	**SPRING 1995**
# 2	*Atriplex californica*	0.84							
	Distichlis spicata	6.97	3.70	76.70	69.28	58.55	57.93	60.09	57.93
	Elymus triticoides		0.93	4.26		1.76		0.17	
	Frankenia grandifolia	2.45	5.56		2.26	4.45	5.59	0.17	5.59
	Grindelia latifolia	3.97	6.48	2.56	1.51	0.94	0.71	0.17	0.71
	Jaumea carnosa	3.97	4.94		1.51	4.68	4.57	2.97	4.57
	Salicornia virginica	81.81	34.88	13.64	25.45	26.7	30.18	36.33	30.18
	Salix lasiolepis								
	Bare								
		REFERENCE SITE	**SUMMER 1990**	**SPRING 1991**	**FALL 1991**	**SPRING 1992**	**FALL 1992**	**FALL 1994**	**SPRING 1995**
# 3	*Atriplex californica*	0.84	9.21	0.31		8.43	2.94	1.39	2.94
	Distichlis spicata	6.97	12.72	7.00	34.13	17.56	20.55	27.67	20.55
	Elymus triticoides			11.98	0.79	5.16	10.21	1.71	10.21
	Frankenia grandifolia	2.45	33.33	33.44	23.81	29.26	21.72	22.76	21.72
	Grindelia latifolia	3.97	15.35	6.69	10.79	9.47	12.23	3.31	12.23
	Jaumea carnosa	3.97	1.54	7.62	0.32				
	Salicornia virginica	81.81	27.85	29.55	25.4	29.26	29.84	42.2	29.84
	Salix lasiolepis								
	Bare								
		REFERENCE SITE	**SUMMER 1990**	**SPRING 1991**	**FALL 1991**	**SPRING 1992**	**FALL 1992**	**FALL 1994**	**SPRING 1995**
# 4	*Atriplex californica*	0.84	18.99	2.14			4.77	2.05	4.77
	Distichlis spicata	6.97	1.4	2.36	7.65		20.52	13.03	20.52
	Elymus triticoides		8.89	7.60	18.19	27.27	16.22	33.17	16.22
	Frankenia grandifolia	2.45	31.15	35.97	36.39		77.19	8.2	77.19
	Grindelia latifolia	3.97		0.11	0.38	3.03	6.97	10.25	6.97
	Jaumea carnosa	3.97	0.19	0.43			0.95	1.21	0.95
	Salicornia virginica	81.81	22.45	18.63	28.36	60.61	18.13	17.85	18.13
	Salix lasiolepis				2.51	9.09	4.77	14.17	4.77
	Bare								
		REFERENCE SITE	**SUMMER 1990**	**SPRING 1991**	**FALL 1991**	**SPRING 1992**	**FALL 1992**	**FALL 1994**	**SPRING 1995**
# 5	*Atriplex californica*	0.84	47.93					0.16	
	Distichlis spicata	6.97	19.46	48.08	60.24	66.32	58.54	47.24	58.54
	Elymus triticoides		0.49	3.69	0.41	0.87		0.1	
	Frankenia grandifolia	2.45							
	Grindelia latifolia	3.97	0.24		2.2	3.05	6.36	6.93	6.36
	Jaumea carnosa	3.97						0.22	
	Salicornia virginica	81.81				4.36	12.11	30.49	12.11
	Salix lasiolepis				2.03	2.62	3.03	4.17	3.03
	Bare								

Notes:
1. Although bare areas were recorder during each monitoring survey, no analysis of these data was made for this study.
2. Data from the Reference Site were obtained during one monitoring survey (6 June, 1995.) These data were used as a standard by which current and historical monitoring results from the Restoration Site were compared to.

(Relative Cover {%} of Selected Species; continued from previous page)

TRANSECT NUMBER	SPECIES NAME	REFERENCE SITE	SUMMER 1990	SPRING 1991	FALL 1991	SPRING 1992	FALL 1992	FALL 1994	SPRING 1995
# 6	*Atriplex californica*	0.84	2.81		26.35		36.33		36.33
	Distichlis spicata	6.97	19.3	5.43	25.6		19.53	27.27	19.53
	Elymus triticoides		29.82	19.84	23.46	42.33	13.94	19.95	13.94
	Frankenia grandifolia	2.45			1.51		2.7		2.7
	Grindelia latifolia	3.97		2.45	4.39	8.73	6.81	4.59	6.81
	Jaumea carnosa	3.97			0.13		0.45		0.45
	Salicornia virginica	81.81			5.02		11.81	2.38	11.81
	Salix lasiolepis				1.25	1.32			
	Bare								
		REFERENCE SITE	**SUMMER 1990**	**SPRING 1991**	**FALL 1991**	**SPRING 1992**	**FALL 1992**	**FALL 1994**	**SPRING 1995**
# 7	*Atriplex californica*	0.84	10.2	3.75	2.58			2.18	
	Distichlis spicata	6.97		2.47	1.18	11.08	4.01		4.01
	Elymus triticoides		2.46	5.49	1.47	5.32	3.43	12.13	3.43
	Frankenia grandifolia	2.45	57.25	42.27	17.4	30.59	21.73	37.67	21.73
	Grindelia latifolia	3.97					0.11		0.11
	Jaumea carnosa	3.97	0.25	0.64				0.16	
	Salicornia virginica	81.81	9.58		16.45	17.55	32.63	44.79	32.63
	Salix lasiolepis			0.46	0.74	0.89	1.43	2.43	1.43
	Bare								
		REFERENCE SITE	**SUMMER 1990**	**SPRING 1991**	**FALL 1991**	**SPRING 1992**	**FALL 1992**	**FALL 1994**	**SPRING 1995**
# 8	*Atriplex californica*	0.84	0.41		2.43				
	Distichlis spicata	6.97	18.83	32.18	14.84	18.07	31.36	26.17	31.36
	Elymus triticoides			0.35					
	Frankenia grandifolia	2.45	39.85	1.73	3.04	3.19	2.26	0.32	2.26
	Grindelia latifolia	3.97	4.06	5.19		2.13	1.36	19.05	1.36
	Jaumea carnosa	3.97							
	Salicornia virginica	81.81	22.65	4.15	10.34	11.69	26.36	11.95	26.36
	Salix lasiolepis								
	Bare								
		REFERENCE SITE	**SUMMER 1990**	**SPRING 1991**	**FALL 1991**	**SPRING 1992**	**FALL 1992**	**FALL 1994**	**SPRING 1995**
# 9	*Atriplex californica*	0.84							
	Distichlis spicata	6.97			3.23	1.14	0.79		0.79
	Elymus triticoides								
	Frankenia grandifolia	2.45	61.29	27.78	10.5	7.5	7.6	33.48	7.6
	Grindelia latifolia	3.97							
	Jaumea carnosa	3.97			0.91	0.26	0.68	0.11	0.68
	Salicornia virginica	81.81	38.71	69.14	84.116	91.1	91.1	66.41	91.1
	Salix lasiolepis								
	Bare								



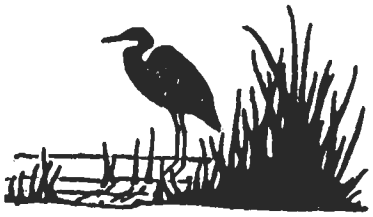


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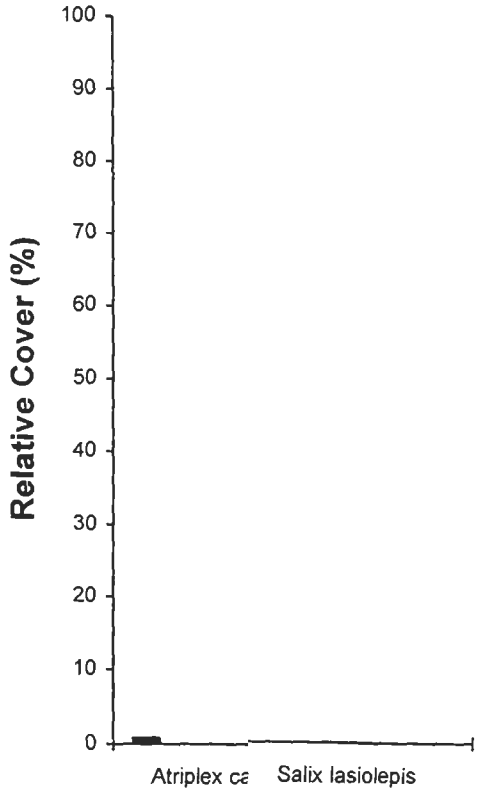
FIGURE 9



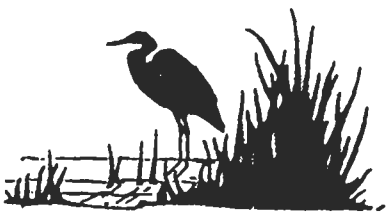


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FIGURE 10

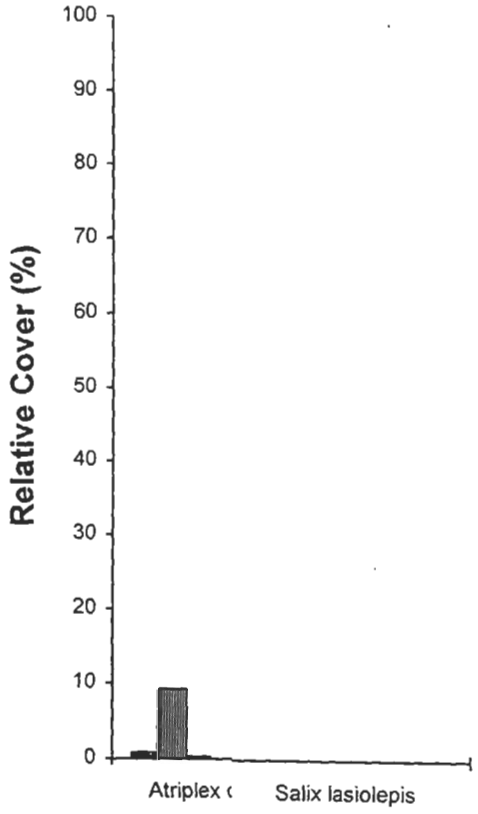

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FIGURE 11

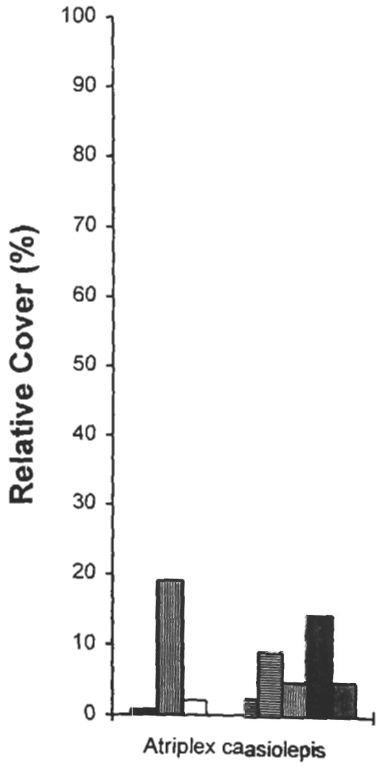

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FIGURE 12

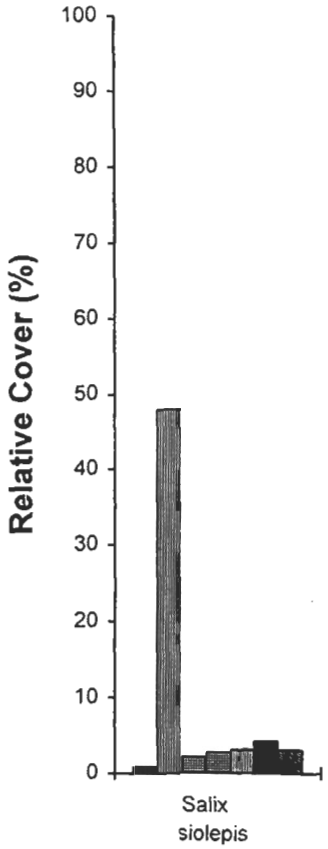

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FIGURE 13

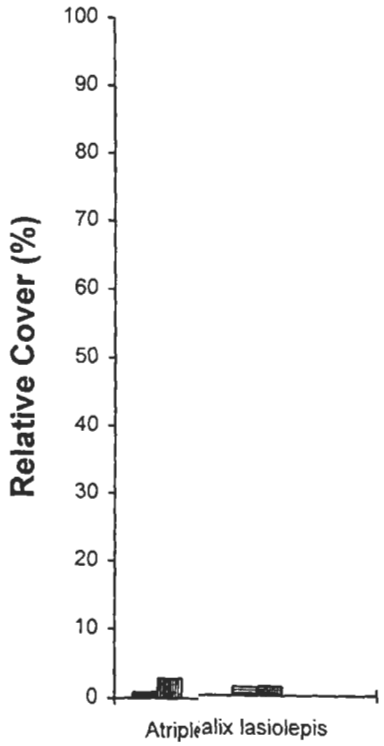

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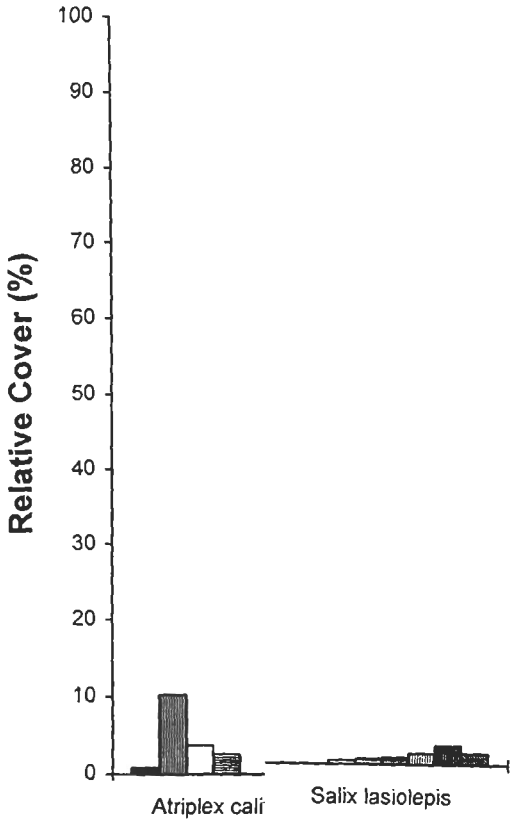
FIGURE 14



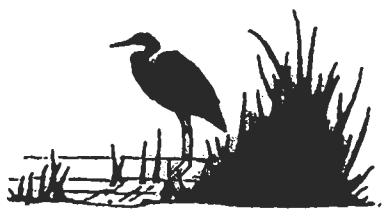


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FIGURE 15

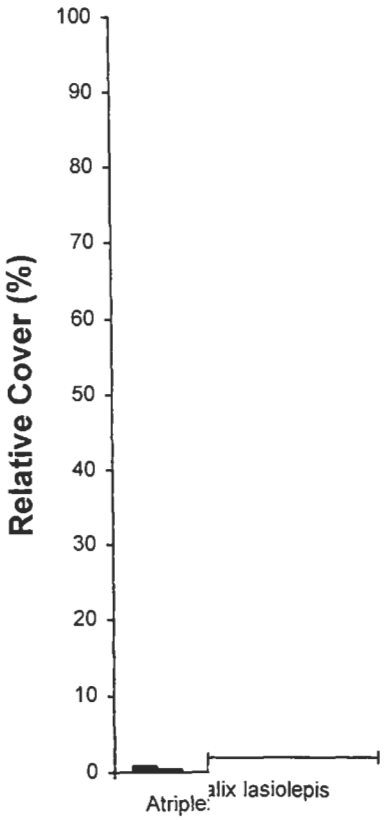

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FIGURE 16

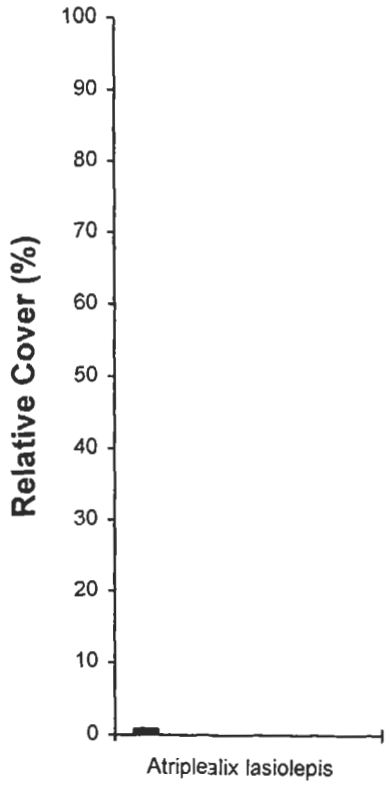

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FIGURE 17

ii. Transitional Area

Wild rye, which occupies the transition areas between the upland and the salt marsh attained a maximum value of 27.27 % in relative cover in the spring of 1992, and appeared on the average in 4.66 samplings out of a total of 7. Gum plant, which also occupies this transitional zone, attained a maximum value of 19..05 % in relative cover in the fall of 1994. It showed a gradual annual increase in all 7 transects where it was present, began to decline in proceeding years, and appeared on the average in 4.80 samplings out of 7.

iii. Peripheral upland

Initially, vegetation cover developed very rapidly at the higher elevations within the transitional and upland zones, while cover developed relatively slowly within the salt marsh area. In general, the upland areas above the tidal zone contain hard dry soil and supports a high density of herbaceous cover composed of a relatively small number of weedy annual and biennial species, **Table 1**. The extent of this herbaceous cover has increased significantly since construction of the project.

Initial colonization of the upland bare soil (slopes and top of the berm) by spear oracle occurred rather rapidly during the first two years, and just as rapidly slowed or disappeared in succeeding years. During summer and fall 1990, the relative cover of this species was 25.49 %. This compares to the 0.79 % average relative cover obtained for the same species in the fall of 1994.

The highly invasive and hard to control *Senecio mikanioides* (German ivy) has firmly established itself along the east-facing slope and the toe course of the berm. This species did not appear in any of the transects between 1990 and 1991, and appeared in one transect in the fall of 1992. By the fall of 1994 it was recorded in 5 transects and attained 13.38 % in relative cover value.

In November 1990, 73 pole cuttings of arroyo willow were planted along the toe course of the eastern levee. During the fall 1994 survey, 38 surviving willow shrubs were recorded, i.e., 52 % survival rate. The surviving willows had attained an average height of 8.44 feet, and an average diameter of 2.66 inches (measured approximately 18 inches from the ground surface.)[5] Towards the southern end of the berm a general decline in vigor and extensive die-off of willow shrubs was observed. As noted in the Year 1 and Year 2 annual monitoring reports, this decline and lack of vigor of the willows and other upland vegetation can be attributed to the harsh substrate condition found at this portion of the site.

[5]The shrubby nature of arroyo willows with multiple trunks did not readily allow DBH (diameter at breast height) measurements to be taken.

b. Plant Species Richness[6]

Species richness data from 1990, 1991, 1992 and 1994 could be directly compared with each other. The average number of plant species identified in all the transects varied somewhat from 1990 to 1994. The highest average number of species(16.89) was obtained in 1991, while the lowest average number (13.13) was recorded in 1990. By 1994, the average number had dropped to 14.78, **Table 5** and **Figure 18**.

The maximum number of 30 species was recorded in 1992, while the minimum number of 20 occurred in 1990. Overall, the greatest number of species were found within the transitional and upland boundaries, while the regularly flooded salt marsh area supported the fewest number of plant species.

B. WILDLIFE MONITORING

The primary objective of the wildlife monitoring was to determine and document the habitat value of the SHRS to birds, and to compare this value to the RS. Birds were the only wildlife group measured qualitatively for this study. Birds have been selected for monitoring because: (a) of their significant ecological value in wetlands and mudflats; (b) they are excellent indicators of habitat quality (Mullen, 1992); and (c) they can readily be observed allowing systematic surveys of their species composition and relative abundance.

1. Data Collection

The SHRS and RS were sampled during winter, spring, summer and fall, with the most sampling conducted during fall and winter. All birds were identified to species level except dowitchers. Seasonal samples were collected to characterize breeding, resident and migrant species. To obtain data on bird populations and species, the observer would walk along the top of the compacted berm at the SHRS, and the access road at the RS.

The SHRS and the RS were both surveyed on each visit, and each seasonal sampling included at least two surveys - one during morning and the other during evening. All birds were identified, visually or by sound, during two 60-minute census periods (2 observation stations x 30 minute/site.)[7] One morning and one afternoon sampling period were completed at the SHRS and the RS to ensure that most species present in the area were seen or heard.

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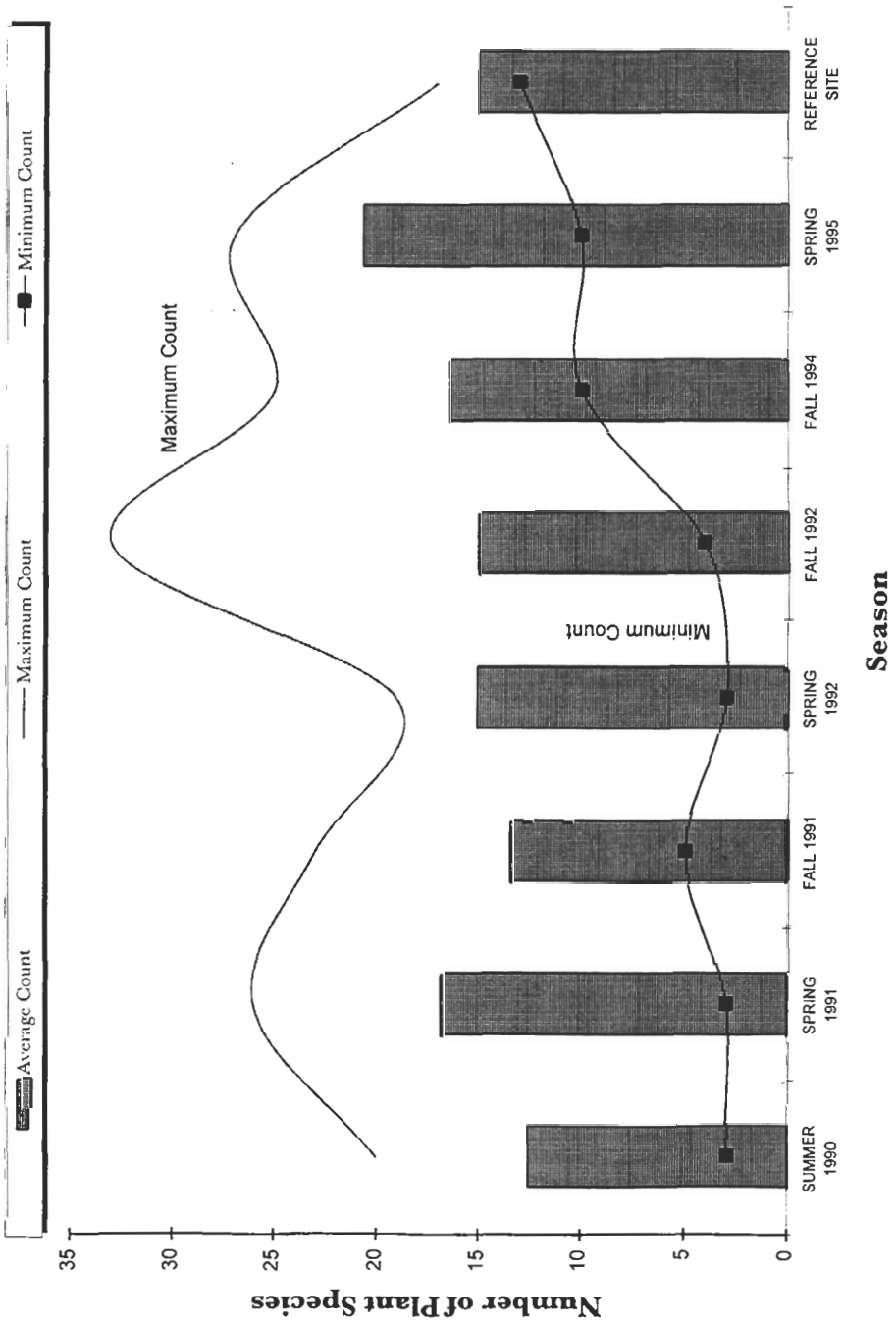
[6]Species Richness is defined herein as the number of species observed and recorded during sampling visits.

[7]Varying numbers of completed sets of bird counts were conducted during Year 1 and Year 2 monitoring periods. The data from this period was analyzed using the SDI method, which allows data to be directly comparable from survey to survey (see discussion elsewhere in this report).

TABLE 5.

Average Annual Plant Species Richness
Moss Landing South Harbor Restoration Project

TRANSECT NO.	NUMBER OF SPECIES							
	SUMMER 1990	SPRING 1991	FALL 1991	SPRING 1992	FALL 1992	FALL 1994	SPRING 1995	REFERENCE SITE
1	9	11	9	12	6	10	23	17
2	10	13	9	11	9	15	18	13
3	20	22	17	19	17	10	20	
4	18	26	21	19	33	25	21	
5	17	23	17	18	18	15	27	
6	19	19	23	19	22	21	26	
7	9	20	11	19	12	15	23	
8	3	15	9	16	14	19	18	
9	9	3	5	3	4	18	10	
Average Count	12.7	16.9	13.4	15.1	15.0	16.4	20.7	15.0
Maximum Count	20	26	23	19	33	25	27	17
Minimum Count	3	3	5	3	4	10	10	13



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Moss Landing South Harbor
Restoration Project
Average Annual Plant
Species Richness

FIGURE 18

2. Data Analysis

a. Species Diversity Index (SDI)

The data analysis methodology employed for the bird monitoring is the Shannon-Weaver Index of General Diversity, or SDI. This method was used to evaluate and compare the habitat values of the SHRS and the RS.

The SDI method involves the analyses of simple ratios between the number of species and the "importance values" (numbers, biomass, productivity, etc.) of the individuals within each species. Its value as an environmental monitoring tool is readily indicated by its most basic tenet: Species diversity tends to be low in physically controlled ecosystems (i.e., subjected to strong physiochemical limiting factors) and high in biologically controlled (natural) ecosystems. (Mullen, 1992.)

The SDI analysis permitted the comparison of the bird populations in both the SHRS and RS. In addition, the SDI treatment of the bird data minimized the importance of variations in the methods of data collection, total monitoring efforts, and permitted a more equitable statements about comparative habitat values at the SHRS and RS. The SDI for the two areas was calculated using the formula:[8]

$$SDI = - \frac{ni}{N} \log_e \frac{ni}{N}$$

The SDI is based on the theory that of the total number of species (in this case, birds) in a habitat, a relatively small percent are usually abundant or common while a large percent are less common. The few common species (dominant) use most of the available resources in a particular habitat. But the richer the habitat, the more likely it will be to provide sufficient extra resources to permit the coexistence of greater numbers of the less common species. It is the presence, therefore, of the less common species which most influences the SDI value and indicates the quality of the habitat, not the size of the population of a given species (Mullen, 1992.)

SDI values below 2.00 usually indicate a naturally poor habitat or one which is highly disturbed as in the case of agricultural lands. SDI values near 3.00 or above are associated with more environmentally healthy or undisturbed habitats.

b. Statistical Analysis

A total of 57 bird species were observed utilizing both the SHRS and the RS. These species were classified into five general groups: waders, gull-like, duck-like, shorebirds and songbirds, **Table 3**. The number of bird species recorded during all the surveys ranges from a low of 7 at

[8] ni = total encounters with a particular species in the habitat.
N = total encounters with all species in the habitat.

the RS to a high of 39 at the SHRS. The SHRS is represented by more species in all seasons than the RS. This result is supported by the high plant species richness obtained at the SHRS, which provides an overall increase in the availability of food sources and, thus an increase in the habitat value of the site. This explanation is further supported by the SDI value obtained from the SHRS and the RS. Species diversity was lowest (0.46) in the relatively stable RS, and highest (2.48) in the SHRS, **Table 6**. SDI values tended to remain unchanged seasonally (fall and winter) over the course of the three years of monitoring in the SHRS, yet they showed significant seasonal annual changes, **Figure 19**.

Shorebirds made up the largest percentage of species counted both at the SHRS and RS, followed by gulls. At the SHRS, species richness of all bird groups decreased annually. The only exception being the fall of 1994, when species diversity slightly increased. The RS also showed a general annual decrease in species diversity, except for winter 1992 and fall 1994, when it increased slightly, **Table 6**.

Bird use of the SHRS and the RS consisted primarily of foraging. Roosting was also common as flocks of gulls, terns and shorebirds were observed resting on exposed soils just above the water surface elevations. Although the SHRS and the RS provides valuable foraging and roosting habitat for migratory and overwintering species, no nesting activities have been recorded in these two areas.

C. EROSION/SEDIMENTATION

In May 1992, several wooden stakes were set in place within the intertidal area of the SHRS in an attempt to monitor sediment transport processes (HRG, 1990a.) The stakes were placed several inches into the ground, and marked with plastic tapes at the existing ground-surface elevations. The purpose of the stakes was to measure sediment deposition and erosion relevant to the position of the plastic markers on the stakes. From the beginning, several shortcomings with using the stakes to quantify erosion/sedimentation became apparent. The most significant shortcomings included: (a) the stakes created eddies around them leading to localized erosion/sedimentation during high and low tide cycles, rendering any measurement taken from them as unreliable; (b) within a few weeks, almost all of the stakes were either lost or dislodged from their intended position by tidal actions, thus significantly reducing the value of any data obtained from them; and (c) although the wooden stakes were eventually replaced by metal rebars, and the problem of displacement of the stakes seemed to have been corrected, a major weakness of the methodology still remained - that the data could not be used to quantify the acreage loss or gain due to erosion/sedimentation.

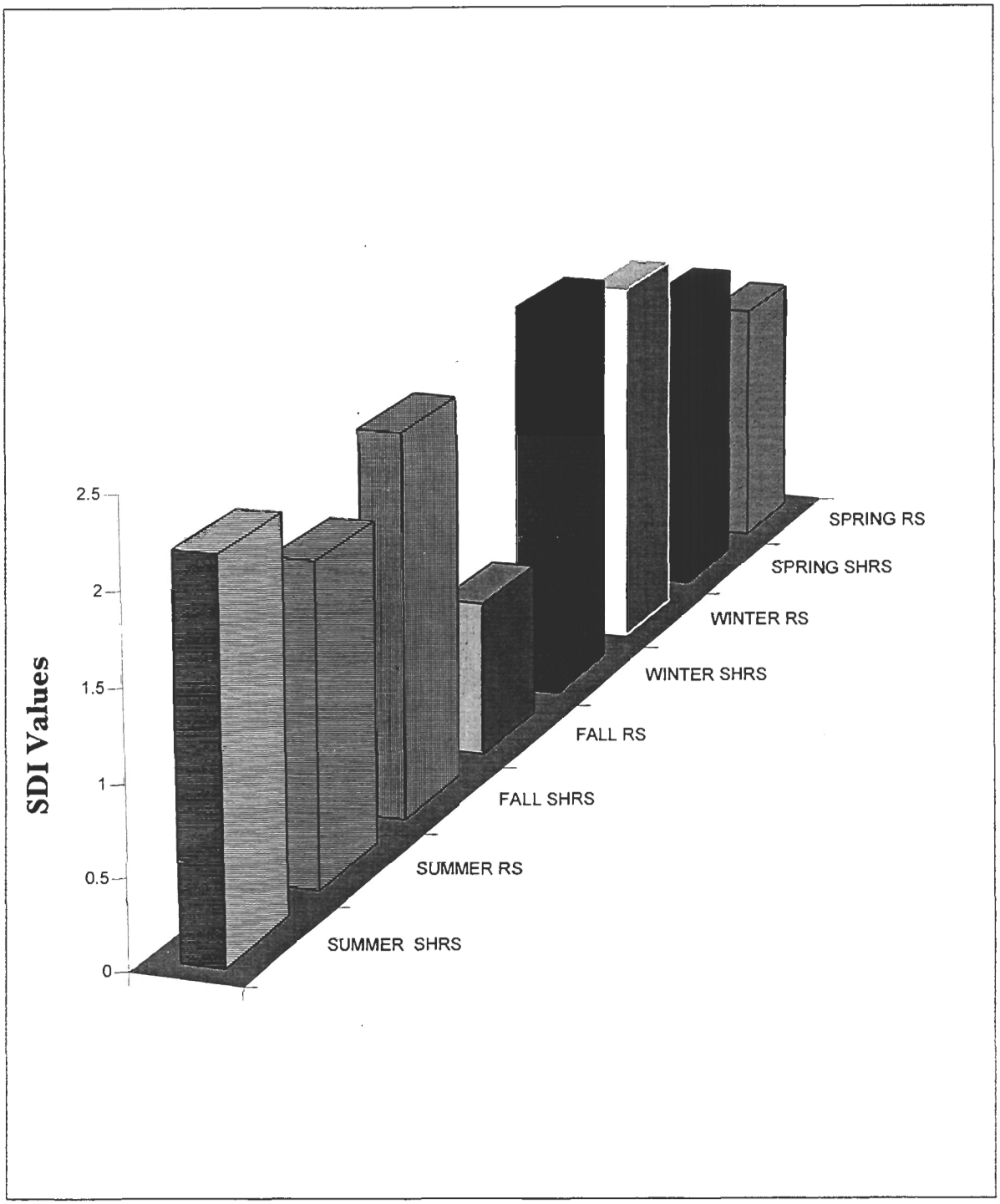
1. Channel Incision

The most significant finding of this study is that an incised channel has become established between the north and south sloughs. The central marsh peninsula has almost completely receded to the east, forming a detached island which appears to be the only feature that remains above flooding level during mid-flood (a period between 1/3 to 2/3 of flood), **Figure 6**.

TABLE 6.

Moss Landing South Harbor Restoration Project
Summary of Data on Birds
Utilizing the SHRS and the Control Sites

	SPECIES DIVERSITY INDEX			NUMBER OF BIRD SPECIES			NUMBER OF INDIVIDUALS		
MONITORING SEASON	SHRS	CONTROL	PERCENT DIFFERENCE	SHRS	CONTROL	PERCENT DIFFERENCE	SHRS	CONTROL	PERCENT DIFFERENCE
SPRING (April-May)	1.86	1.5	19.35	12	7	41.67	80	20	75.00
SUMMER (Aug.-Sept.)	2.55	NO DATA		34	NO DATA		300	NO DATA	
WINTER (Dec.-Jan.)	2.34 +/- 0.16	2.18 +/- 0.65	6.84	26.67 +/- 9.5	26.33 +/- 7.1	1.27	268 +/- 69.1	171.67 +/- 127	35.94
FALL (Oct.-Nov.)	2.33 +/- 0.19	1.56 +/- 0.01341	33.05	31 +/- 7.5	18 +/- 6.1	41.94	431 +/- 125.3	261 +/- 105	39.44



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Moss Landing South Harbor
Restoration Project
Annual Variations in SDI Values

FIGURE 19

The channel incision was first observed in 1991 and had a dimension of 1-2 feet wide and six inches deep, over a distance of 100 feet (HRG, 1991.) The continued growth of this channel was reported in the 1992 Annual Report (HRG, 1992.) Currently, the channel incision measures approximately 55 feet wide and two feet deep over a distance of 100 feet.

The original grading plan (*Moss Landing Harbor Mitigation & Restoration Study*; Connmass, 1988) shows topographic features which are consistent with the text of the wetland mitigation plan, Moss Landing Harbor Wetland Mitigation Plan (Jones & Stokes, 1989.) However, the figures representing the site design in the Jones & Stokes plan are not consistent with the text. The 1989 Jones & Stokes plan states that topographic features at the mitigation site will include - "...two broad branching slough channels, several smaller tributary channels, a marsh plain, a slope between the marsh plain and the upland and a low berm on the upland... The slough channel bottoms will be approximately 3 feet above MLLW and measure 20-40 feet wide... The branches of the sloughs will be positioned to facilitate drainage from the surrounding uplands. The smaller tributary channels will measure approximately 1 foot wide at their bottom and 1 foot deep, with 1:1 side slopes. They will meander through the marsh plain and enter the slough channels at approximately right angels. The tributary channels will convey runoff from adjacent uplands, improve tidal flushing through the marsh, and reduce potential mosquito habitat." These features, however, are not depicted in any of the figures presented in the Jones & Stokes plan. On the other hand, the features are clearly shown in the original drawings prepared by Connmass in 1988.

Comparison between the figures in the 1989 Jones & Stokes plan and Connmass' final grading plan, which was used to construct the project (Connmass, 1990) revealed identical features that are shared between the two. Both plans show two broad sloughs with wide entrances (approximately 100 feet wide) at the river channel, which taper to rather narrow channels (approximately 10 feet wide) towards the center of the restoration site. No tributary channels are shown in either the Jones & Stokes plan or the Connmass plan. Drainage of the upland areas are facilitated by a swale, rather than being conveyed via tributary channels as originally planned.

The 1988 Connmass plan was evidently changed sometime between 1988 and 1989, although no reference is made regarding these alterations in any of the documents examined. It is most probable that: (a) the severe tapering features of the slough channels as shown both in the final grading plan and mitigation plan; and (b) the absence of a network of steep-sided tributary slough channels contributed to the rapid erosion of the central marsh plain. It is most likely that the tapering nature of the two sloughs concentrated and directed tidal flows toward the edges of the marsh plain, increased water velocities and thereby accelerated the process of suspending and transporting sediments from the narrower end of the channels during each low tide. Most likely, it extended the channel incision and channel widening processes as the central marsh plain continues to slump and recede into the Old Salinas River Channel.

2. Analysis of Topographic Surveys

During Year 3 monitoring period, the SHRS was surveyed using a hand level, rod and tape. The survey results were compared with Connmass' final grading plan (Conmass, 1989) and the Year 2 topographic survey conducted in July 1991 (AG Surveyors.) Measurement of the aerial extent of erosion at the SHRS was estimated using a prelinimeter and aerial photographs.

After the completion of the grading operation, erosional features predominated the shoreward face of the relict railroad levee, located along the south west corner of the SHRS. This area seems to have stabilized in recent years, although some of the pickleweed marsh area was lost by cleavage and slumping of the marsh surface.

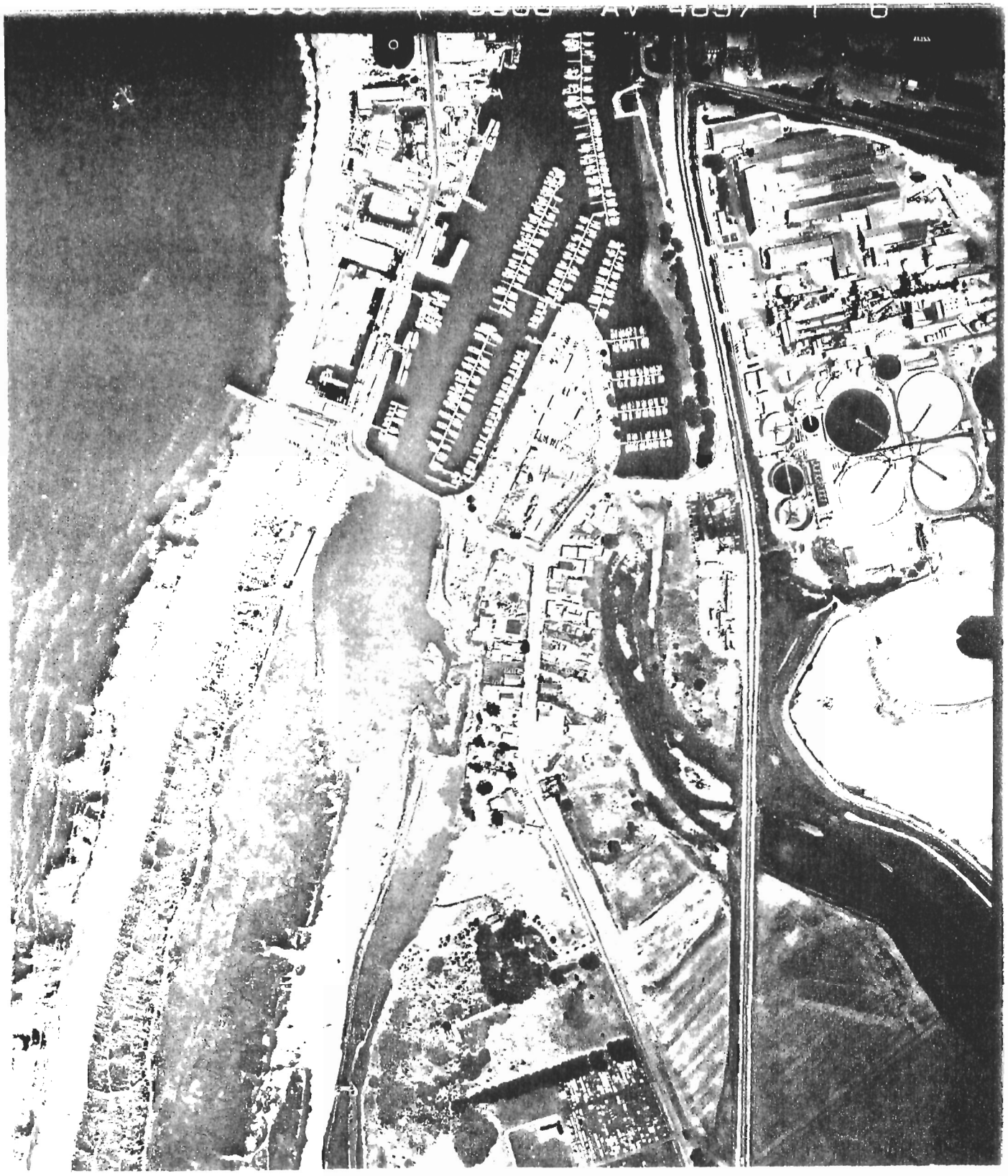
Erosion and channel incision at the central peninsula was observed soon after completion of the project. The conclusion of Year 1 and Year 2 monitoring reports was that the site would adjust itself to a stable salt marsh complex of a marsh plain intercepted by a network of slough channels, much like what is prevalent in the Old Salinas River Channel and Elkhorn Slough. This conclusion may have had some merit had the central marsh plain been well vegetated, and a network of slough channels had been created as envisioned by the Jones and Stokes' mitigation plan.

Currently, approximately 0.29 acre of the central marsh plain has been lost by erosion. The marsh plain has been cut down to a hard, compacted clay surface where approximately 12-16 inches of uncompacted soil layer has been lost from the top surface. An incised channel measuring approximately 24 inches deep, 110 feet long and 55 feet wide has formed, **Figure 20**. This incised channel has effectively cut off the marsh plain from the pickleweed marsh located along the west facing slope of the berm. The marsh plain has receded to the east and is in effect an island which remains submerged under average tidal conditions. A contour map showing current conditions is presented in **Figure 6**. A yearly account of acreage losses in each habitat has been calculated and presented in **Table 2** and **Figure 6**.

D. SOIL CHARACTERISTICS

Upland soils in the project consist of imperfectly-drained to well-drained soils. In general the soil characteristics include: sandy soils on the southern half of the project, with silt and silty sand prevailing on the northern half. Levee soils are sand and sandy loams. The salt marsh and mudflat areas are composed primarily of clay derived from relict deposits of the Old Salinas River Channel and dredge spoils disposed at the site in more recent years. Extensive clay deposits underlay much of the lower elevation flats and marsh plains.

The purpose of the soil analysis was to determine any needs for amendment during the revegetation phase of the project. Five soil samples were collected in Year 3 at the previously established sampling stations. Samples were analyzed by a laboratory method for salinity, nutrient content, $_{p}$H and other applicable parameters. The results of the soil test for Year 1 and Year 1 are given in **Table 7**.



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Moss Landing South Harbor
Restoration Project
Aerail Photograph of the SHRS, 1995.
Approximately Five Years After Construction

FIGURE 20

Table 7.

Results of Chemical Analysis of Soil Samples (Year 1 and Year 2)
Moss Landing South Harbor Restoration Project

Sample Name	ph	EC	Nitrate	P	K	Ca	Mg	Organic Content (%)
1991								
B2	7.7	31.4	13	17	215	1400	320	1
B1	7.6	14.3	19	21	245	3000	350	0.5
B3	8.2	30.4	16	18	275	1200	310	1
B4	7.9	21.2	29	24	355	1800	400	2.7
B5	7.7	24.2	20	50	440	3000	430	5.1
1994								
A	7.6	44.7	10	19	1230	850	1260	1.1
B	8.5	12.1	11	112	467	720	442	1
C	7.8	15.5	2	32	238	370	293	0.3
E	7.7	13.7	7	54	369	730	376	0.9
F	7.6	49.1	8	53	1250	1200	1570	1

Notes:

1. **B2= A; B1=B; B3=C; B4=E; B5=F**
2. **All Tests Conducted by A & L Western Agricultural Laboratories, Watsonville, California**

In general, lower levels of organic matter content, $_pH$, and nitrate levels were obtained from Year 3 samples, as compared to the 1991 results. Soil salinity exhibited a marked increase from the previous years, while the results of other parameters were mixed.

Soil samples were mildly alkaline to alkaline in all samples, ranging in pH values from a low of 7.6 to 8.5. PH values remained relatively stable between Year 1 and Year 3, except at sample locations B (Year 3) and B1(Year 1) where an increase in alkalinity was recorded. Sediment salinity showed a hundred fold increase in sample F (Year 3) as compared to sample B5 (Year 1). The samples were obtained from the southern portion of the SHRS where vegetation die-offs and a general lack of vigorous self-recruitment has been recorded. Soil salinity increased 42 % in sample A (Year 3) as compared to sample B2 (Year 1). The largest decrease in salinity was exhibited in sample C (Year 3) as compared to B3 (Year 1).

The unexpected result, lower soil salinity measurements in the tidal salt marsh area in 1994 as compared to 1990, can be attributed to the drought years of 1986 - 1991. Drought generally increases soil salinity due to the lack of rainfall and increased evaporation (Josselyn, 1983.)[9]

Percent organic content of samples increased by 10% in sample A (Year 3) as compared to B2 (Year 1); and 100% in sample B (Year 3) as compared to B1 (Year 1.) The low lying area to the east of the berm where samples B and B1 were collected produces large quantities of organic debris since it supports dense stands of both native and non-native vegetation. Apparently, the mass of vegetation contributes to the accumulation of organic matter in the soil, resulting in the measured increase of soil organic content.

E. PHOTO MONITORING

Photographic panoramas taken at various times during Year 3 monitoring and a few others from previous years are presented in **Figures 21 - 26**. These photographs are intended to show vegetation establishment and changing topography of the site. **Figures 27** and **Figure 28** show aerial photographs of the SHRS before and after construction of the project.

VIII. CONCLUSIONS

The results of this study documented that salt marsh vegetation has become well established at the SHRS through revegetation and self-recruitment. Desirable wetland plant species such as pickleweed, fleshy jaumea and alkali heath appear throughout the nine monitoring transects. Natural succession of all the vegetation communities seem to be developing satisfactorily. Distribution of the vegetation along a topographic gradient and tidal influence seems to follow expected patterns, although distinct wetland upland zonation and transitional boundaries were not readily observable.

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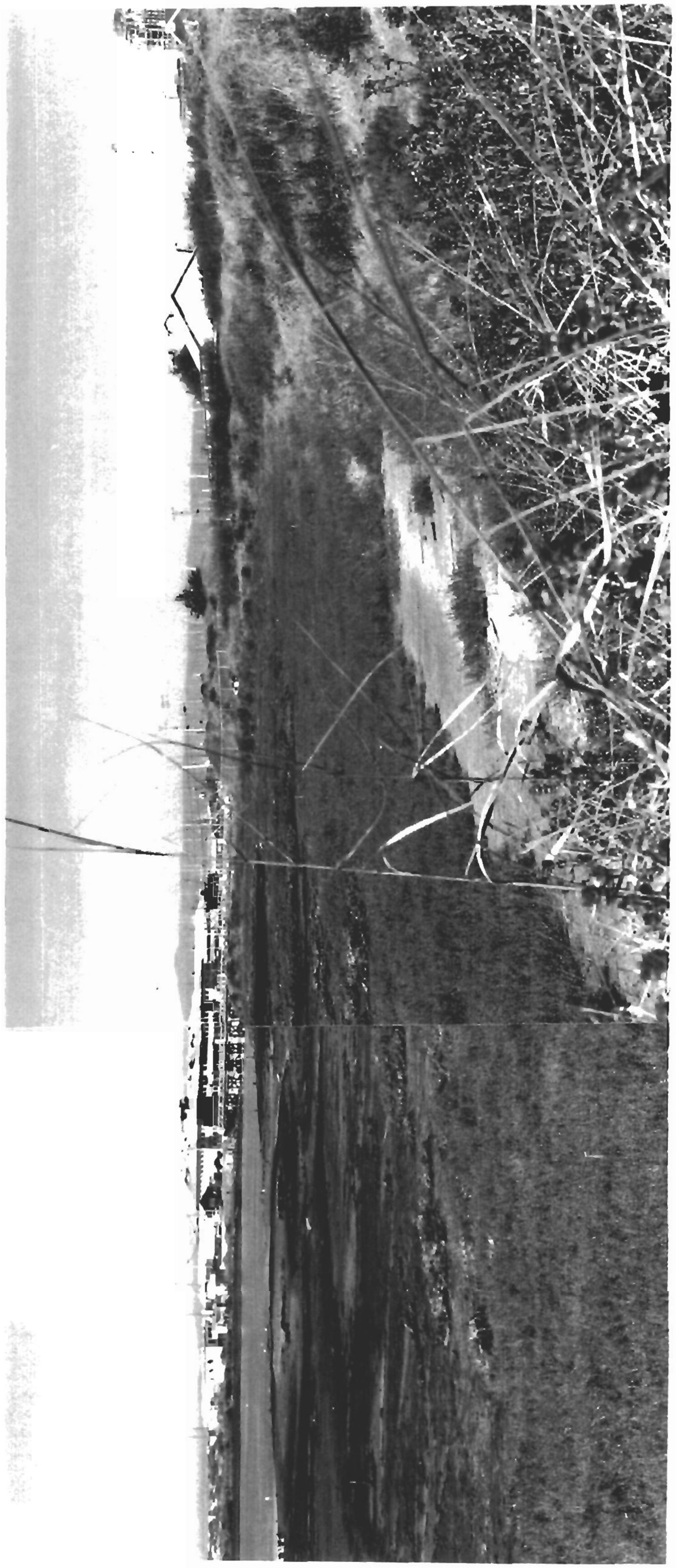
[9]1990 soil samples were obtained in January 1990. 1994 soil samples were obtained in September 1994.



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Moss Landing South Harbor
Restoration Project
Panoramic View of the
Project Area

FIGURE 21

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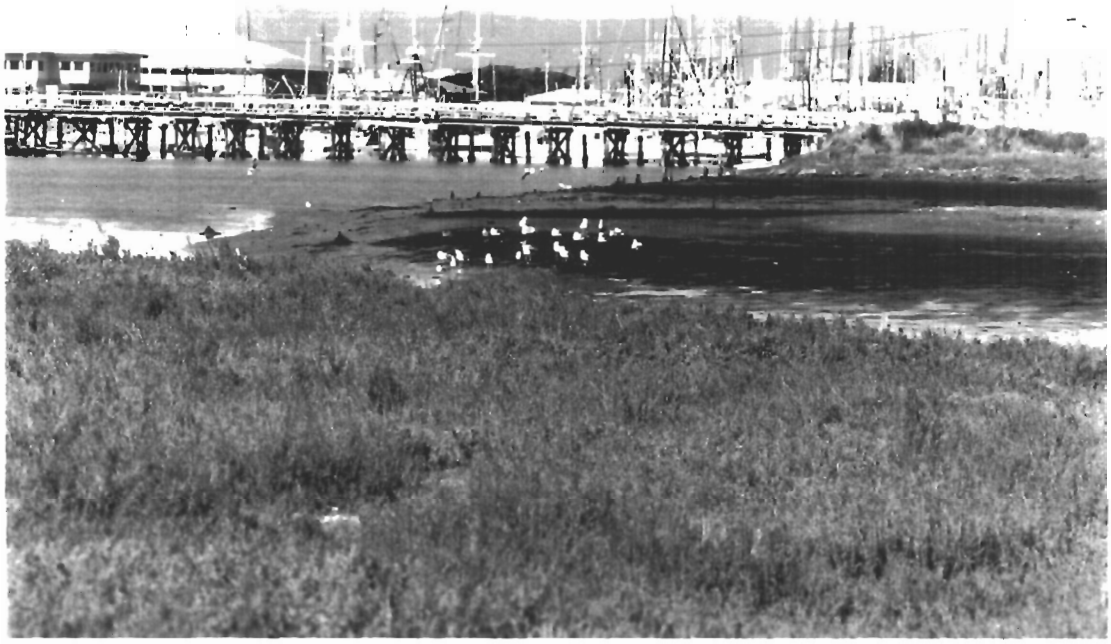
Moss Landing South Harbor
Restoration Project
Vegetation Development
and Establishment

FIGURE 22



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Moss Landing South Harbor
Restoration Project
Waterbirds and Shorebirds
Utilizing the Project Area

FIGURE 23

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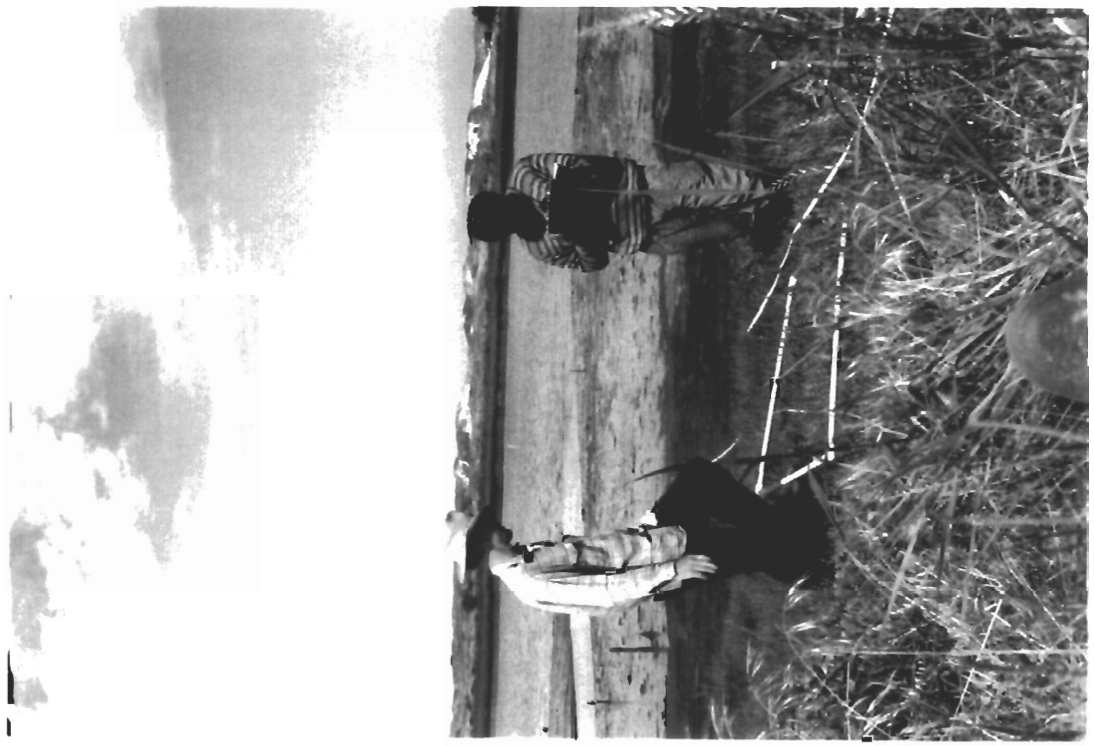
Moss Landing South Harbor
Restoration Project
Showing the Channel Incision
and the Marsh Plain Erosion

FIGURE 24



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Moss Landing South Harbor
Restoration Project
Investigators Collecting
Vegetation Data

FIGURE 25

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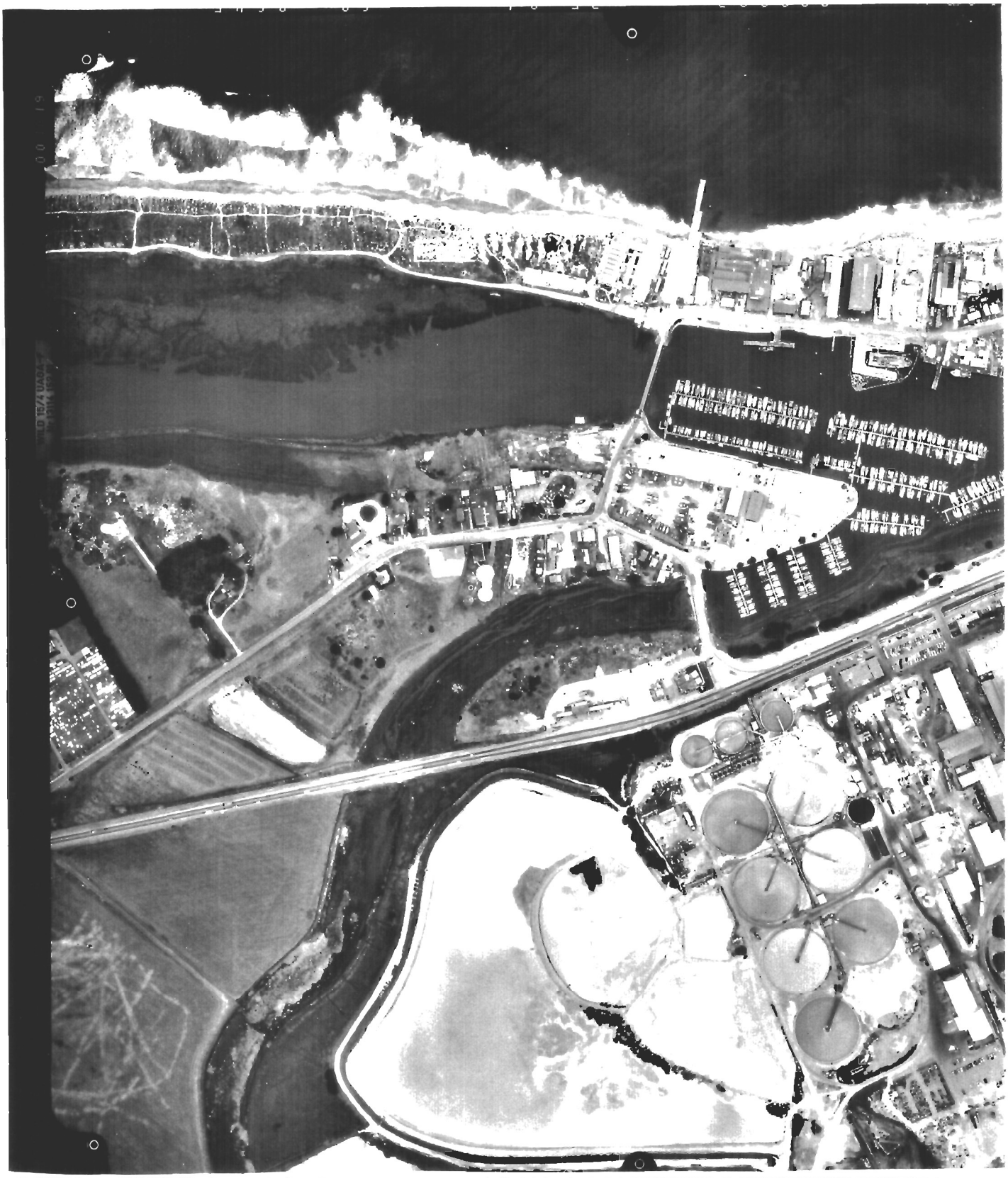
Moss Landing South Harbor
Restoration Project
Panoramic View of the Reference Site (RS),
Showing the Pickleweed Marsh Plain

FIGURE 26



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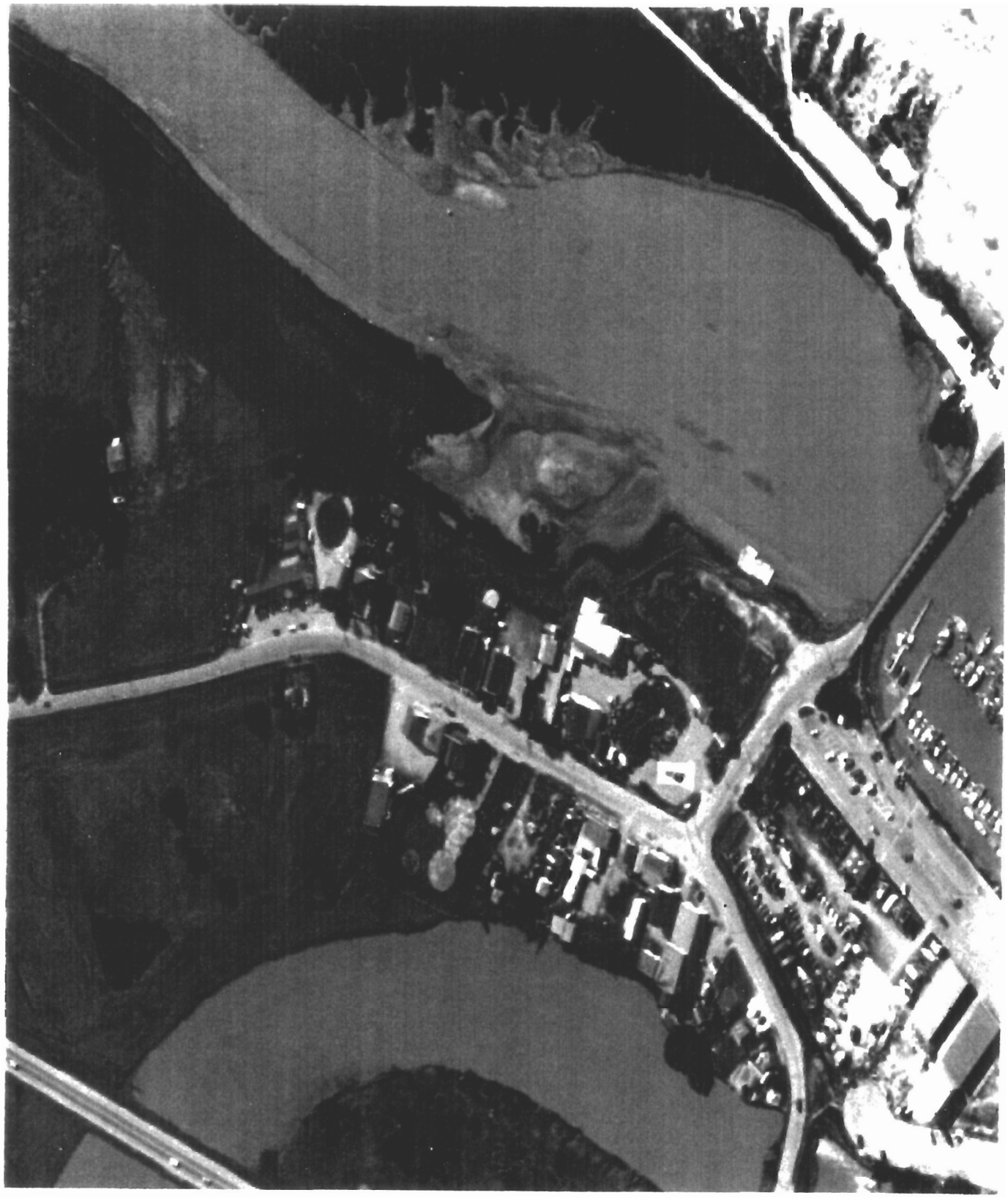
Moss Landing South Harbor
Restoration Project
Aerial Photograph of the SHRS, 1989.
Approximately One Year Prior to Construction

FIGURE 27



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Moss Landing South Harbor
Restoration Project
Aerial Photograph of the SHRS, 1992.
Approximately Two Years After Construction

FIGURE 28

Revegetation using salvaged top soil material has been shown to be very effective in accelerating colonization of barren areas by desirable salt marsh species. Saltgrass seems to have benefitted the most by revegetation using salvaged plant material as this species appears to have become firmly established at the SHRS.

Plant species richness is highest at the SHRS as compared to the RS. The net effect of high species richness measurement is the increased availability of food and shelter to wildlife species as demonstrated in the higher diversity of birds recorded at the SHRS than the RS.

The SHRS is being used by a wide variety of bird species and continues to provide habitat values that are higher than the RS. Bird survey data from the SHRS indicate the presence of average to above average wildlife values, while bird surveyS from the RS indicate the presence of below average to poor wildlife values.

Bird species abundance is also higher at the SHRS as compared to the RS. The higher measurements of bird species diversity and abundance indicate a higher carrying capacity of the SHRS than the RS.

While most of the SHRS has attained a degree of stability, the central marsh plain continues to erode, perhaps threatening its complete loss and disintegration by tidal action. To date, approximately 0.29 acre of a central salt marsh plain created by the project has been lost by erosion.

IX. ATTAINMENT OF THE PERFORMANCE STANDARDS

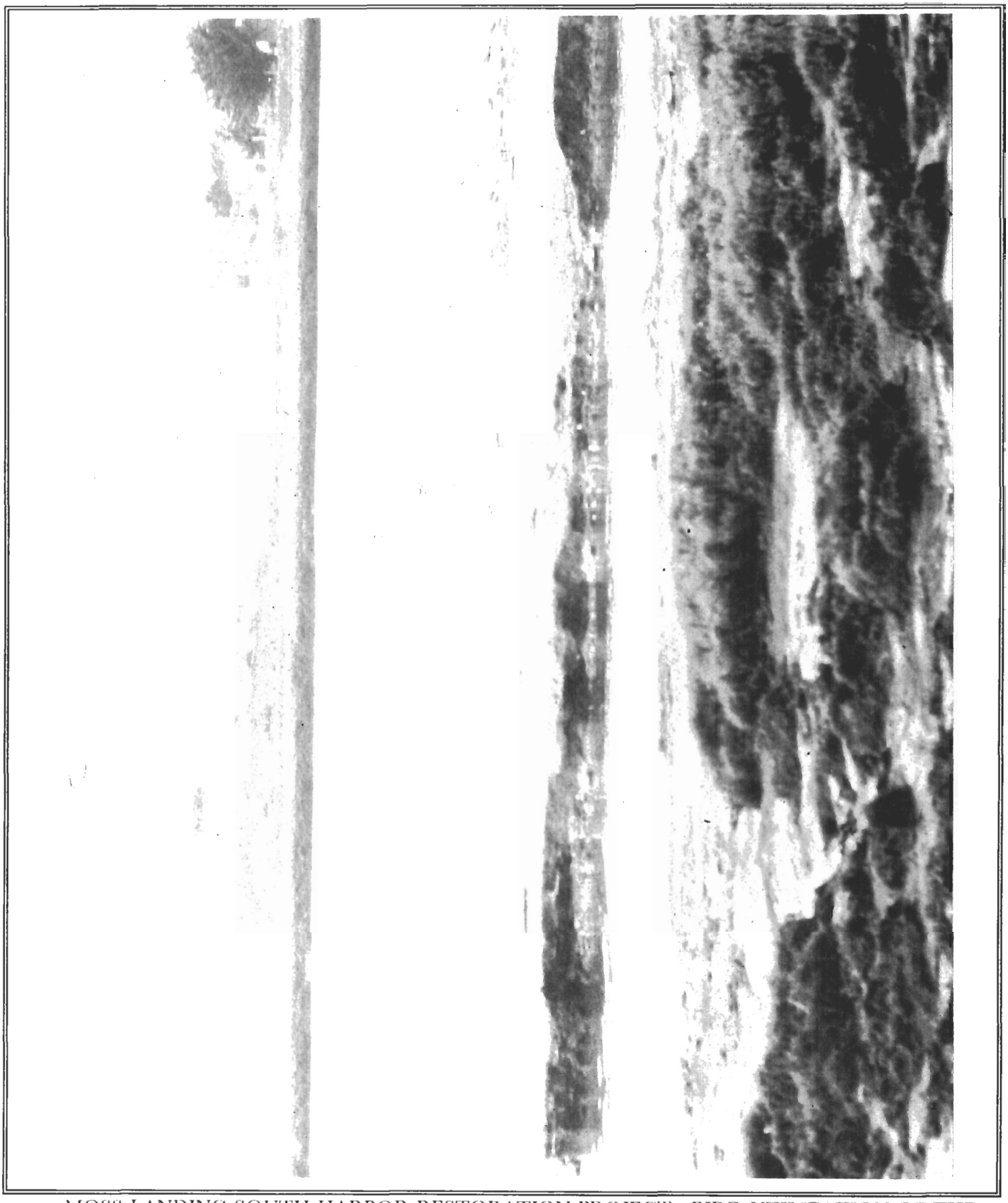
The performance standards for the SHRS are described in the restoration plan prepared by Jones and Stokes (JAS, 1989). An evaluation of the current status of the SHRS relative to the attainment of the performance standards is presented below:

A. MUDFLATS

The created mudflats in the SHRS remain unvegetated and open to daily tidal flows. No ponding during low tides has been observed. Thus, the performance standards set forth for the mudflat habitat have essentially been met. There is in fact a net increase of the intertidal mudflat habitat as a direct result of channel incision and continued erosion of the central marsh plain.

B. PICKLEWEED MARSH

Establishment of pickleweed on the pickleweed marsh in the SHRS has increased yearly and is exhibiting a continued trend toward percent cover comparable to the RS. What is most significant, however, is that relative cover of other salt marsh species at the SHRS far exceeds those measured for the RS. Thus, the habitat value of the SHRS is considered to be higher than the RS because of its diverse assemblages of plant life.



MOSS LANDING SOUTH HARBOR RESTORATION PROJECT: BIRD UTILIZATION OF THE PROJECT SITE AT LOW TIDE. NOTICE THE INCISED CHANNEL AND THE RECEDING MARSH PLAIN.

It should be noted that the pickleweed marsh development on the central marsh plain has not occurred due to the loss of the marsh plain by erosion. There is, therefore, a net loss of pickleweed marsh habitat at the SHRS, and the performance standard has not been met.

C. SALTGRASS MARSH

Saltgrass has been successfully established at the SHRS. Relative cover of saltgrass within all transects has exceeded that of the RS in 4.7 surveys out of a total of 7. The performance standard set forth for the saltgrass habitat has been satisfactorily met for this project.

D. PERIPHERAL UPLAND

Survival and establishment of upland vegetation at the SHRS has produced mixed results. Gum plant has increased annually and has exceeded the relative cover measurements obtained from the RS within all the transects it appeared in.

The top of the compacted berm was not revegetated after grading because of its anticipated use as access road for a future extension of the berm towards the south. Weedy non-native species now colonize and dominate the upland area, and seem to follow a typical succession of disturbed areas as discussed above.

These early colonizing weedy species prepare the harsh substrate for the more desirable species by releasing organic matter and modifying the otherwise depleted soil. They also contribute large quantities of seeds and provide cover to wildlife (birds, amphibians, reptiles and small mammals.) Therefore, the abundance of non-native plants in the upland areas of the SHRS should not by itself be considered a failure, especially if proper remedial actions can be implemented - namely revegetation and weed eradication. Top priority, however, should be assigned to the removal of German ivy from the SHRS.

X. RECOMMENDATIONS

1. Erosion of the central marsh plain is the single most problematic issue facing the SHRS. Various alternatives including re-contouring, erosion control measures and revegetation should be evaluated to re-establish this area. A thorough monitoring of the erosion/sedimentation processes that are at work within the project area is recommended to develop a viable restoration alternative before the entire marsh plain completely disappears. The most viable alternative would be to re-construct the central peninsula using the more or less stable pickleweed marsh-mudflat complex found within the Old Salinas River Channel as a model.

2. The top of the compacted low berm should be revegetated so that the peripheral upland habitat values can be improved.

3. Maintenance of the SHRS should continue with greater emphasis given to the eradication of German ivy and the removal of trash from the site.

4. The number of vegetation monitoring transects can be reduced by approximately half without affecting the monitoring results. A total of 5 transects are expected to be sufficient for data collection.

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