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GOOA 96337

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FULL REPORT.

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A PRELIMINARY ENVIRONMENTAL
ASSESSMENT OF WETLAND RESTORATION
ALTERNATIVES FOR BIG LAGOON
AT MUIR BEACH, MARIN COUNTY

Prepared for

The California Department of Transportation
District IV

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TABLE OF CONTENTS

	<u>Page No.</u>
I. INTRODUCTION	1
II. SUMMARY AND CONCLUSIONS	3
III. NATURAL CONDITIONS AND HISTORIC CHANGES AT BIG LAGOON	5
A. Natural Physical Setting	5
1. Geomorphic Evolution of the Site	5
2. Lagoon Morphology	6
3. Historic Sediments	6
4. Hydrologic Regime of the Wetland/Lagoon System	7
5. Hydrology of Redwood Creek	8
B. Natural Ecosystems	8
1. Riparian	9
2. Freshwater Lagoon	10
3. Tidal Lagoon	13
4. Upland: Beach Dunes and Hillsides	13
5. Historic Fisheries	14
C. Historic Changes	15
1. Land Use Changes	15
2. Physical Changes	17
3. Ecological Changes	19
IV. EXISTING CONDITIONS	24
A. Geomorphology and Hydrology	24
1. Topography and Site Layout	24
2. Hydrology and Freshwater Inflows	25
3. Redwood Creek Channel Morphology	28

4.	Flood Hazards	29
5.	Wave Climate and Beach Morphology	30
6.	Lagoon Hydrodynamics and Morphology	31
7.	Groundwater	34
8.	Water Quality	35
B.	Ecosystems	37
1.	Wetland and Former Wetland Habitats	37
2.	Non-Wetland Habitats (Dunes and Hillsides)	51
3.	Fisheries	53
4.	Special Status Species	56
5.	Jurisdictional Wetlands	58
C.	Land Use/Recreation	59
1.	Green Gulch Farm	59
2.	Muir Beach Community	59
3.	Golden Gate Dairy Horse Stables	60
4.	Banducci Flower Farm	60
5.	Golden Gate National Recreation Area	60
6.	Existing Uses of the Proposed Wetlands Restoration Site	61
V.	FUTURE CONDITIONS	62
A.	Physical	62
1.	Sea Level Rise	62
2.	Earthquake Risk	62
3.	Flood Risk	62
4.	Sedimentation	63
B.	Ecological	63
1.	Regional Conditions	63
2.	Local Conditions	63

	<u>Page No.</u>
C. Land Use/Recreation	64
1. Horse Use	64
2. Agricultural Use	64
VI. RESTORATION OBJECTIVES	65
A. GGNRA Resource Management and Planning Objectives	65
B. Caltrans Mitigation Objectives	65
C. Technical Objectives for Wetlands Restoration	66
D. Land Use Objectives	67
1. General Objectives	67
2. Public Access	68
3. Park Facilities	68
4. Community Character	69
VII. OPPORTUNITIES AND CONSTRAINTS	70
A. Opportunities	70
1. Physical	70
2. Ecological	71
3. Land Use	72
B. Constraints	73
1. Physical	73
2. Ecological	74
3. Land Use	74
VIII. DESCRIPTION OF RESTORATION ALTERNATIVES	75
A. No Action	75
1. Wetland Restoration	75
2. Land Use	75

B.	Restore Historic Wetland	76
1.	Wetland Restoration	76
2.	Plant Restoration Recommendations	78
3.	Land Use	80
C.	Restore Historic Wetland and Preserve Riparian Woodlands	82
1.	Wetland Restoration	82
2.	Plant Restoration Recommendations	82
3.	Land Use	82
D.	Expand Backwater Pond into Lower Pasture	84
1.	Wetland Restoration	84
2.	Plant Restoration Recommendations	85
3.	Land Use	85
E.	Enlarge Tidal Lagoon and Restore Dunes	86
1.	Wetland Restoration	86
2.	Plant Restoration Recommendations	87
3.	Land Use	87
F.	Parking Alternatives Identified but not Further Considered for this Project	88
1.	Remote Parking at the Ballfield	88
2.	Remote Parking in the Lower Fields of Green Gulch	89
IX.	ANALYSIS OF RESTORATION ALTERNATIVES	90
A.	No Action	90
1.	Physical Impacts	90
2.	Ecological Impacts	92
3.	Land Use and Community Impacts	93
B.	Restore Historic Wetland	94
1.	Physical Impacts	94

2.	Ecological Impacts	98
3.	Land Use and Community Impacts	103
C.	Restore Historic Wetland; Preserve Riparian Woodlands	104
1.	Physical Impacts	104
2.	Ecological Impacts	107
3.	Land Use and Community Impacts	107
D.	Backwater Pond/Wetland	108
1.	Physical Impacts	108
2.	Ecological Impacts	111
3.	Land Use and Community Impacts	111
E.	Enlarge Tidal Lagoon and Restore Dunes	112
1.	Physical Impacts	112
2.	Ecologic Impacts	113
3.	Land Use and Community Impacts	114
X.	ALTERNATIVES FOR DISPOSAL OF EXCAVATED MATERIAL	115
A.	Disposal beyond the Redwood Creek Green Gulch Watershed	115
B.	Green Gulch Fields 6 and 7	115
C.	Banducci Flower Bulb and Heather Farm	116
D.	Riding Ring and State Park Land above Banducci	117
E.	The Ballfield Area in Lower Franks Valley	118
F.	Disposal Along the Perimeter of the Restored Wetland	118
XI.	REFERENCES	120
	ACKNOWLEDGEMENTS	126

LIST OF TABLES

Table II-1	Summary of Restoration Alternatives
* Table III-1	Historic Occurrences of Amphibians and Reptiles in Marin County, California.
* Table III-2	Current Observations for Big Lagoon, 1993.
* Table III-3	Terrestrial Mammals Occurring Historically or Currently within the Big Lagoon Wetland and Riparian Areas and Adjacent Habitats
Table IV-1	Plants Observed at Big Lagoon
Table IV-2	Mean Monthly Rainfall and Evaporation
Table IV-3	Historical Flow Data on Redwood Creek and Green Gulch
Table IV-4	Monthly Redwood Creek Flow Volumes, 1992-93
Table IV-5	Summary of Lagoon Conditions, 1992-93
Table IV-6	Summary of Water Quality Data for Redwood Creek and Green Gulch
* Table IV-7	Nitrogen and phosphorus Levels (mg/l) in Redwood Creek Watershed in 1992 and 1993
Table IV-8	Aquatic Insects Collected at Big Lagoon from September 1992 through July 1993
* Table IV-9	Bird survey Dates, Times, and Station Coverage at Big Lagoon, May 29, 1992 to August 9, 1993
Table IV-10	Bird Species Recorded at Big Lagoon on 1992-1993 Surveys and as Incidental Sitings
* Table IV-11	Number of Bird Species and Individuals Recorded at 15 Stations in Big Lagoon, 1992-1993
Table IV-12	Sensitive Bird Species Recorded at Big Lagoon According to Federal, State or County Listings
Table IV-13	Density Estimates for Coho and Steelhead Collected in Redwood Creek in 1992 and 1993
Table IV-14	Dissolved Oxygen in the Pool Upstream of the Foot Bridge on Redwood Creek at Muir Beach in 1992 and 1993
Table IV-15	Salinities of Redwood Creek Lagoon in 1992 and 1993
* Table IV-16	Water Temperatures in Redwood Creek Lagoon in 1992 and 1993
* Table IV-17	Number of Fish of Different Species Collected by Seine in the Lagoon/Estuary at Muir Beach in 1992 and 1993
Table IX-1	Special Species Recognized by CNPS
Table IX-2	Water Balance for Alternative - Historic Wetland
Table IX-3	Water Balance for Alternative C - Historic Wetland, Preserve Existing Riparian Habitat
Table X-1	Water Balance for Alternative D—Backwater Pond and Wetland
	Summary of Potential Dredge Disposal Locations

LIST OF FIGURES

- Figure I-1 Big Lagoon Site Location

- Figure III-1 Historical Map of Big Lagoon, 1853
- Figure III-2 Soil Coring Profiles
- Figure III-3 Lagoon as Shown on 1892 USGS Quadrangle
- Figure III-4 1946 Aerial Photo of the Big Lagoon Area
- Figure III-5 1965 Aerial Photo of the Big Lagoon Area
- Figure III-6 Vegetation Types at Big Lagoon

- Figure IV-1 Big Lagoon Site Layout
- Figure IV-2 Cross Section of Site
- Figure IV-3 Redwood Creek Watershed Map
- Figure IV-4 Daily Average Flows in Redwood Creek, 1992-93
- Figure IV-5 Estimated Flow-Duration Curve for Redwood Creek derived from Arroyo Corte Madera Data
- Figure IV-6 Profile of the Redwood Creek Bed
- Figure IV-7 Cross Section of Redwood Creek at Pacific Way
- Figure IV-8 FEMA 100-Year Floodplain Boundaries
- Figure IV-9 Wave Direction Rose for the COE San Francisco Hindcast Station
- Figure IV-10 Monthly Average Wave Power for the San Francisco Deep Water Wave Buoy, 1992-93
- Figure IV-11 Monthly Average Wave Steepness for the San Francisco Deep Water Wave Buoy, 1992-93
- Figure IV-12 Comparison of Winter and Summer Beach Crest Profile
- Figure IV-13 Comparison of Winter and Summer Beach Transects
- Figure IV-14 Johnson Criteria for Lagoon Closure
- Figure IV-15 Lagoon Water Levels, May 1992
- Figure IV-16 Lagoon Water Levels, January 1993
- Figure IV-17 Location of Monitoring Wells
- Figure IV-18 Monthly Water Levels in Monitoring Wells, 1992-1993
- Figure IV-19 Water Quality Data in the Tidal Lagoon
- Figure IV-20 Water Quality Data in Redwood Creek at the Footbridge
- Figure IV-21 Water Quality Data in Redwood Creek at the Backwater Channel
- Figure IV-22 Location of the Nine Vegetation Transects
- Figure IV-23 Vegetative Cover along Four Habitat Types
- Figure IV-24 Vegetative Cover along Pasture Transects
- Figure IV-25 Locations of Aquatic Insect and Benthic Invertebrate Survey Stations in Big Lagoon
- Figure IV-26 Seasonal Abundance of Major Groups of Aquatic Insects Found in Night Traps
- Figure IV-27 Changes in the Seasonal Abundance of Major Aquatic Crustacean Groups Found in Nocturnal Traps

LIST OF FIGURES (continued)

- Figure IV-28 Seasonal Abundance of Amphibian Larvae Found in Nocturnal Traps
- Figure IV-29 Benthic Invertebrates and Insect Larvae Abundances during 1993 Season at Big Lagoon
- Figure IV-30 Survey Route and Locations of Critical Amphibian and Reptile Habitats in Big Lagoon
- Figure IV-31 Total Number of Times of Occurrence of each Species of Amphibian and Reptile at Big Lagoon, 1993
- Figure IV-32 Mean Number of Adult Amphibians and Reptiles Observed at Big Lagoon during 1993
- Figure IV-33 Estimated Abundance of Amphibian Larvae at Big Lagoon during 1993
- Figure IV-34 Locations of Bird Survey Stations at Big Lagoon
- Figure IV-35 Total Number of Individuals and Species of Birds Counted during 11 Surveys at Big Lagoon, May 29, 1992 to August 9, 1993
- Figure IV-36 Average Number of Bird Species and Individuals at Riparian Footpath Stations and Pasture Stations
- Figure IV-37 Average Number of Bird Species and Individuals at Redwood Creek Stations and Riparian Vegetation Stations
- Figure IV-38 Locations of Bird and Mammal Nest Sites, Red-Legged Frog, Western Pond Turtle, and Native Grasses at Big Lagoon
- Figure IV-39 Vegetative Cover along Upland Habitat Transect
- Figure IV-40 Proposed Offsite Mitigation for the Marin 1 Road Repair Project
- Figure IV-41 Existing Conditions
-
- Figure VIII-1 Restoration Alternative A - No Action with Management Modifications
- Figure VIII-2 Restoration Alternative B - Historic Wetland
- Figure VIII-3 Land Use Alternative B - Historic Lagoon
- Figure VIII-4 Restoration Alternative C - Historic Wetland
- Figure VIII-5 Land Use Alternative C - Modified Historic Lagoon
- Figure VIII-6 Restoration Alternative D - Backwater Pond and Wetland
- Figure VIII-7 Land Use Alternative D - Backwater Lagoon
- Figure VIII-8 Restoration Alternative E - Enlarge Tidal Lagoon and Restore Dunes
-
- Figure IX-1 Stage-Area Curve for Alternative B
- Figure IX-2 Stage-Area Curve for Alternative C
- Figure IX-3 Stage-Area Curve for Alternative D
- Figure IX-4 Locations of Potential Disposal Sites

APPENDICES

Appendix A Interpretation of Soil Corings

Appendix B Biologic Sampling Methods

Appendix C Water Quality Data Collected During Fish Surveys

I. INTRODUCTION

As a result of the reconstruction of Highway 1 at the Lone Tree Slide in Marin County, the California Department of Transportation (Caltrans) is required to mitigate for the loss of 5.6 acres of marine habitat. In 1991 an interagency technical advisory committee (TAC) was formed to establish mitigation goals and objectives and evaluate potential mitigation sites. After reviewing several sites within the Marin County coastal zone, removal of artificial fill in Bolinas Lagoon and wetland restoration at Big Lagoon were identified as having the highest potential for satisfying compensatory mitigation requirements.

In June of 1992 a preliminary design was developed for removal of about 2 acres of intertidal fill at Bolinas Lagoon. This portion of the mitigation has been approved by the agencies, and construction has been completed. Caltrans is now required to mitigate for the remaining 3.6 acres of marine impacts.

Big Lagoon is located near the community of Muir Beach in Marin County (Figure I-1). The site is at the downstream end of the Redwood Creek watershed, and currently includes an intermittently-tidal lagoon as well as riparian and seasonal wetland habitat. The site was identified as having high potential for mitigation for the following reasons:

- The Redwood Creek watershed is unique among California coastal watersheds of its size because it remains largely undeveloped and is protected as State and Federal Park lands. The riparian corridor is relatively intact upstream of Big Lagoon and has recovered rapidly from the adverse impacts of historic grazing.
- From an ecosystem perspective the Big Lagoon area can provide key freshwater wetland and transitional estuarine habitat, and in its modified and degraded state has previously been identified as a weak link in the Redwood Creek ecosystem. The existing wetlands are fragmented and vulnerable to sedimentation, hydrologic changes, and invasion by exotic species.
- Redwood Creek currently contains sustainable populations of coho salmon and steelhead, as well as other special status species.
- Although much of the potential restoration at the site is freshwater habitat, the lagoon is near the Lone Tree Slide and provides important habitat for fish species that migrate to the ocean.

- Historical information indicates that the site once supported a large freshwater lagoon and wetland system, most of which was lost in the last century due to sedimentation, filling, and channelization.

To evaluate the potential for wetland restoration at Big Lagoon, Caltrans retained a team of consultants that included Philip Williams and Associates, Ltd. (PWA, hydrologists), Moss Landing Marine Laboratories (MLML, ecologists), and Dr. Jerry Smith of San Jose State University (fisheries). John Northmore Roberts and Associates and the National Park Service also provided input on land use issues under a separate contract with the Golden Gate National Park Association. This team of consultants was asked to develop restoration alternatives and prepare a preliminary environmental assessment to address the following issues:

- How did the historical wetland system function, and how did it evolve into the current wetland?
- How does the existing wetland system function in terms of ecology and hydrology.
- What are the existing ecological values of the site?
- What are the alternatives for wetland restoration that recreate historic wetland functions and enhance wildlife habitat?
- How can wetland restoration minimize conflicts with existing land uses?
- What are the impacts and benefits of each alternative in terms of ecosystems, land use, and hydrology?

Because of the importance of Big Lagoon in the context of the larger Redwood Creek ecosystem, the consultant team was asked to develop planning alternatives in coordination with National Park Service objectives for restoration of the entire site. Caltrans would then contribute to the overall restoration effort to meet its 3.6 acre compensatory mitigation requirement.

This alternatives assessment will be used as the basis for further environmental review and public input through the CEQA/NEPA process. At the completion of this process a preferred alternative will be identified, and a detailed design will be developed for construction.

II. SUMMARY AND CONCLUSIONS

1. Under natural conditions the Big Lagoon site supported a 30-acre wetland ecosystem that included a freshwater lagoon, seasonal wetlands, dunes, and an intermittently tidal lagoon. These wetlands provided habitat for numerous species of invertebrates, birds, amphibians, fish, mammals, and plants.
2. Most of this habitat was lost between 1853 and the present through sedimentation, channelization, levee construction, filling, and dune removal. Predictably, alien vegetation invaded areas currently impacted by human activities.
3. Although the current Redwood Creek riparian corridor still has important habitat value, the loss of historic wetland has significantly reduced habitat for fish, amphibians, many bird species, and mammals. Many species which were once numerous on the site are now either not present or reduced to isolated and potentially vulnerable breeding populations.
4. The existing wetlands are fragmented and vulnerable to sedimentation, hydrologic changes, and invasion by exotic species.
5. In addition to the No Action alternative (Alternative A), four wetland restoration alternatives have been identified to enhance the functioning of the natural wetland system and restore historic habitat values. These alternatives would provide critical freshwater lagoon and wetland habitat for the Redwood Creek ecosystem, and would benefit fish, amphibians, birds, mammals, and wetland plants. The alternatives are summarized in Table II-1 and described below:

- **Historic Wetland Restoration (Alternative B)**

Most of the pre-1853 freshwater lagoon and seasonal wetlands would be restored. Levees and artificial fill would be removed, and Redwood Creek would be restored to its original course. This alternative would in the long-term provide the greatest habitat values, but would also require the most excavation and short-term disruption of existing habitats.

- **Restore Historic Wetland and Preserve Riparian Woodlands (Alternative C)**

Redwood Creek would be moved to its original course, and much of the pre-1853 freshwater lagoon would be restored as in Alternative B. However, excavation within the existing riparian habitat downstream of Pacific Way would be minimized.

- **Backwater Pond and Wetland (Alternative D)**

A backwater pond and seasonal wetland would be excavated in the Green Gulch pasture, and connected to lower Redwood Creek through a breach in the pasture levee. Redwood Creek would remain in its current alignment. This alternative could also be done as Phase I of Alternatives B and C, and is designed to meet the Caltrans mitigation requirements.

- **Enlarge the Intermittently Tidal Lagoon and Restore Dunes (Alternative E)**

The tidal lagoon would be increased by 0.8 acres, and fill would be removed from the area between the lagoon and parking lot picnic area. Dunes would be allowed to evolve naturally. This alternative could be done alone or as part of any of the other restoration alternatives.

6. As shown in Table II-1, the alternatives create as much as 2.3 acres and enhance up to 13.9 acres of wetland. The extent of existing jurisdictional wetlands on-site (including degraded seasonal wetlands) limits the potential for wetland creation, and the 3.6 acre Caltrans mitigation requirement will have to be met through a combination of wetland creation and enhancement.
7. Six potential sites for disposal of excavated material have been identified in lower Franks Valley and Green Gulch. There is sufficient disposal capacity within the Redwood Creek watershed for any of the restoration alternatives.
8. All of the restoration alternatives would require changes to recreation and public access in the area. Therefore, alternative locations for these activities have been proposed for each wetland restoration alternative.

Table III - 1

Historic occurrences of amphibians and reptiles in Marine County,
California. Current observations from Big Lagoon, 1993.

COMMON NAME	SCIENTIFIC NAME	OBSERVATIONS	
		Historical	Current *
Amphibians			
Arboreal Salamander	<i>Aneides lugubris</i>	.	
California Newt	<i>Taricha tarosa</i>	.	.
California Slender Salamander	<i>Batrachoseps attenuatus</i>	.	.
Ensatina	<i>Ensatina eschscholtzi</i>	.	.
Pacific Giant Salamander	<i>Dicamptodon ensatus</i>	.	
Pacific Tree Frog	<i>Pseudacris regilla</i>	.	.
Red-legged Frog	<i>Rana aurora draytonii</i>	.	.
Rough-skinned Newt	<i>Taricha granulosa</i>	.	.
Western Toad	<i>Bufo boreas</i>	.	.
Yellow-legged Frog	<i>Rana boyleii</i>	.	
Reptiles			
Common Garter Snake	<i>Thamnophis sirtalis</i>	.	
Gopher Snake	<i>Pituophis melanoleucus</i>	.	
Northern Alligator Lizard	<i>Elgaria coeruleus</i>	.	
Ringneck Snake	<i>Diadophis punctatus</i>	.	
Rubber Boa	<i>Charina bottae</i>	.	
Southern Alligator Lizard	<i>Elgaria multicarinata</i>	.	
Western Aquatic Garter Snake	<i>Thamnophis couchi</i>	.	
Western Fence Lizard	<i>Sceloporus occidentalis</i>	.	.
Northwestern Pond Turtle	<i>Clemmys marmorata marmorata</i>		.
Western Skink	<i>Eumeces skiltonianus</i>	.	
Western Terrestrial Garter Snake	<i>Thamnophis elegans</i>	.	
Yellow-bellied Racer	<i>Coluber constrictor</i>	.	

* Reptile sitings at Big Lagoon do not include upland habitats.

Table III - 2

Terrestrial mammals occurring historically or currently within the Big Lagoon wetland and riparian areas and adjacent habitats. I = introduced from North America; A = alien, introduced from outside North America; P = potentially present; E = extirpated; CSC = California species of special concern; 2 = Federal candidate for listing. (From Jameson and Peeters 1988, Ingles 1965, Zeiner et al 1990.)

Common name	Scientific name	Note
MARSUPIALS		
Opposums (Didelphidae)		
Opposum	<i>Didelphis marsupialis</i>	I
INSECTIVORES		
Shrews (Soricidae)		
Ornate Shrew	<i>Sorex ornatus</i>	
Pacific Shrew	<i>Sorex pacificus</i>	
Trowbridge Shrew	<i>Sorex trowbridgei</i>	
Vagrant Shrew	<i>Sorex vagrans</i>	
Moles (Talpidae)		
Shrew Mole	<i>Neurotrichus gibbsii</i>	
California Mole	<i>Scapanus latimanus</i>	
BATS		
Evening bats (Vespertilionidae)		
Pallid Bat	<i>Antrozous pallidus</i>	CSC
Big Brown Bat	<i>Eptesicus fuscus</i>	
Red Bat	<i>Lasiurus borealis</i>	
Hoary Bat	<i>Lasiurus cinereus</i>	
Pacific Western Big-eared Bat	<i>Plecotus townsendi</i>	2
Western Pipistrelle	<i>Pipistrellus hesperus</i>	
California Myotis	<i>Myotis californica</i>	
Long-eared Myotis	<i>Myotis evotis</i>	
Little Brown Myotis	<i>Myotis lucifugus</i>	
Fringed Myotis	<i>Myotis thysanodes</i>	
Long-legged Myotis	<i>Myotis volans</i>	
Yuma Myotis	<i>Myotis yumanensis</i>	
Silver-haired Bat	<i>Lasionycteris noctivagans</i>	
Free-tailed Bats (Molossidae)		
Brazilian Free-tailed Bat	<i>Tadarida brasiliensis</i>	
Greater Western Mastiff Bat	<i>Eumops perotis californicus</i>	2
CARNIVORES		
Ursidae		
California Grizzly	<i>Ursus arctos</i>	E
Weasels (Mustelidae)		
Long-tailed Weasel	<i>Mustela frenata</i>	
Short-tailed Weasel	<i>Mustela erminea</i>	
Mink	<i>Mustela vison</i>	

Table III - 2 continued

Striped Skunk	<i>Mephitis mephitis</i>	
Spotted Skunk	<i>Spilogale putorius</i>	
Badger	<i>Taxidea taxus</i>	CSC
River Otter	<i>Lutra canadensis</i>	
Racoons (Procyonidae)		
Ringtail	<i>Bassariscus astutus</i>	
Raccoon	<i>Procyon lotor</i>	
Dogs (Canidae)		
Coyote	<i>Canis latrans</i>	
Gray Fox	<i>Urocyon cinereoargenteus</i>	
Red Fox	<i>Vulpes fulva</i>	P,A
Cats (Felidae)		
Mountain Lion	<i>Felis concolor</i>	
Bobcat	<i>Lynx rufus</i>	
RODENTS		
Mountain beavers (Aplodontiidae)		
Point Reyes Mountain Beaver	<i>Aplodontia rufa phaea</i>	2
Squirrels (Sciuridae)		
Yellow-cheeked chipmunk	<i>Tamias ochrogenys</i>	
Sonoma chipmunk	<i>Tamias sonomae</i>	
Douglas' Squirrel	<i>Tamiasciurus douglasii</i>	
California Ground Squirrel	<i>Spermophilus beecheyi</i>	
Western Gray Squirrel	<i>Sciurus griseus</i>	I,P
Gray Squirrel	<i>Sciurus carolinensis</i>	
Fox Squirrel	<i>Sciurus niger</i>	I,P
Pocket gophers (Geomyidae)		
Pocket Gopher	<i>Thomomys bottae</i>	
Pocket mice (Heteromyidae)		
California Kangaroo Rat	<i>Dipodomys californicus</i>	P
Native rats and mice (Cricetidae)		
Deer Mouse	<i>Peromyscus maniculata</i>	
Piñon Mouse	<i>Peromyscus truei</i>	
Western Harvest Mouse	<i>Reithrodontomys megalotis</i>	
Dusky-footed Wood Rat	<i>Neotoma fuscipes</i>	
California Vole	<i>Microtus californicus</i>	
Red Tree Vole	<i>Arborimus longicaudus</i>	CSC
Western Red-backed Vole	<i>Clethrionomys californicus</i>	
Muskrat	<i>Ondatra zibethica</i>	I
Old world rats and mice (Muridae)		
House Mouse	<i>Mus musculus</i>	A
Norway Rat	<i>Rattus norvegicus</i>	A
Black Rat	<i>Rattus rattus</i>	A
Jumping mice (Zapodidae)		
Point Reyes Jumping Mouse	<i>Zapus trinotatus orarius</i>	2,CSC

Plants observed at Big Lagoon and their estimated relative abundance within each habitat type

LIFE CYCLE AND GROWTH FORMS: annual (a), biennial (b), perennial (p), shrub (s), tree (t), vine (v).

HABITAT: Dominant (D), Abundant (A), Occasional (O).

* Alien species

COMMON NAME	SCIENTIFIC NAME	LIFE	HABITAT					
			riparian	aquatic	disturbed	pasture	marsh	dune
✓ Alkali heath	<i>Frankenia salina</i> = <i>F. grandifolia</i>	p						
✓ Alkali rye grass	<i>Leymus triticoides</i>	p					O	
✓ American brooklime	<i>Veronica americana</i>	p		O	O		O	A
✓ American dogwood	<i>Cornus sericea</i> ssp. s. = <i>C. californica</i>	s			O			
✓ American dune grass	<i>Leymus mollis</i>	p						
✓ American water fern	<i>Azolla filiculoides</i>	a		O				D
✓ Annual bluegrass	* <i>Poa annua</i>	a						
✓ Arroyo willow	<i>Salix lasiolepis</i>	t	A					
✓ Beach bur	<i>Ambrosia chamissonis</i>	p						
✓ Bermuda grass	* <i>Cynodon dactylon</i>	p					O	D
✓ Birdfoot trefoil	<i>Lotus corniculatus</i>	p				O		
✓ Black cottonwood	<i>Populus balsamifera</i> var. <i>trichocarpa</i>	t			A			
✓ Black mustard	* <i>Brassica nigra</i>	a	O		O			
✓ Blue dicks	<i>Dichelostemma capitatum</i>	p		A	O	O	O	O
✓ Blue wildrye	<i>Elymus glaucus</i>	p						O
✓ Blue-eyed grass	<i>Sisyrinchium bellum</i>	a						A
✓ Bluegrass	<i>Poa</i> sp.	p						O
✓ Bog rush	<i>Juncus effusus</i> var. <i>brunneus</i>	p				O		O
✓ Bracken	<i>Pteridium aquilinum</i>	p		O		O		
✓ Brass buttons	* <i>Cotula coronopifolia</i>	p						O
✓ Britilly ox-tongue	* <i>Picris echioides</i>	ab		O	O	O	O	
✓ Broad-leaved cat-tail	<i>Typha latifolia</i>	p	D		O		A	O
✓ Brome	<i>Bromus carinatus</i> var. <i>maritimus</i>	p						
✓ Brome	<i>Bromus vulgaris</i>	p						
✓ Bull mallow	* <i>Malva nicaeensis</i>	ap			O			
✓ Bull thistle	* <i>Cirsium vulgare</i>	a						
✓ Bush morning glory	<i>Calystegia occidentalis</i> ssp. o.	v	O		A	O		O

COMMON NAME SCIENTIFIC NAME

LIFE

HABITAT

			terrestrial	aquatic	disturbed	pasture	marsh	dune	upland
California blackberry	<i>Rubus ursinus</i>	s	O		O	O			O
California buckeye	<i>Aesculus californica</i>	t							
California burdock	<i>*Medicago polymorpha = M. hispida</i>	a		O	A	O			O
California canary grass	<i>Phalaris californica</i>	p			O				
California figwort	<i>Scrophularia californica</i>	p	O	O	O		O	O	
California horkelia	<i>Horkelia californica</i> ssp. c.	p							
California man-root	<i>Marah fabaceus</i>	p	O						O
California mugwort	<i>Artemisia douglasiana</i>	p	O		O				
California oat grass	<i>Danthonia californica</i>	p					A		A
California poppy	<i>Eschscholzia californica</i>	p				O			O
California rose	<i>Rosa californica</i>	s	O						O
California sagebrush	<i>Artemisia californica</i>	s			O				
Calla lily	<i>*Zantedeschia aethiopica</i>	p	O						A
Canada thistle	<i>*Cirsium arvense</i>	b			O	O			O
Capweed	<i>*Arctotheca calenutula</i>	p							
Charlock	<i>*Sinapis kaber</i>	a			O				O
Cheeseweed	<i>*Malva parviflora</i>	a			O				
Chick lupine	<i>Lupinus microparpus</i> var. m.	a			O				
Coast clover	<i>Trifolium wormskoldii</i>	p		A	A	A			
Coast hedge nettle	<i>Stachys chamissonis</i>	p	O						O
Coast tarweed	<i>Madia sativa</i>	a			O	A			O
Common monkey flower	<i>Mimulus guttatus</i>	a,p		O		O			O
Common plantain	<i>*Plantago major</i>	p		O		A			O
Common rush	<i>Juncus patens</i>	p	O						
Common snowberry	<i>Symphoricarpos albus</i>	s	O						
Common sow thistle	<i>*Sonchus oleraceus</i>	a			O				O
Common tule	<i>Scirpus acutus</i>	p		O					
Common velvet grass	<i>*Holcus lanatus</i>	p		O	O	O			O
Common vetch	<i>*Vicia sativa</i>	a	O	O	A	O			O
Common yarrow	<i>Achillea millefolium</i>	p							
Cow parsnip	<i>Hieracium lanatum</i>	p			O				A
Coyote brush	<i>Baccharis pilularis</i>	s			O				
Creeping bent	<i>*Agrostis stolonifera</i>	p	O	O			O		D

COMMON NAME SCIENTIFIC NAME

LIFE

HABITAT

		riparian	aquatic	disturbed	pasture	marsh	dune	upland
Creeping spike rush	<i>Eleocharis macrostachya</i>	p						
Curly dock	* <i>Rumex crispus</i>	p	A		A			
Cut-leaved geranium	* <i>Geranium dissectum</i>	p	O	O	A	O		
Cut-leaved plantain	* <i>Plantago coronopus</i>	a	O	O				A
✓ Dallis grass	* <i>Paspalum dilatatum</i>	ab	O	O				
✓ Davy's manna grass	<i>Glyceria leptostachya</i>	p	O	O				
English ivy	* <i>Hedera helix</i>	p						
English plantain	* <i>Plantago lanceolata</i>	v	A					
✓ European beach grass	* <i>Ammophila arenaria</i>	p	O					D
European hair grass	* <i>Aira caryophylla</i>	p					A	
✓ Farmer's foxtail	* <i>Hordeum murinum</i> ssp. <i>leporinum</i>	a		A	O	O		O
Fennel	* <i>Foeniculum vulgare</i>	a		O	O	O		
✓ Fescue	* <i>Vulpia myuros</i> var. <i>m.</i>	p						
Field mustard	* <i>Brassica rapa</i> = <i>B. campestris</i>	a		A				O
✓ Forget-me-not	* <i>Myosotis latifolia</i>	p	O					
French broom	* <i>Cenista monspessulana</i>	s	O	O				
✓ Garden nasturtium	* <i>Tropaeolum majus</i>	ap	O					
German ivy	* <i>Senecio mikanioides</i>	v	A	A				
Giant horsetail	<i>Equisetum telmateia</i>	p	O	O				
Harding grass	* <i>Phalaris aquatica</i> = <i>P. tuberosa</i>	p		O	O			A
✓ Hedge bindweed	<i>Calystegia sepium</i>	p		O	O			
✓ Hedgehog dogtail	* <i>Cynosurus echinatus</i>	v	O					
✓ Himalayan blackberry	* <i>Rubus discolor</i>	p		O				O
✓ Hoary nettle	<i>Urtica dioica</i> ssp. <i>holosericea</i>	s		C				
✓ Horseweed	<i>Conyza canadensis</i>	a	A					
Hottentot fig	* <i>Carpobrotus edulis</i>	a		O				
✓ Hyssop loosestrife	* <i>Lythrum hyssopifolium</i>	p						O
✓ Iris-leaved rush	<i>Juncus xiphioides</i>	a	O	O				
Italian ryegrass	* <i>Lolium multiflorum</i>	p	O	O				
Jaumea	<i>Jaumea carnosa</i>	a	O	O	D	O		O
Jubata grass	* <i>Cortaderia jubata</i>	p						
✓ Kikuyu grass	* <i>Pennisetum clandestinum</i>	p	O	O	O	O		
✓ Knotgrass	<i>Paspalum distichum</i>	p	D	D	O	D	O	

COMMON NAME SCIENTIFIC NAME

LIFE

HABITAT

			riparian	aquatic	disturbed	pasture	marsh	dune	upland
			A						
✓ Lady fern	<i>Adiantum felix-femina</i>	p							
✓ Leafy bent grass	<i>Agrostis pallens</i>	p				O			O
✓ Little quaking grass	* <i>Briza minor</i>	a							O
✓ Lizard tail	<i>Eriophyllum staechadifolium</i>	p						O	O
✓ Low barley	<i>Hordeum depressum</i>	a				O			
✓ Low club rush	<i>Scirpus cernuus</i>	a		A					
✓ Lupine	<i>Lupinus rivularis</i>	s				O			
✓ Marsh pennywort	<i>Hydrocotyle ranunculoides</i>	p	A			O			
✓ Meadow barley	<i>Hordeum brachyantherum</i>	p				O			
✓ Meadow chickweed	<i>Cerastium arvense</i>	p							O
✓ Meadow foxtail	* <i>Alopecurus pratensis</i>	p				O	A		
✓ Melic	<i>Melica sp.</i>	p							O
✓ Milk thistle	* <i>Silybum marianum</i>	ab				O			O
✓ Miner's lettuce	<i>Claytonia perfoliata</i>	a			O				
✓ Monterey pine	* <i>Pinus radiata</i>	t		O		O			
✓ Morning glory	<i>Calystegia purpurata ssp. p.</i>	v		O					
✓ Myoporum	* <i>Myoporum laetum</i>	t				O			
✓ New Zealand spinach	* <i>Tetragonia tetragonioides</i>	a				O			
✓ Nighthshade	* <i>Solanum sarrachoides</i>	a	O						
✓ Orchard grass	* <i>Dactylis glomerata</i>	p				O			O
✓ Pacific grindelia	<i>Grindelia stricta</i>	p						O	
✓ Pacific sanicle	<i>Sanicula crassicaulis</i>	p							O
✓ Pacific silverweed	<i>Potentilla anserina ssp. pacifica = P. eggedii</i>	p		O	O	O	D		
✓ Pennyroyal	* <i>Mentha pulegium</i>	p	O	O	O	A			
✓ Pineapple weed	* <i>Chamomilla suaveolens</i>	p				O	O		
✓ Poison hemlock	* <i>Conium maculatum</i>	a				D	O	O	A
✓ Poison oak	<i>Toxicodendron diversilobum</i>	s				O			A
✓ Prairie bulrush	<i>Scirpus robustus</i>	p		A					
✓ Prickle-fruited buttercup	* <i>Ranunculus muricatus</i>	ab				O			O
✓ Prickly sow thistle	* <i>Sonchus asper</i>	a				O	O	O	
✓ Purple needlegrass	<i>Nassella lepidia</i>	p							A
✓ Purple sand spurry	* <i>Spergularia rubra</i>	ap				O	O		
✓ Rabbit's foot grass	* <i>Polypogon monspeliensis</i>	a			A	D	A		

COMMON NAME SCIENTIFIC NAME

LIFE

HABITAT

		t	riparian	D	aquatic	D	disturbed	pasture	marsh	dune	upland
✓ Red alder	<i>Alnus rubra</i>										
✓ Red elderberry	<i>Sambucus racemosa</i> var. <i>r.</i>	s		O			O				
✓ Redwood sorrel	<i>Oxalis oregana</i>	p		O							
✓ Rescue grass	<i>Bromus catharticus</i>	p					O				
✓ Ripgut brome	<i>Bromus diandrus</i>	p					C	O	O	O	
✓ Rough cat's ear	<i>Hypochaeris radicata</i>	p		O			O		O		O
✓ Salsify	<i>Triglopon portifolius</i>	b		O			O		O		
✓ Salt grass	<i>Distichlis spicata</i>	p					O		O	A	O
✓ Salt marsh sand spurry	<i>Spergularia marina</i>	a									O
✓ Salt rush	<i>Juncus leserii</i>	p		O		O	O	O	D		
✓ Scarlet pimpernel	<i>*Aragallis arvensis</i>	a				O	O	O	O		
✓ Sea rocket	<i>*Cakile maritima</i>	p							O	A	
✓ Sedge	<i>Carex</i> spp.	p		O							
✓ Sheep sorrel	<i>*Rumex acetosella</i>	p					O				O
✓ Shining / yellow willow	<i>Salix lucida</i> ssp. <i>lasianдра</i>	t		D				O	O		
✓ Shore pine	<i>Pinus contorta</i> var. <i>c.</i>	t					O				
✓ Six-week's fescue	<i>*Vulpia bromoides</i>	a					O				O
✓ Slender wild oat	<i>*Avena barba</i>	a					A		O		O
✓ Small-fruited bulrush	<i>Scirpus microcarpus</i>	p		O		O					
✓ Smaller duckweed	<i>Lemna minor</i>	p			A						
✓ Smooth cat's ear	<i>*Hypochaeris glabra</i>	a					O				
✓ Sneezeweed	<i>Helenium puberulum</i>	p				O					
✓ Soap plant	<i>Chloragalum pomeridianum</i>	p									O
✓ Soft chess	<i>*Bromus hordeaceus</i> = <i>B. mollis</i>	a				O	O	O			O
✓ Sourclover	<i>*Melilotus indica</i>	a				O	A				
✓ Spear oracle = Fat hen	<i>Atriplex triangularis</i> = <i>A. patula</i>	a							O		
✓ Stinging phacelia	<i>Phacelia malvifolia</i>	a									O
✓ Sweet-scented bedstraw	<i>*Galium triflorum</i>	p		O							
✓ Tall cyperus	<i>Cyperus eragrostis</i>	p			A			O	O		
✓ Tall fescue	<i>*Festuca arundinacea</i>	p				O	O				O
✓ Thimbleberry	<i>Rubus parviflorus</i>	s		O			O				
✓ Three square	<i>Scirpus americanus</i>	p			D			O	O		
✓ Toad rush	<i>Juncus bufonius</i>	a		O	O			A			

COMMON NAME SCIENTIFIC NAME

LIFE

HABITAT

		riparian	aquatic	disturbed	pasture	marsh	dune	upland
Water buttercup	<i>Ranunculus aquatilis</i>	p	O		O			
Water cress	<i>Rorippia nasturtium-aquaticum</i>	p	O	A				
Water parsley	<i>Oenanthe sermentosa</i>	p	O	A	O	O		
Water plantain	<i>Alisma plantago-aquatica</i>	p	O	O		O		
Water smartweed	<i>Polygonum punctatum</i>	a,p	O	O		O		
Waterpepper	<i>Polygonum hydropiperoides</i>	p	O	O				
Weedy cudweed	<i>Gnaphalium luteo-album</i>	a			O			
Western sword fern	<i>Polystichum munitum</i>	p	A					
White clover	<i>Trifolium repens</i>	p	A	O	D			
White sweetclover	<i>*Melilotus alba</i>	ab		O				
White-stemmed flairee	<i>*Erodium moschatum</i>	a		A				O
Whorled dock	<i>*Rumex conglomeratus</i>	p	O	O	A	O		
Wild oat	<i>*Avena fatua</i>	a		O				
Willow herb	<i>Epilobium ciliatum = E. watsoni</i>	p	O	O				
Wood groundsel	<i>*Senecio sylvaticus</i>	a	O	O	O			
Yellow bush lupine	<i>Lupinus arboreus</i>	s		O				O
Yellow sand verberna	<i>Abronia latifolia</i>	p		O			A	
Yellow trefoil	<i>*Medicago lupulina</i>	a		O				O

TOTAL SPECIES

ER CENT ALIEN SPECIES

181	51	54	89	58	46	16	52
45%	31%	43%	54%	59%	57%	38%	52%

TABLE IV-1
MEAN MONTHLY RAINFALL AND EVAPORATION

Month	Mean Precip (in)	Mean Evap (in)	Mean PET (in)	Available Water (in)
OCT	2.49	2.39	1.67	0.82
NOV	6.24	0.98	0.69	5.55
DEC	4.74	0.53	0.37	4.37
JAN	5.73	0.39	0.27	5.46
FEB	5.62	0.84	0.59	5.03
MAR	5.68	2.68	1.88	3.80
APR	2.39	3.71	2.60	0.00
MAY	0.39	5.53	3.87	0.00
JUN	0.26	6.42	4.49	0.00
JUL	0.20	7.30	5.11	0.00
AUG	0.16	5.68	3.98	0.00
SEP	0.53	3.91	2.74	0.00
TOTAL	34.43	40.36	28.25	25.03

Notes

Precipitation data from Muir Woods daily records

Evaporation Data from Lagunitas Reservoir Pan

Potential Evapotranspiration (PET) Computed from Pan Evaporation using a pan coefficient of 0.7

TABLE IV-2.

HISTORICAL FLOW DATA ON REDWOOD CREEK AND GREEN GULCH

Date	Location	Agency	Conditions	Instantaneous Flow (cfs)
02/13/62	Redwood Creek at Frank Valley Road	USGS	Annual Storm Peak	880
10/13/62	Redwood Creek at Frank Valley Road	USGS	Annual Storm Peak	800
01/20/64	Redwood Creek at Frank Valley Road	USGS	Annual Storm Peak	100
01/06/65	Redwood Creek at Frank Valley Road	USGS	Annual Storm Peak	410
01/04/66	Redwood Creek at Frank Valley Road	USGS	Annual Storm Peak	1300
01/21/67	Redwood Creek at Frank Valley Road	USGS	Annual Storm Peak	295
01/30/68	Redwood Creek at Frank Valley Road	USGS	Annual Storm Peak	630
12/15/68	Redwood Creek at Frank Valley Road	USGS	Annual Storm Peak	1040
01/21/70	Redwood Creek at Frank Valley Road	USGS	Annual Storm Peak	1780
08/74	Lower Redwood Creek	NPS	Dry Weather	0.56
09/74	Lower Redwood Creek	NPS	Dry Weather	0.31
01/31/86	Redwood Creek at Muir Woods	USGS	Winter	51
01/31/86	Redwood Creek at Pacific Way	USGS	Winter	86
01/30/86	Green Gulch Creek	USGS	Winter	9.9
06/26/86	Redwood Creek at Muir Woods	USGS	Summer	0.77
06/26/86	Redwood Creek at Pacific Way	USGS	Summer	0.66
06/25/86	Green Gulch Creek	USGS	Summer	0.01
02/13/87	Redwood Creek at Muir Woods	USGS	Winter	114
03/13/87	Redwood Creek at Pacific Way	USGS	Winter	30
03/13/87	Green Gulch Creek	USGS	Winter	1.2
06/10/87	Redwood Creek at Muir Woods	USGS	Summer	0.62
06/12/87	Redwood Creek at Pacific Way	USGS	Summer	0.68
06/12/87	Green Gulch Creek	USGS	Summer	0.01
01/05/88	Redwood Creek at Muir Woods	USGS	Winter	42
01/05/88	Redwood Creek at Pacific Way	USGS	Winter	73
03/23/88	Green Gulch Creek	USGS	Winter	0.04
06/07/88	Redwood Creek at Muir Woods	USGS	Summer	0.7
06/07/88	Redwood Creek at Pacific Way	USGS	Summer	0.78
06/02/88	Green Gulch Creek	USGS	Summer	0.01
09/04/88	Redwood Creek at Frank Valley Road	NPS	Dry Weather	0.06

TABLE IV-3

MONTHLY REDWOOD CREEK FLOW VOLUMES, 1992-1993

Month	Flow Volume (ac-ft)	PET Losses by Wetland Plants	
		(ft)	(ac-ft)
Mar. 92	875	0.20	1.00
Apr	213	0.28	1.38
May	56	0.40	2.00
Jun	72	0.46	2.31
Jul	17	0.54	2.69
Aug	7.3	0.41	2.06
Sep	2.7	0.29	1.44
Oct	7.1	0.18	0.88
Nov	1.5	0.08	0.38
Dec	927	0.04	0.19
Jan 93	3892	0.03	0.13
Feb	2246	0.06	0.31
Mar	787	0.20	1.00
Apr	514	0.28	1.38
May	146	0.40	2.00
Jun	220	0.46	2.31
Jul	37	0.54	2.69
Aug	22	0.41	2.06
Sep	7	0.29	1.44
Aug-Oct 1992 (excluding 10/28 storm)	10.5	0.9	4.38
Aug-Sep 1993	28.9	0.7	3.50

TABLE IV-4
SUMMARY OF LAGOON CONDITIONS, 1992-1993

Period	Lagoon Conditions	Lagoon Elevations (ft. NGVD)	Max. Tide Range (ft. NGVD)	Berm Height (ft. NGVD)	Maximum Salinity (ppt)	Avg. Wave Power (ft.-lbs/ft.-s)	Wave Steepness (b/f)	Mean Inflows (cfs)	Peak Inflows (cfs)	Comments
5/01 - 5/26/92	Open, Tidal on Spring Tides	3.0 - 4.8	-3.7 +3.9	3						
5/27 - 6/08/92	Lagoon gage out	7	-3.8 +4.5	7		2866	0.017	1	1.2	
6/08 - 6/24/92	Open, Tidal on Spring Tides	3.0 - 4.6	-3.9 +3.7	3		3540	0.02	0.71	0.71	
	Closing on High Tide					2627	0.023	0.56	NA	Closes on higher highs, fills for about 1-day, and breaches on low tide
6/24/92	Closure Event	4.0 - 4.2	-1.0 +2.9	6		2600	0.006	0.5	0.5	
6/24 - 6/29/92	Fully Closed	3.0 - 5.5	-3.2 +4.2	6		1142	0.005	0.44	NA	
6/29 - 7/04/92	Open, Tidal on Spring Tides	3.0 - 5.0	-3.8 +4.4	3		2394	0.02	3.5	15	Rapid filling due to early summer inflows
7/05 - 7/08/92	Open, Tidal on Spring Tides	3.0 - 4.5	-2.5 +3.6	3		1920	0.023	0.35	0.35	1.4" storm on 29th and 30th breaches lagoon
	Closing on High Tide									Similar to early June behavior
7/08 - 10/29/92	Fully Closed	5.5 - 2.0	-3.3 +4.3	6	6.0 - 15.0	3100	0.018	0.1	0.30	
10/29/92	Open, Tidal on Spring Tides	3.5 - 6.0	-2.5 +4.1	3.5		5400	0.026	3.3	20	Closed lagoon; losses exceed inflows
10/30 - 12/01/92	Closed, temporary breaches	3.2 - 5.5	-3.8 +4.4	3.2 - 6	16.5	5300	0.016	0.02	0.2	First winter storm (2")
12/02 - 12/10/92	Transitional breaching	3.1 - 5.8	-3.4 +4.7	3.1	0.2	11503	0.021	40	160	
12/11/92 - 2/4/93	Open, Partially Tidal	1.3 - 5.5	-4.1 +5.1	1.3 - 3.3	0	6700	0.02	39	400	First major winter storms
2/04 - 3/08/93	Lagoon gage out	NA	-3.3 +4.9		0	10580	0.019	34	130	Tidal lagoon with periods of high storm flows
3/93	Closure Event	NA	-1.8 +2.6	4.5		8000	0.01	17	18	Beach berm is severely eroded
3/08 - 6/16/93	Open, Nonlidal	4.5 - 3.0	-3.6 +4.0	3.5	0 - 18.5	NA	NA	7.2	70	Beach berm builds rapidly during this period
6/16 - 6/29/93	Open, Tidal on Spring Tides	3.0 - 4.5	NA	3		NA	NA	1.6	2	High inflows, only highest tides enter lagoon
6/30 - 7/31/93	Open, Tidal on Spring Tides	3.4 - 5.6	NA	3.4	31	NA	NA	0.62	1	
	Closing on High Tide									Temporary closures, lasting as long as 2-days
8/1/93	Closure Event	5.0	-3.7 +3.3	6		NA	NA	0.4	0.4	Closures appear to occur on higher high tides
8/1 - 9/15/93	Fully Closed	5.5 - 2.8	NA	6		NA	NA	0.29	0.4	
										Rapid decline in water level

TABLE IV-5

SUMMARY OF WATER QUALITY DATA FOR REDWOOD CREEK AND GREEN GULCH

Proj #925, Redwood Creek Wells
Compilation of Water Quality Data

Location	Date	Q (cfs)	Conduct. (us/cm)	pH	Temp. (C)	D.O. (mg/l)	Fecal		NO2&3 (mg/l)	Phos (mg/l)	Turb. (NTU)	NH3	Data Source
							Colif.	Colif.					
							(#/100ml)	(#/100ml)					
Muir Woods	01/31/86	51.00	136	7	12	10.4	77		<.1	0.01			USGS
Muir Woods	06/26/86	0.77	212	7.3	14	9.8	290		<.1	0.01			USGS
Muir Woods	02/13/87	114.00	118	7.9	12.5	10.4	46		0.14	0.08			USGS
Muir Woods	06/10/87	0.62	215	7.5	14	8.7	5		<.1	<.1			USGS
Muir Woods	01/05/88	42.00	148	7.8	10	11.1	27		0.22	0.01			USGS
Muir Woods	06/07/88	0.70	225	7.9	13.5	9.2	34		0.1	<.1			USGS
Above Banducci	11/14/90			7.5	9		30		<.05		0.7		MBCC
Above Banducci	12/11/90			7.6	9		23		<.05		3		MBCC
Above Banducci	01/22/91			7.8	6				0.1		0.2		MBCC
Above Banducci	02/05/91			7.8	9		130		0.55				MBCC
Above Banducci	02/20/91			7.8	10		4		0.32		0.9		MBCC
Above Banducci	03/04/91			7.7	10		110		0.35		13		MBCC
Above Banducci	03/13/91			7.7	9		30		0.23		9.5		MBCC
Above Banducci	03/27/91			7.5	9		30		0.32		16		MBCC
Above Banducci	08/31/93						23		<.012	<.01		<.05	PWA
Above Banducci	08/31/93						33		<.012	<.01		<.05	PWA
Above Banducci	08/31/93						49		<.012	<.01		<.05	PWA
Below Banducci	08/31/93						240		0.011	<.01		<.05	PWA
Below Banducci	08/31/93						140		<.012	<.01		<.05	PWA
Below Banducci	08/31/93						540		0.021	0.094		<.05	PWA

TABLE IV-5 (continued)

Location	Date	Q (cfs)	Conduct. (us/cm)	pH	Temp. (C)	D.O. (mg/l)	Fecal	NO2&3 (mg/l)	Phos (mg/l)	Turb. (NTU)	NH3	Data Source
							Colif. (#/100ml)					
Pacific Way	01/31/86	86.00	155	7.2	12	10.2	870	0.19	0.01			USGS
Pacific Way	06/26/86	0.66	226	7.4	14	8.8	110	<.1	0.01			USGS
Pacific Way	03/13/87	30.00	178	7.3	11.5	10.7	8000	0.1	<.01			USGS
Pacific Way	06/12/87	0.68	228	7.8	12.5	8.6	280	<.1	<.01			USGS
Pacific Way	01/05/88	73.00	176	7.5	10.5	10.8	50	0.58	0.02			USGS
Pacific Way	06/07/88	0.78	242	7.9	12	9.4	110	0.39	<.01			USGS
Pacific Way	08/31/93						>2400	0.021	0.013		<.05	PWA
Pacific Way	08/31/93						>2400	0.015	<.01		<.05	PWA
Pacific Way	08/31/93						920	<.012	<.01		<.05	PWA
Upper Green Gulch	01/30/86	9.90	202	7.2	12.5	10.1	370	1	<.01			USGS
Upper Green Gulch	06/25/86	0.01	463	7.4	15.5	7.4	13	<.1	0.02			USGS
Upper Green Gulch	03/13/87	1.20	261	7.4	14	10.2	500	0.68	<.01			USGS
Upper Green Gulch	06/12/87	0.01	518	7.4	13.5	6.4	23	0.54	<.01			USGS
Upper Green Gulch	03/23/88	0.04	434	7.6	12.5	7.5	10	0.82	<.01			USGS
Upper Green Gulch	06/02/88	0.01	461	7.6	13	6.3	3	<.1	<.01			USGS
Lower Green Gulch	08/31/93						240	<.012	<.01		<.05	PWA
Lower Green Gulch	08/31/93						110	<.012	<.01		<.05	PWA
Lower Green Gulch	08/31/93						130	<.012	0.02		<.05	PWA

TABLE IV-6

**NITROGEN AND PHOSPHORUS LEVELS (mg/l)
IN REDWOOD CREEK WATERSHED IN 1992 AND 1993**

Site	Date		N as NO	N as NH3	P as PO4
Beach Footbridge	17 Jun 92		0.8	--	0.15
	23 Jul 92		ND	ND	0.1
	4 Jun 93		ND	ND	0.1
	4 Jun 93	rain	0.5	0.3	0.2
	9 Jun 93		0.7	0.2	0.1
	24 Jun 93		1.7	ND	0.1
	19 Aug 93		0.7	ND	0.1
Backwater above Delta	17 Jun 92		ND	--	0.1
	4 Jun 93		ND	0.2	0.2
	9 Jun 93		2.6	0.2	0.1
	24 Jun 93		1.1	ND	0.1
	19 Aug 93		0.5	0.2	0.1
Culvert from Green Gulch	17 Jun 92		ND	--	0.3
	4 Jun 93		1.2	0.2	0.03
Green Gulch Channel	17 Jun 92		ND	--	0.1
	23 Jul 92		ND	0.2	0.15
	4 Jun 93	rain	1.1	0.2	0.3
	9 Jun 93		1.1	0.6	0.1
	24 Jun 93		ND	ND	0.2
	19 Aug 93		1.6	ND	0.1
Road Bridge @ Muir Beach	17 Jun 92		1.0	ND	1.5
	23 Jul 92		ND	0.2	0.15
	4 Jun 93	rain	1.6	0.3	0.1
	9 Jun 93		0.1	ND	0.05
	24 Jun 93		1.8	ND	0.1
	19 Aug 93		0.4	ND	0.1
Downstream of Diversions	24 Jun 93		ND	ND	0.1

Table IV - 7

Aquatic insects found at Big Lagoon from September 1992 through July 1993.

Order	Common Name	Family
Coleoptera	Predaceous water beetle	Dytiscidae ✓
Coleoptera	Whirligig water beetle	Gyrinidae ✓
Coleoptera	Scavenger water beetle	Hydrophilidae ✓
Coleoptera	Crawling water beetle	Haliplidae ✓
Coleoptera	Round sand water beetle	Omophronidae ✓
Hemiptera	Backswimmer	Notonectidae ✓
Hemiptera	Water boatman	Corixidae ✓
Hemiptera	Giant water bug	Belostomatidae ✓
Hemiptera	Waterscorpion	Nepidae ✓
Hemiptera	Water Strider	Gerridae ✓
Ephemeroptera	Small mayfly	Baetidae ✓
Odonata	Dragon flies	Aeshnidae ✓
Odonata	Damsel flies	
Trichoptera	Caddis flies	Leptoceridae ✓
Plecoptera	Stone flies	
Diptera		Dixidae ✓
Diptera		Chaeoboridae ✓
Diptera	Midge	Chironomidae ✓
Diptera		Ceratopogonida ✓
Diptera	Mosquito	Culicidae ✓
Collembola	Springtail	Poduridae ✓

Table IV - 8

Bird survey dates, times, and station coverage at Big Lagoon, May 29, 1992 to August 9, 1993.

STATION	Date	5/29/92	7/28/92	10/22/92	11/25/92	1/20/93	2/5/93	4/13/93	5/5/93	6/10/93	7/11/93	8/9/93
	Time	1100-1410	0700-1030	0840-1205	0740-1110	0840-0930	0845-1100	0715-0935	0820-1115	0810-1115	0750-1100	0740-1030
1		•	•	•	•		•	•	•	•	•	•
2		•	•	•	•		•	•	•	•	•	•
3			•	•	•		•	•	•	•	•	•
4		•	•	•	•		•	•	•	•	•	•
5		•	•	•	•		•	•	•	•	•	•
6		•	•	•	•		•	•	•	•	•	•
7			•	•	•		•	•	•	•	•	•
8		•	•	•	•	•	•	•	•	•	•	•
9								•	•	•	•	•
10		•	•	•	•		•	•	•	•	•	•
11			•	•	•		•	•	•	•	•	•
12		•	•	•	•	•	•	•	•	•	•	•
13		•	•	•	•	•	•	•	•	•	•	•
14						•						
20		•	•	•	•		•	•	•	•	•	•
30		•	•	•	•							

Numbered species were recorded during 10-min. station counts, arranged here in decreasing order of total abundance.
 # = total n all sightings

- * observed at qualitatively surveyed beach station
- * observed outside bird station boundaries or on non-survey day

Terrestrial Associates

Feeding on terrestrial vegetation/associated insects			
Brewer's Blackbird	188	Audubon's Warbler	7
Red-winged Blackbird	110	Swainson's Thrush	6
Pine Siskin	89	American Crow	5
Song Sparrow	52	Hermit Thrush	5
House Finch	48	Northern Flicker	4
Chestnut-backed Chickadee	35	Black-headed Grosbeak	3
Rock Dove	25	Purple Finch	3
American Goldfinch	21	Fox Sparrow	2
White-crowned Sparrow	21	Marsh Wren	2
Anna's Hummingbird	18	American Redstart	1
Wilson's Warbler	17	Hairy Woodpecker	1
Golden-crowned Sparrow	17	House Wren	1
Mourning Dove	15	Lesser Goldfinch	1
Scrub Jay	15	Pygmy Nuthatch	1
European Starling	12	✓Rufous-sided Towhee	1
American Robin	11	Bewick's Wren	1
California Towhee	10		
Ruby-crowned Kinglet	10		
Aerial Insect Feeders			
Tree Swallow	39	Turkey Vulture	3
Barn Swallow	38	Red-tailed Hawk	1
Northern Rough-winged Swallow	37		
Black Phoebe	10		
Cliff Swallow	10		
Violet-green Swallow	10		
Raptors			
		American Kestrel	•
		Black-shouldered Kite	•
		Cooper's Hawk	•
		Great-horned Owl	•
		Northern Harrier	•
		Peregrine Falcon	•
		Red-shouldered Hawk	•

Wetland Associates

Benthic invertebrate feeders			
Killdeer	21	Black Oystercatcher	*
Western Gull	7	Marbled Godwit	*
Herring Gull	3	Ring-billed Gull	*
Lesser Yellowlegs	1	Whimbrel	*
Spotted Sandpiper	1	Willet	*
Mew Gull	•	Brown Pelican	*
Wandering Tattler	•	California Gull	•
		Common Snipe	•
Piscivores			
Great Blue Heron	8	Double-crested Cormorant	1
Snowy Egret	7	Horned Grebe	1
Black-crowned Night Heron	4	Green-backed Heron	•
Belted Kingfisher	2	Osprey	•
Great Egret	2		
Feeding on aquatic vegetation/associated invertebrates			
Mallard	119	American Coot	•
American Wigeon	105	Cinnamon Teal	•
Common Yellowthroat	3	Brant	•
American Green-winged Teal	1	Canada Goose	•
Barrow's Goldeneye	1	Common Merganser	•
Common Goldeneye	1	Eurasian Wigeon	•
Red-necked Phalarope	1	Virginia Rail	•
		Bufflehead	•

Number of bird species and individuals recorded at 15 stations in Big Lagoon, 1992-1993.

Table IV-10

STATIONS No. Locations	Approx. Size (m2)	TOTAL OBSERVED (total all surveys) species indiv.	# SURVEYS	AVERAGE #/SURVEY		AVERAGE #/m2 (x.001)	
				species mean sd	individuals mean sd	species mean sd	individuals rank mean sd
1 Lagoon	2000	26 97	10	2.6 3.20	9.7 7.45	10 1.3 1.60	10 4.9 3.73
2 Riparian Footpath	600	24 159	10	2.4 2.66	15.9 22.9	4 4.0 4.43	4 26.5 38.17
3 above bridge	600	15 45	9	1.7 1.39	5.0 2.5	8 2.8 2.32	9 8.3 4.17
4 above bridge	600	20 88	10	2.0 2.49	8.8 6.86	7 3.3 4.14	6 14.7 11.43
6 Redwood Creek	450	16 54	10	1.6 1.26	5.4 4.45	6 3.6 2.81	7 12.0 9.89
7	450	15 44	9	1.7 1.80	4.9 4.73	5 3.7 4.01	8 10.9 10.51
5 Riparian Vegetation	250	18 119	10	1.8 1.52	11.9 15.28	6 7.2 6.10	2 47.6 61.11
9	250	12 37	5	2.4 1.22	7.4 4.28	2 9.6 4.90	3 29.6 17.11
8 Pasture	2500	20 130	11	1.8 0.83	11.8 10.34	12 0.7 0.33	11 4.7 4.14
12	2500	17 83	12	1.4 1.45	6.9 5.01	13 0.6 0.58	13 2.8 2.00
13	2500	14 115	13	1.1 1.37	8.8 17.80	14 0.4 0.55	12 3.5 7.12
10 Dense willows	150	15 73	10	1.5 1.62	7.3 16.48	1 10.0 10.80	1 48.7 109.86
11 Kikuyu meadow	1600	13 277	9	1.4 1.59	30.8 75.23	11 0.9 0.99	5 19.2 47.02
20 Beach (qualitative)	n/a	10 142	10	1 1.5	14.2 16.78		
30 Chaparral	500	4 5	4	1.0 0.82	1.3 0.96	9 2.0 1.63	14 2.5 1.91

SPECIES	STATUS		
	<u>Federal</u>	<u>State</u>	<u>Audubon</u> <u>Marin County</u>
I All Life Stages Considered Sensitive			
American Peregrine Falcon	Endangered	Endangered	
Black Oystercatcher			•
California Brown Pelican	Endangered	Endangered	
Common Merganser			•
Common Yellowthroat,			
Saltmarsh subspecies	Candidate 2	Special Concern	
Green-backed Heron			•
Olive-sided Flycatcher	Management Concern		
Red-shouldered Hawk			
Tricolored Blackbird	Candidate 2	Special Concern	•
Virginia Rail			
Yellow Warbler		Special Concern	
II Only Nest Sites/Rookeries Considered Sensitive			
Barrow's Goldeneye		Special Concern (breeding)	
Black-crowned Night Heron		NDDB** listing (rookeries)	•
Black-shouldered Kite		NDDB listing (nesting)	
California Gull		Special Concern (nesting colony)	
Cooper's Hawk		Special Concern (nesting)	
Double-crested Cormorant		Special Concern (rookery)	
Great Blue Heron		NDDB listing (rookeries)	•
Great Egret		NDDB listing (rookeries)	•
Northern Harrier		Special Concern (nesting)	
Osprey		Special Concern (nesting)	
Snowy Egret		NDDB listing (rookeries)	•

* California Department of Fish and Game. 1993; California Department of Fish and Game. 1992a; California Department of Fish and Game. 1992b;

Tate, J. 1986; Shuford, W. D. 1993. ** Natural Diversity Data Base

TABLE IV-12

**DENSITY ESTIMATES (number of fish per 100 feet)
FOR COHO AND STEELHEAD COLLECTED
ON REDWOOD CREEK IN 1992 AND 1993**

(*Data for site 5 are actual capture totals, not density estimates).

Site	Sample Date	Habitat Types Sampled				Length Sampled (feet)	Density		
		Pool	Glide	Run	Riffle		Coho	Steelhead	
							0+	1/2+	
1. Muir Woods	20 Aug 92	30%	53%	12%	5%	302	84	19	8
	24 Jun 93	45	23	22	9	233	91	52	4
2. 3rd Bridge	19 Sep 92	60	15	7	19	166	30	16	7
	19 Aug 93	63	12	10	15	253	30	26	5
3. Downstream of Diversions	19 Sep 92	19	37	dry		250	13	6	1
						129 wet			
	14 Nov 92					250	4	6	0.4
	24 Jun 93	55	29	9	7	210	25	90	3
	10 Sep 93	51	34	9	6	221	16	72	4
4. 1st Bridge	23 Jul 92	39	56	2	4	314	54	49	1
	14 Aug 92								
	14 Nov 92	39	56	2	4	314	33	29	2
	8 Jun 93	27	35	32	5	255	39	55	4
	10 Sep 93	26	49	16	9	271	14	34	1
5. *Pools Above Delta	23 Jul 92	70	30			200	59	22	3
	14 Aug 92	70	30			200	6	2	3
	14 Nov 92	70	30			200	0	0	0
	4 Jun 93	99				50	29	14	4
	8 Jun 93	70	30			200	17	6	2
	19 Aug 93	70	30			200	6	16	0
	10 Sep 93	70	30			200	4	9	0

TABLE IV-13

**DISSOLVED OXYGEN (mg/l) IN THE POOL UPSTREAM
OF THE FOOT BRIDGE ON REDWOOD CREEK
AT MUIR BEACH IN 1992 AND 1993.**

Depth (m)	1992 Dates								
	17 Jun	23 Jun		14 Aug		19 Sep		14 Nov	
	11:10 Cloudy	11:30	16:50	10:15	16:50	9:20	17:20	9:30	14:35
		Fair		Overcast		Overcast		Fair	
Surface	9.9	8.6	10.2	6.8	9.5	4.3	4.7	8.9	9.3
0.25	9.7	8.4	10.2	6.4	9.4	4.2	4.5	8.6	9.1
0.5	9.7	8.2	10.3	5.4	9.0	4.0	4.5	8.4	8.9
0.75	9.7	8.6	10.3	4.5	6.1	3.8	4.5	8.3	7.7
0.8						3.8	4.3		
1.0	9.8	18.0		20+	4.2	4.2		6.2	6.3
1.1	9.9							6.0	5.9
1.15		20+	17.3						
1.2				1.9	2.7				

Depth (m)	1993 Dates					
	4 Jun	9 Jun	24 Jun	19 Aug		10 Sep
	9:45 Rain	17:00 Fair	18:30 Fair	9:00/17:15 Fair by 10:00		9:40 Overcast
Surface	9.2	10.0	9.2	5.9	8.8	6.5
0.25	9.1	9.9	9.2	5.9	8.5	6.2
0.5	9.0	9.8	9.0	5.9	9.1	4.7
0.75	9.0	9.8	9.0	6.0	9.3	4.7
1.0	9.0	9.8	8.8	6.1	9.1	5.0
1.15			8.6	5.8	9.5	
1.2						
1.25	8.8	8.2				4.2
1.35	3.6					

TABLE IV-14

SALINITIES OF REDWOOD CREEK LAGOON IN 1992 AND 1993

Depth (m)	1992 Dates				
	17 Jun*	23 Jun	14 Aug	19 Sep	14 Nov
Surface	0.0	0.6	5.3	5.4	3.6
0.05	1.0				
0.15	1.0				
0.2	6.6				
0.25	13.3	0.6	5.3	5.5	3.9
0.5	19.9	0.6	5.3	5.6	18.1
0.65				5.6	
0.75	21.5	0.6	5.3		21.8
0.8			5.3		
1.0		0.6			26.6
1.05		2.3			
1.15		4.2			26.6

Depth	1993 Dates				
	4 Jun*	9 Jun*	24 Jun*	19 Aug	10 Sep
Surface	0.6	0.2	0.1	0.5	0.7
0.25	2.6	0.2	0.1	0.6	0.7
0.3	9.3				
0.5	16.3	0.2	0.1	0.6	0.7
0.55		0.1			
0.65					0.7
0.7		0.2			
0.75				1.1	
0.8	19.0				
0.9	19.3			3.6	
1.0				6.7	
1.2				7.6	

* sandbar was open.

TABLE IV-15

WATER TEMPERATURES IN REDWOOD CREEK LAGOON IN 1992 AND 1993

Depth (m)	1992 Dates							
	17 Jun* 14:00	23 Jun 10:50	18:10	14 Aug 10:50	17:10	19 Sep 10:00	14 Nov 9:55	15:05
Surface	16.9	20.1	23.5	18.4	21.2	15.6	11.7	16.0
0.05	17.6							
0.15	17.4							
0.2	17.4							
0.25	18.8	19.8	23.7	19.0	21.3	15.8	11.4	15.6
0.5	20.1	19.6	23.8	19.4	21.3	15.8	16.0	17.3
0.65				16.3				
0.75	20.5	19.7	23.8	19.4	21.3		20.3	20.4
0.8		19.4	21.3					
1.0		19.7	23.8				21.3	21.7
1.05		19.8						
1.15		19.8	23.7				22.2	22.4

Depth (m)	1993 Dates					
	4 Jun* 12:05	9 Jun 18:05	24 Jun* 19:35	19 Aug 10:10	17:45	10 Sep 10:15
Surface	14.6	16.4	19.7	16.6	20.8	18.4
0.25	14.6	17.3	19.8	17.0	21.3	18.3
0.3	14.7					
0.5	15.4	17.0	19.6	16.9	21.3	18.6
0.55			19.6			
0.65						18.6
0.7		16.6				
0.75	16.4			16.9	21.4	
0.8	16.4					
0.9				18.6	21.4	
1.0				20.2	23.1	
1.2				20.6	23.1	

TABLE IV-16

**NUMBER OF FISH OF DIFFERENT SPECIES COLLECTED BY SEINE
IN THE LAGOON/ESTUARY AT MUIR BEACH IN 1992 AND 1993**

Species	1992			1993	
	23 Jul	14 Aug	14 Nov	4 Jun	19 Aug
Steelhead		24			16
Coho				21	
Threespine Stickleback	1000+	+	+	1000+	500+
Staghorn Sculpin	3	4		7	
Striped Bass	5	65	21		3
Yellowfin Goby					1
Starry Flounder		1			

Table IV - 17

Special species recognized by CNPS (Smith and Berg 1988) which may have historically occurred at Big Lagoon. Code is the status recognized by the CNPS: larger number indicates greater problem concerning: rarity - endangerment - distribution.

Scientific Name	Common Name	Code	Habitat
<i>Alopecurus aequalis</i> var. <i>sonomensis</i>	Sonoma alopecurus	3-3-3	marsh
<i>Elymus californicus</i>	California bottlebrush grass	1-1-3	forest
<i>Calamagrostis crassiglumis</i>	Thurber's reed grass	3-3-1	marsh
<i>Campanula californica</i>	Swamp harebell	1-2-3	marsh
<i>Cordylanthus maritimus</i> var. <i>palustris</i>	Point Reyes bird's beak	2-2-2	salt marsh
<i>Erysimum franciscanum</i>	San Francisco wallflower	1-2-3	dunes
<i>Grindelia humilis</i>	Marsh gumplant	1-1-3	salt marsh
<i>Layia carnosa</i>	Beach layia	3-3-3	dunes
<i>Lupinus tidestromii</i> var. <i>layneae</i>	Point Reyes lupine	3-3-3	dunes
<i>Pleuropogon refractus</i>	Nodding semaphore grass	1-2-1	forest
<i>Polygonum marinense</i>	Marin knotweed	3-3-3	salt marsh

TABLE IX-1

WATER BALANCE FOR ALTERNATIVE B -- HISTORIC WETLAND

Month	Inflow Volume (ac-ft)	Open Water Evaporation (ft)	Losses (ac-ft)	PET Losses by Wetland Plants (ft)	(ac-ft)	Total Losses (ac-ft)	Drop in Water Level (ft)	Turnover Frequency (per period)
Mar. 92	875	0.16	0.80	0.20	2.24	3.04	0.0	68.4
Apr	213	0.22	1.10	0.28	3.08	4.18	0.0	16.7
May	56	0.32	1.60	0.40	4.48	6.08	0.0	4.4
Jun	72	0.37	1.85	0.46	5.18	7.03	0.0	5.7
Jul	17	0.43	2.15	0.54	6.02	8.17	0.0	1.4
Aug	7.3	0.33	1.65	0.41	4.62	6.27	0.0	0.6
Sep	2.7	0.23	1.15	0.29	3.22	4.37	0.3	0.2
Oct	7.1	0.14	0.70	0.18	1.96	2.66	0.0	0.6
Nov	1.5	0.06	0.30	0.08	0.84	1.14	0.0	0.1
Dec	927	0.03	0.15	0.04	0.42	0.57	0.0	72.4
Jan 93	3892	0.02	0.10	0.03	0.28	0.38	0.0	304.0
Feb	2246	0.05	0.25	0.06	0.70	0.95	0.0	175.5
Mar	787	0.16	0.80	0.20	2.24	3.04	0.0	61.5
Apr	514	0.22	1.10	0.28	3.08	4.18	0.0	40.1
May	146	0.32	1.60	0.40	4.48	6.08	0.0	11.4
Jun	220	0.37	1.85	0.46	5.18	7.03	0.0	17.2
Jul	37	0.43	2.15	0.54	6.02	8.17	0.0	2.9
Aug	22	0.33	1.65	0.41	4.62	6.27	0.0	1.7
Sep	7	0.23	1.15	0.29	3.22	4.37	0.0	0.5
Aug-Oct 1992 excluding 10/28 storm)	10.5	0.7	3.50	0.9	9.80	13.30	0.6	0.8
								2.3
Aug-Sep 1993	28.9	0.6	2.80	0.7	7.84	10.64	0.0	
Annual Total						44.84		

TABLE IX-2

**WATER BALANCE FOR ALTERNATIVE C --
HISTORIC WETLAND, PRESERVE EXISTING RIPARIAN HABITAT**

Month	Inflow Volume (ac-ft)	Open Water		PET Losses by		Total Losses (ac-ft)	Drop in Water Level (ft)	Turnover Frequency (per period)
		Evaporation	Losses	Wetland Plants				
		(ft)	(ac-ft)	(ft)	(ac-ft)			
Mar. 92	875	0.16	0.74	0.20	1.50	2.24	0.0	78.1
Apr	213	0.22	1.01	0.28	2.06	3.07	0.0	19.0
May	56	0.32	1.47	0.40	3.00	4.47	0.0	5.0
Jun	72	0.37	1.70	0.46	3.47	5.17	0.0	6.5
Jul	17	0.43	1.98	0.54	4.03	6.01	0.0	1.5
Aug	7.3	0.33	1.52	0.41	3.09	4.61	0.0	0.7
Sep	2.7	0.23	1.06	0.29	2.16	3.21	0.1	0.2
Oct	7.1	0.14	0.64	0.18	1.31	1.96	0.0	0.6
Nov	1.5	0.06	0.28	0.08	0.56	0.84	0.0	0.1
Dec	927	0.03	0.14	0.04	0.28	0.42	0.0	82.8
Jan 93	3892	0.02	0.09	0.03	0.19	0.28	0.0	347.5
Feb	2246	0.05	0.23	0.06	0.47	0.70	0.0	200.5
Mar	787	0.16	0.74	0.20	1.50	2.24	0.0	70.3
Apr	514	0.22	1.01	0.28	2.06	3.07	0.0	45.9
May	146	0.32	1.47	0.40	3.00	4.47	0.0	13.1
Jun	220	0.37	1.70	0.46	3.47	5.17	0.0	19.7
Jul	37	0.43	1.98	0.54	4.03	6.01	0.0	3.3
Aug	22	0.33	1.52	0.41	3.09	4.61	0.0	2.0
Sep	7	0.23	1.06	0.29	2.16	3.21	0.0	0.6
Aug-Oct 1992 (excluding 10/28 storm)	10.5	0.7	3.22	0.9	6.56	9.78	0.0	0.9
Aug-Sep 1993	28.9	0.6	2.58	0.7	5.25	7.83	0.0	2.6
Annual Total						32.98		

TABLE IX-3

WATER BALANCE FOR ALTERNATIVE D - BACKWATER POND AND WETLAND

Month	Inflow Volume (ac-ft)	Open Water		PET Losses by		Total Losses (ac-ft)	Drop in Water Level (ft)	Turnover Frequency (per period)
		Evaporation	Losses (ft) (ac-ft)	Wetland Plants	(ft) (ac-ft)			
Mar. 92	875	0.16	0.35	0.20	1.82	2.17	0.0	125.0
Apr	213	0.22	0.48	0.28	2.50	2.99	0.0	30.5
May	56	0.32	0.70	0.40	3.64	4.34	0.0	8.0
Jun	72	0.37	0.81	0.46	4.21	5.02	0.0	10.3
Jul	17	0.43	0.95	0.54	4.89	5.84	0.0	2.5
Aug	7.3	0.33	0.73	0.41	3.75	4.48	0.0	1.0
Sep	2.7	0.23	0.51	0.29	2.62	3.12	0.2	0.4
Oct	7.1	0.14	0.31	0.18	1.59	1.90	0.0	1.0
Nov	1.5	0.06	0.13	0.08	0.68	0.81	0.0	0.2
Dec	927	0.03	0.07	0.04	0.34	0.41	0.0	132.5
Jan 93	3892	0.02	0.04	0.03	0.23	0.27	0.0	556.0
Feb	2246	0.05	0.11	0.06	0.57	0.68	0.0	320.8
Mar	787	0.16	0.35	0.20	1.82	2.17	0.0	112.4
Apr	514	0.22	0.48	0.28	2.50	2.99	0.0	73.4
May	146	0.32	0.70	0.40	3.64	4.34	0.0	20.9
Jun	220	0.37	0.81	0.46	4.21	5.02	0.0	31.4
Jul	37	0.43	0.95	0.54	4.89	5.84	0.0	5.3
Aug	22	0.33	0.73	0.41	3.75	4.48	0.0	3.1
Sep	7	0.23	0.51	0.29	2.62	3.12	0.0	1.0
Aug-Oct 1992 (excluding 10/28 storm)	10.5	0.7	1.54	0.9	7.96	9.50	0.0	1.5
Aug-Sep 1993	28.9	0.6	1.23	0.7	6.37	7.60	0.0	4.1
Annual Total						32.04		

TABLE X-1**SUMMARY OF POTENTIAL DREDGE DISPOSAL LOCATIONS**

Location	Capacity (cy)	Average Disposal Depth (feet)	Maximum Truck Haul (feet)
Green Gulch Fields 6 and 7	24000	4	1300
Banducci Fields	80,000-120,000	2-3	5800
Riding Ring and State Park Land	24,000-36,000	2-3	7500
Former Ballfield	18,000-27,000	2-3	3000
On-site Uplands Near Hwy 1	20000	8	1000

APPENDIX B

Biologic Sampling Methods

XII. APPENDIX- METHODS

A. Methods

Physical

Grain Size

Field Methods:

Sediment samples for grain size analysis were collected from three stations within the lower lagoon. Lagoon stations were roughly equally spaced, with station one near the lower end (the "mouth", when open to tidal flow), station two in the middle, and station three near the upstream end of the lagoon. Samples were collected using stainless steel implements. An approximately 80g subsample from the top 2cm of the sediment surface was placed in a zip-lock bag for grain-size analysis. Samples were labeled with an external label on the bag with an additional internal label.

Laboratory methods:

Sample Preparation

The samples were analyzed whole; no subsampling or splitting was performed. All weights in all analyses were read and recorded to the nearest 0.01g. The samples were placed into numbered pre-weighed beakers and were dried at less than 55°C to prevent collapse of the clays. Samples were allowed to cool for at least one hour to equilibrate to the atmosphere, then weighed. After the sample was dried, the debris was removed, with any sediment adhering to the debris being washed into the sample container. The debris/shell fragments were dried, weighed, and listed on the data sheet, but not included in the computation of sediment size statistics. The stock container (50g/l) of 'Calgon' dispersant was stirred to ensure homogeneity, and 100 ml added to each beaker to prevent flocculating. Lumps were broken up using a rubber-tipped probe, then the sample beakers placed in an ultrasonic cleaner for 15 minutes for disaggregation. Samples were then wet-sieved through a No. 230 4 phi (0.0625 mm) stainless-steel sieve. Silts, clays, and colloidal material passing through the sieve were not retained and were allowed to flow down the drain. The coarse fraction was placed into a pre-weighed beaker, dried at 55°C, allowed to acclimate, then weighed. Analysis of March 1993 sediments was limited to this rough percent fine/percent coarse characterization. The preponderance of coarse sediments in samples from all three stations (see below) suggested that further analysis of the

coarse fraction was necessary. In accordance, the coarse fraction from the May and September 1993 sampling dates were analyzed by sieve analysis using a mechanical shaker for 15 minutes and the following sieves: No. 10 (2.0 mm), 18 ((1.0 mm), 60 (0.25 mm), 80 (0.177 mm), 120 (0.125 mm), and 170 (0.088 mm). After shaking, each sieve was inverted onto a large piece of paper and tapped 5 times to free stuck particles. The sieve fractions were added cumulatively to a pre-tared weighing dish, and the cumulative weight after each addition determined to 0.01g. Each sample was returned to its original beaker and saved until the sample computations were completed and checked for errors.

Data Analysis

Fractional weights and percentages of fine (silt, clay, and colloidal, particle size $< 63 \mu\text{m}$) and coarse (coarse sand, medium/fine sand, and pebbles/gravel, particle sizes $\geq 63 \mu\text{m}$) fractions, as well as Folk & Ward parameters (mean and median grainsize, sorting coefficient, skewness, and kurtosis were calculated using custom software on a Macintosh 2 computer.

Ecological Methods

Vegetation

Five major plant associations were recognized on the lowlands. They were identified by visual survey of the site from the ground and by a supplemental overview inspection looking down from the adjacent hills. They were pasture, marsh, disturbed, riparian and dune. Upland habitat of modified coastal scrub grew adjacent to the site on the surrounding hills. Eight permanent transects were established for quantitative sampling (Figure 2).

Vegetation was also assessed qualitatively and semiquantitatively. Regional distribution of species and approximate cover were noted by walking over the entire study site. The whole area was generally searched to locate all species, including those of the dense riparian woodland. Since the upland was peripheral to the study it was not surveyed thoroughly and only species that occurred along the transect or were important components were included in the species list. Seasonal changes in species composition and reproductive state of plants were noted. Aerial photographs were used to assess general seasonal trends in plant composition and cover over the area. Aerial photographs and recorded oral histories provided the basis for review of probable historical conditions and subsequent changes.

Quantitative plant surveys to measure per cent cover by species were conducted a total of 5 times, approximately quarterly, along 20 m transects (Figure 3). An additional transect was put in the upland. Transects were positioned through the most typical, homogenous, sections of each habitat. Transects were marked by a small pvc stake at each end and visual lineups were established to facilitate finding the stakes. Generally the habitats were small relative to the length of the transect consequently, transects generally ran through the middle of each area. Lists of species in each habitat type were generated from quantitative transect surveys as well as qualitative evaluations. Habitat types graded into each other or were bordered by disturbed areas with many weeds, and species were often recorded from the edges of habitat types. Dune habitat was sampled by semiquantitative assessment of the community remnants on individual sand mounds.

Quantitative sampling was carried out by stretching a 20m tape between each pair of stakes and placing a quadrat of a quarter meter square area at each of ten points along the tape. The points had been selected each sampling period using a table of random numbers. The random point-quadrat method was employed. The quadrat was covered with a grid dividing it into 100 equally spaced intersects and it defined the sampling area. Ten intersects were chosen each sampling period using a table of random numbers. Data were obtained by recording the species which occurred under each of the ten selected intersect points. The raw quantitative data are archived at Moss Landing Marine Laboratories and may be used for long-term comparisons.

Scientific and common names are the most current according to Hickman (1993). Long-recognized common and scientific names that have been replaced are noted in parentheses in Table 3.

Freshwater Aquatic Invertebrates

Although we initially sampled insect fauna at 17 stations in seven habitat types (Figure 5), we have refined our study to concentrate on aquatic species because they will be most profoundly affected by the proposed mitigation. Our approach, therefore, has been to compare and contrast insect families found in the ditches with those associated with Redwood Creek as a means of evaluating how increasing pond habitat at Muir Beach will influence the relative abundance and composition of aquatic insect and crustacean fauna.

We have adopted this approach because it is in the horse pasture stations that the most dramatic changes will occur following the creation of the proposed

freshwater pond. Sampling of the existing stations and new stations to be established after the creation of the mitigation pond, will enable us to compare the stream habitats with the more stagnant ditch wetlands, and to document the insect colonization sequence in the pond when created.

We have also entered into an informal collaboration with Ray Peterson, an entomologist and resident naturalist at the Audubon Canyon Ranch (ACR), a few miles from the Muir Beach restoration site. Ray has been documenting aquatic insect recolonization patterns following the creation of a small pond at ACR, and has agreed to share his data, technology, species lists and taxonomic expertise with us if the mitigation pond is created. Our ultimate goal will be to evaluate the success of the Muir Beach restoration project by comparing the recolonization sequence and temporal insect community patterns in the newly created pond with those of the more "natural" and already established pond at ACR. This inter-study comparison will be possible because we have adopted Ray's highly effective nocturnal trapping technique for the remainder of the Muir Beach project.

Seasonal changes were tracked via quarterly, qualitative and quantitative sampling at these sites. Qualitative sampling was done during the day by sweeping through the water with a 0.01m^2 insect net at 7 aquatic stations (Figure 5). Quantitative sampling was done using three replicate, lighted, nocturnal traps placed in Redwood Creek at station 14 and in Ditch 3 at station 15. These two stations used for quantitative sampling were chosen because they offered the best comparison of a quiet stream habitat (#14) with the most persistent of the seasonal "ponds" at the Muir site (#15). Both sites supported emergent vegetation, but the #14 Redwood Creek Backwater site is more directly influenced by the physical dynamics and ecology of the creek than the ditch at #15 which is separated from the creek by a culvert. Insects were preserved in 75% isopropyl alcohol, sorted and identified to family (Powell and Hogue 1979, Borror and White 1970, Lehmkuhl 1979).

Qualitative monitoring only was done on 29 May and 24 September, 1992. Qualitative and quantitative monitoring were done in late winter (6 March 1993), spring (2 May, 1993), and summer (9 July, 1993).

Tidal Lagoon Invertebrates

Since there is a gradient of fresh and salt water mixing in lower Big Lagoon, we selected three stations along the salinity gradient from the mouth to the head of this lagoon area (Figure 5). Quantitative samples were taken during three seasons

from the three stations. Six replicate cores were collected from each station to describe the benthic infaunal communities in the lagoon. Sediment was sampled to measure changes in grain size. Cores were 0.0072 m² in area (the same standard core used in the Lone Tree marine monitoring). Cores were washed over a 0.5 mm screen. Screen residues were preserved in 4% formaldehyde solution and later transferred to 70% propanol. Animals were sorted from residues, identified to lowest taxon, and counted.

Amphibians and Reptiles

Visual encounter surveys were conducted on foot primarily at night and approximately twice a month from December 1992 to February 1993. Monthly surveys were conducted after that time. Surveys followed an established route designed to encounter the primary wetland and riparian habitats at Big Lagoon (Figure 10). Surveys were scheduled during and immediately after rainfall to coincide with periods of greatest herpetological activity. Animals were located using flashlights, identified and counted. Locations of sightings were marked on topological maps. Larvae were identified by sampling with a dip-net and counted.

Qualitative observations on the species composition and relative abundance of reptiles were made on each monthly amphibian survey in the late afternoon. In addition, three longer morning surveys of the same amphibian survey route (Figure 10), as well as the major habitats for plant sampling (Figure 3), were made to look for reptiles.

Birds

Birds at Big Lagoon were quantitatively surveyed on eleven dates between 29 May 1992 and 9 August 1993 (Table 5). Birds were originally surveyed by a primary observer and an occasional assistant observer every two months. Beginning April 93, a local birder and long-time Muir Beach resident was contracted to conduct monthly surveys¹.

Permanent stations were established in all wetland and former wetland habitats (Figure 14); boundaries for each station were set using existing landmarks. Though most stations were visited on all sampling dates, some changes were made during the 11/4-year sampling period to enhance coverage of the most

¹Note that results are presented only through the end of the most recent full quarter completed prior to this report (June-August 93), but monthly surveys are continuing.

important habitats (Table 5). Surveys of the single upland station (Station 30) were discontinued after November as it was deemed far more useful to increase coverage of habitats in the lowland areas which might be impacted by restoration efforts. Station 9 was added in April 93 to sample a riparian area which a local birder had observed supporting large numbers of birds over several years of observations (O. Onorato, pers. comm.). Station 14 was created in response to the complete inundation of Station 13 in January 93. This station site included a 10 m swath to the north and east of Station 13. In January 93 it was heavily utilized by sitting and wading waterfowl, though the middle of the pond (i.e. Station 13) was devoid of birds. Station 14 will be used to enhance qualitative observations of bird wetland edge preferences when Station 13 is inundated; previous qualitative observations indicate nominal use (at best) of Station 14 during drier times of the year.

During surveys, each station was visited for 10 minutes. During this period, all birds were identified to species and counted; if possible, behavior was also recorded. At most stations, the observer consistently made all observations from a single location. However, due to the long, narrow shape of the riparian habitat being surveyed, Stations 6 and 7 were surveyed by slowly walking along the vehicle road from north to south.

Qualitative observations were made incidental to regular surveys to supplement the bird species list and to better document breeding use of areas within Big Lagoon. However, these were not the primary focus of the field work, and should therefore be considered supplementary to more comprehensive surveys conducted specifically for these purposes. All species names used in text and figures are accepted common names established by the American Ornithologists' Union (1983,1985).

Grainsize characteristics of sediments from three stations in the lower lagoon area of Muir Beach during March - September, 1993. Fractional percentages of four grainsize categories are shown. Due to type of analysis used, data for only the percentage of fine sediment ($<0.063\text{mm}$ particle diameter) was obtained for March 1993 samples (see results discussion). $n = 1$ in all cases.

FRACTIONAL PERCENT

Date	Station	Pebbles/ Gravel ($>1.0\text{mm}$)	Coarse Sand (0.500mm)	Medium/ Fine Sand (0.063mm)	Medium/Coarse Fine Silt ($<0.063\text{mm}$)
March-4	1	-	-	-	0.54
	2	-	-	-	0.11
	3	-	-	-	0.51
May-13	1	0.04	1.02	98.66	0.29
	2	50.34	20.94	28.30	0.42
	3	69.56	8.52	21.59	0.33
September-3	1	10.30	18.15	71.11	0.43
	2	0.13	13.33	86.37	0.18
	3	10.51	5.10	84.07	0.32

Grainsize characteristics of sediments from three stations in the lower lagoon area of Muir Beach during March - September, 1993. Folk and Ward statistics are shown. Due to type of analysis used, no Folk and Ward statistics could be calculated for March 1993 samples (see results discussion). $n = 1$ in all cases.

FOLK & WARD STATISTICS (phi)

Date	Station	Mean	Median	Sorting
March-4	1	-	-	-
	2	-	-	-
	3	-	-	-
May-13	1	3.37	3.99	0.80
	2	0.14	-0.02	1.16
	3	-0.24	-1.05	1.15
September-3	1	1.42	1.69	0.89
	2	1.82	1.92	0.39
	3	1.78	2.01	0.78

Grainsize characteristics of sediments from three stations in the lower lagoon area of Muir Beach during March - September, 1993. Fractional percentages of four grainsize categories are shown. Due to type of analysis used, data for only the percentage of fine sediment (<0.063mm particle diameter) was obtained for March 1993 samples (see results discussion). n = 1 in all cases.

FRACTIONAL PERCENT

Date	Station	Pebbles/ Gravel (>1.0mm)	Coarse Sand (0.500mm)	Medium/ Fine Sand (0.063mm)	Medium/Coarse Fine Silt (<0.063mm)
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	2	-	-	-	0.11
	3	-	-	-	0.51
May-13	1	0.04	1.02	98.66	0.29
	2	50.34	20.94	28.30	0.42
	3	69.56	8.52	21.59	0.33
September-3	1	10.30	18.15	71.11	0.43
	2	0.13	13.33	86.37	0.18
	3	10.51	5.10	84.07	0.32

Grainsize characteristics of sediments from three stations in the lower lagoon area of Muir Beach during March - September, 1993. Folk and Ward statistics are shown. Due to type of analysis used, no Folk and Ward statistics could be calculated for March 1993 samples (see results discussion). n = 1 in all cases.

FOLK & WARD STATISTICS (phi)

Date	Station	Mean	Median	Sorting
March-4	1	-	-	-
	2	-	-	-
	3	-	-	-
May-13	1	3.37	3.99	0.80
	2	0.14	-0.02	1.16
	3	-0.24	-1.05	1.15
September-3	1	1.42	1.69	0.89
	2	1.82	1.92	0.39
	3	1.78	2.01	0.78