

July 1994
Comments 0422
Dave

1993 Redwood Creek Estuary Annual Monitoring Report

Redwood National Park
P.O. Box 7
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by
Dave Anderson

This summary of Redwood National Park (RNP) activities is required by the special conditions of permit No. 18974N36 (Appendix A). It details the 1993 estuary resource management activities of Redwood National Park and steps followed to pursue a long-term solution to the land use/resource problems of the Redwood Creek estuary.

Project Location

The Redwood Creek estuary is located 2.5 miles west of Orick, California. Flood control levees completed in 1968 channelize the lower 3.2 miles of Redwood Creek and extend into the estuary (Figure 1). The levees have changed the circulation and sedimentation patterns in the estuary. The last oxbow of the river, now called the South Slough was bypassed by the south levee, and later reconnected in 1987 by gated culverts; a mitigation project to offset fish losses from construction of the U.S. Highway 101 Park Bypass. The North Slough outlet channel is partially filled with sand preventing complete water circulation with the embayment. The permit authorizes water level management in the estuary when the level exceeds 6.0 ft Mean Sea Level (MSL). This event occurs during the summer and fall when the mouth closes, the estuary water level rises, and results in flooding of adjacent private land. The permit also allowed the deepening and widening of the channels of the North and South Sloughs.

Fish Monitoring

The Peterson mark and recapture method (Youngs and Robson 1978) was used to estimate juvenile salmonid fish numbers in the Redwood Creek embayment. A blue mark was applied to the caudal or anal fin using a Panjet needleless injector and Alcian Blue dye. Fish were seined using a 150 foot long, 15 foot wide, 1/4 inch mesh beach seine. Fish were marked the first two days, allowed to mix the third day, and seined on the fourth day to determine the ratio of marked to unmarked fish. Population estimates for adipose fin clipped chinook salmon were calculated two ways: (1) using the Peterson mark and recapture method, and (2) multiplying their percentage of occurrence in seined samples by the total estimated number of wild and fin clipped chinook salmon. In addition, fork length measurements were obtained from each of 200 chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*) juveniles, and weight measurements and scales are taken from 30 juveniles of each species. Other salmonid species, coastal cutthroat trout (*O. clarki*), half-pounder steelhead, and coho salmon (*O. kisutch*), which were uncommon, were also measured.

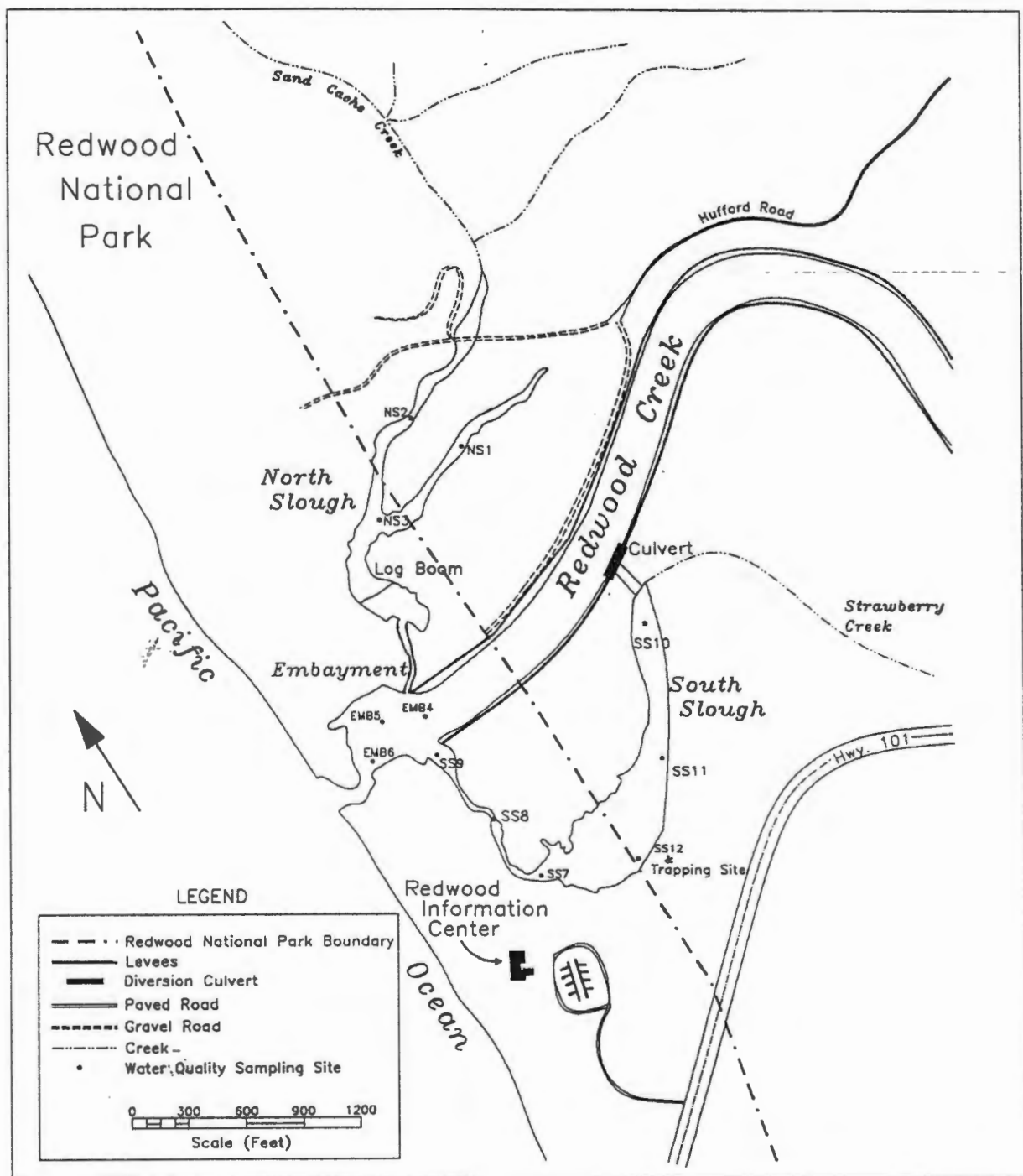


Figure 1. Map of the Redwood Creek estuary, Humboldt County, California, including the embayment, north and south sloughs.

During the 1993 summer/fall field season, four population estimates and eight length/weight measurements were conducted between June 14 and September 23, 1994. The chinook salmon population declined during the summer and fall, and the steelhead population decreased, then increased, before declining again in the fall (Table 1). The mean fork length and weight of chinook salmon and steelhead trout increased during the summer and fall sampling period (Tables 2, 3, and 4). Mean steelhead fork length and weight increase is variable because the mean includes several age classes. The mean length of wild and CalTrans Prairie Creek hatchbox raised chinook were similar, and based on the decreasing percentage of wild fish compared to adipose fin clipped hatchbox fish, it appears the wild fish migrated to the ocean earlier in the season, and were replaced by the fin clipped fish which migrated into the embayment later in the season (Table 5). A total of 62,410 hatchbox chinook were released into Prairie Creek on June 17 and July 2 and 3, but only 8,260 chinook smolts, both wild and adipose fin clipped, were estimated to have passed through their downstream migrant traps on Prairie Creek (Farro 1993). The traps were in place from mid May through late May, and mid June through late August. No juvenile coho salmon, adult steelhead or salmon were seined in the embayment. Forty coastal cutthroat trout, 10 of which were hatchery plants in Stone Lagoon, and one half-pounder steelhead were seined (Table 6).

Due to dense aquatic vegetation, seining is not effective in the south slough. The south and north sloughs were trapped three times and once, respectively. Two fyke nets with 3-foot diameter hoops, quarter inch mesh size, and two 15-foot long wing nets set at a 90° angle were used to trap fish. One net is placed in the upstream direction and the other in the downstream direction for 24 hours. We can not estimate populations by trapping, but it does demonstrate utilization of the slough by salmonids. A total of 14 chinook (one of which had an adipose fin clip), 17 steelhead trout, and 12 cutthroat trout were captured in the south slough (Table 7). None were marked with blue dye. After trapping 25 hours on July 19 and 20, only 9 three spined stickleback were captured in the two fyke traps in the north slough. The water in the slough was very dark and smelled of hydrogen sulfide.

Water Quality Monitoring

Water quality in the Redwood Creek estuary was measured a total of four times during the months of June, July, August, and September. Water temperature (°C), dissolved oxygen (ppm), specific conductivity @ 25°C (µmhos), salinity (o/oo), and pH were measured at one foot intervals at 12 stations distributed throughout the estuary (Figure 1). The measured minimum and maximum values of the water quality parameters are presented in Table 8. Daytime summer/fall water quality was adequate for salmonids in the main embayment, although the water temperatures were at marginal levels. Warm water entering the embayment from upstream and low embayment water levels because the mouth was open, contributed to the high water temperatures. The north slough was not isolated from the rest of the estuary as the outlet channel remained open, but it did not receive tidal influence from the embayment. It consisted of freshwater and had very high water temperatures and low dissolved oxygen levels, making the slough unsuitable for salmonid survival. The south slough was generally saline at the bottom, had adequate dissolved oxygen, but high water temperatures.

Table 1. Population estimates and 95% confidence intervals of all chinook salmon, wild and adipose clipped fish (from CalTrans Prairie Creek hatchbox project), and hatchbox fish estimated numbers based on the percentage of adipose clipped chinook salmon seined, and steelhead trout in the Redwood Creek Estuary, Humboldt County, California, between 6/14 and 9/23/93. (Population estimates rounded-off to the nearest ten). Mouth denotes if Redwood Creek mouth was open to the ocean or closed.

1993 DATE	MOUTH	Population Estimates of Chinook Salmon				Population Estimates of Steelhead Trout (95% Confidence Interval)
		Total Population (95% Confidence Interval)	Wild Fish (95% Confidence Interval)	Adipose Clipped (95% Confidence Interval)	Adipose Clipped (No. based on % occurrence)	
6/28,29, 7/1	OPEN	17,990 (13,780 - 22,220)	17,960 (13,760 - 22,170)	2 ^a	60	4,930 (3,420 - 6430)
7/26,27,29	OPEN	5,130 (2,370 - 7,890)	5,230 (2,280 - 8,180)	63 (15 ^a - 170)	17	1,000 (96 ^a - 2,320)
8/23,24,26	OPEN	1,830 (1,610 - 2,050)	890 (730 - 1,050)	950 (800 - 1,100)	970	2,740 (1,240 - 4230)
9/20,21,23	OPEN	117 ^a	32 ^a	85 ^a	85 ^a	810 (56 ^a - 2,340)

^a Population estimate not possible. Number represents actual fish seined.

Table 2. Mean fork length (mm) and weight (g), with standard deviation, range, and sample numbers of wild juvenile chinook salmon seined in the Redwood Creek estuary, Humboldt County, California, during the summer and fall of 1993. Mouth denotes if Redwood Creek mouth was open to the ocean or closed.

Redwood Creek Estuary Juvenile Chinook Salmon - WILD FISH Summer/Fall 1993							
1993 DATE	MOUTH	Mean Fork Length (mm) (No. Sampled)	Std. Dev. (mm)	Range (mm)	Mean Weight (g) (No. Sampled)	Std. Dev. (g)	Range (g)
6/14	OPEN	57.2 (216)	4.8	46 - 74	1.9 (30)	0.6	1.0 - 4.1
6/28,29,7/1	OPEN	73.9 (215)	6.2	56 - 92	4.6 (29)	1.2	2.6 - 7.5
7/14	OPEN	71.1 (142)	6.7	49 - 88	4.2 (28)	1.4	1.9 - 7.9
7/26,27,29	OPEN	81.4 (213)	6.0	62 - 99	5.6 (30)	1.7	2.1 - 8.8
8/11	OPEN	87.6 (152)	8.4	75 - 118	7.8 (17)	2.0	4.6 - 10.5
8/23,24,26	OPEN	96.8 (114)	8.4	75 - 118	10.2 (8)	2.8	7.4 - 15.9
9/09	OPEN	102.0 (9)	8.1	91 - 111	12.8 (9)	2.9	8.4 - 16.6
9/20,21,23	OPEN	91.4 (32)	8.0	76 - 108	8.6 (9)	2.0	6.8 - 13.1

Table 3. Mean fork length (mm) and weight (g), with standard deviation, range, and sample numbers of adipose fin clipped juvenile chinook salmon seined in the Redwood Creek estuary, Humboldt County, California, during the summer and fall of 1993. Adipose clipped fish are from the CalTrans Prairie Creek hatchbox project. Mouth denotes if Redwood Creek mouth was open to the ocean or closed.

Redwood Creek Estuary Juvenile Chinook Salmon - ADIPOSE CLIPPED HATCHBOX FISH Summer/Fall 1993							
1993 DATE	MOUTH	Mean Fork Length (mm) (No. Sampled)	Std. Dev. (mm)	Range (mm)	Mean Weight (g) (No. Sampled)	Std. Dev. (g)	Range (g)
6/14	OPEN	(0)	--	--	(0)	--	--
6/28,29,7/1	OPEN	71.0 (2)	8.5	65 - 77	4.8 (1)	--	4.8
7/14	OPEN	71.3 (3)	2.1	69 - 73	4.4 (2)	0.1	4.3 - 4.5
7/26,27,29	OPEN	83.3 (7)	5.7	75 - 93	(0)	--	--
8/11	OPEN	86.6 (74)	5.2	73 - 101	7.1 (13)	1.1	5.9 - 9.2
8/23,24,26	OPEN	94.6 (131)	6.9	79 - 111	9.5 (22)	2.6	6.5 - 15.4
9/09	OPEN	105.3 (15)	7.5	92 - 118	14.0 (15)	5.0	9.2 - 29.6
9/20,21,23	OPEN	92.0 (85)	5.4	81 - 106	8.7 (20)	1.4	6.0 - 11.3

Table 4. Mean fork length (mm) and weight (g), with standard deviation, range, and sample numbers of juvenile steelhead trout seined in the Redwood Creek estuary, Humboldt County, California, during the summer and fall of 1993. Mouth denotes if Redwood Creek mouth was open to the ocean or closed.

Redwood Creek Estuary Juvenile Steelhead Trout Summer/Fall 1993							
1993 DATE	MOUTH	Mean Fork Length (mm) (No. Sampled)	Std. Dev. (mm)	Range (mm)	Mean Weight (g) (No. Sampled)	Std. Dev. (g)	Range (g)
6/14	OPEN	112.4 (14)	11.1	95 - 128	14.5 (14)	4.2	8.6 - 20.9
6/28,29,7/1	OPEN	125.0 (206)	16.7	51 - 193	24.0 (30)	14.6	11.8 - 95.2
7/14	OPEN	136.5 (86)	13.6	106 - 179	29.2 (30)	7.1	17.1 - 43.8
7/26,27,29	OPEN	135.7 (30)	37.6	55 - 214	30.7 (30)	21.5	2.0 - 102.4
8/11	OPEN	140.2 (80)	27.8	68 - 193	36.5 (30)	15.1	6.7 - 66.7
8/23,24,26	OPEN	132.5 (213)	30.0	76 - 201	37.6 (30)	28.0	5.7 - 90.4
9/09	OPEN	150.6 (46)	23.3	100 - 190	41.9 (30)	19.3	13.4 - 78.9
9/20,21,23	OPEN	164.2 (56)	26.0	115 - 219	53.5 (31)	28.8	22.2 - 113.8

Table 5. Chinook salmon mean fork length (mm) of wild and adipose clipped fish, and the percentage of adipose fin clipped juvenile chinook salmon seined in the Redwood Creek Estuary, Humboldt County, California, between 6/14 and 9/23/93. Adipose fin clipped fish originated from the CalTrans Prairie Creek hatchbox project mitigating for the effects of the October 1989 storm that transported sediment into Prairie Creek from the U.S. 101 Bypass.

Summer/Fall 1993 Redwood Creek Estuary Juvenile Chinook Salmon			
1993 DATE	Mean Fork length (mm) Wild Ad Clipped (No. sampled)		% Adipose Clipped (AD ÷ (AD + Wild))
6/14	57.2 (216)	(0)	0.0% (0/0)
6/28,29,7/1	73.9 (215)	71.0 (2)	0.3% (7/2119)
7/14	71.1 (142)	71.3 (3)	2.1% (3/145)
7/26,27,29	81.4 (213)	83.3 (7)	3.0% (15/500)
8/11	87.6 (152)	86.6 (74)	35.8% (179/500)
8/23,24,26	96.8 (114)	94.6 (131)	52.9% (487/920)
9/09	102.0 (9)	105.3 (15)	62.5% (15/24)
9/20,21,23	91.4 (32)	92.0 (85)	72.7% (85/117)

Table 6. Mean fork length (mm) and weight (g), with standard deviation, range, and sample numbers of coastal cutthroat trout and half-pounder steelhead trout seined in the Redwood Creek estuary, Humboldt County, California, during the summer and fall of 1993. Mouth denotes if Redwood Creek mouth was open to the ocean or closed.

Summer/Fall 1993 Redwood Creek Estuary Coastal Cutthroat Trout							
1993 DATE	MOUTH	Mean Fork Length (mm) (No. Sampled)	Std. Dev. (mm)	Range (mm)	Mean Weight (g) (No. Sampled)	Std. Dev. (g)	Range (g)
6/14	OPEN	(0)	--	--	(0)	--	--
6/28,29,7/1	OPEN	301.7 ^a (10) 193.3 ^b (21)	28.0 18.3	253 - 340 164 - 231	-- --	-- --	-- --
7/14	OPEN	236.3 (3)	10.3	225 - 245	--	--	--
7/26,27,29	OPEN	(0)	--	--	(0)	--	--
8/11	OPEN	215 (1)	-	215	120.0 (1)	--	120
8/23,24,26	OPEN	(0)	--	--	--	--	--
9/09	OPEN	226 (1)	--	226	107.9 (1)	--	107.9
9/20,21,23	OPEN	279.5 (4)	44.3	222 - 320	130.0 (1)	--	113.0
Redwood Creek Estuary Half-Pounder Steelhead							
9/20, 21,23	OPEN	337 (1)	--	--	--	--	--

^a Adipose clipped coastal cutthroat trout originating from Stone Lagoon

^b Wild coastal cutthroat trout

Table 7. Sampling dates, trap hours, combined numbers from both fyke nets, and percentages of fish trapped in the south slough, Redwood Creek estuary, Humboldt County, California, during the summer and fall of 1993.

Date	7/12-13/93		8/30-31/93		9/28-29/93	
Trapping Time (hours)	23.25 ^a 24.50 ^b		24.0 ^a 24.0 ^b		24.0 ^a 24.0 ^b	
SPECIES	Number	%	Number	%	Number	%
Three spined stickleback	2,785	93.6	138	95.8	270	93.4
Shiner Surfperch (Adults)	57	1.9	4	2.8	2	0.7
(Juveniles)	(56) (1)	(1.9) (<0.1)	(0) (4)	(0) (2.8)		
Staghorn Sculpin	1	<0.1	1	0.7	2	0.7
Prickly Sculpin	93	3.1	-	-	13	4.5
Sucker	-	-	1	0.7	-	-
Chinook Salmon	14	0.5	-	-	-	-
Steelhead Trout	16	0.5	-	-	1	0.3
Cutthroat Trout	11	0.4	-	-	1	0.3
Total Number	2,977		144		289	

^a Upstream facing fyke net

^b Downstream facing fyke net

Table 8. Minimum and maximum water quality parameters; temperature (°C), salinity (o/oo), specific conductivity at 25°C (μmhos), dissolved oxygen (ppm) and pH, measured at one-foot intervals, and depths (ft), in the Redwood Creek estuary, Humboldt County, California, for 4 months during the summer and fall of 1993. Sampling dates were 6/22, 7/22, 8/30, and 9/28/93.

Station	TEMPERATURE (°C)		SALINITY (o/oo)		SPECIFIC CONDUCTIVITY (@25°C μmhos)		DISSOLVED OXYGEN (ppm)		pH		DEPTH (ft)	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
NORTH SLOUGH												
NS1	13.0	20.5	0	0	147	385	0.1	5.6	5.3	6.2	13	14
NS2	13.0	20.5	0	4.5	89	8333	0.1	5.6	5.9	6.4	11	14
NS3	14.0	20.0	0	0	79	432	0.1	11.1	6.0	6.4	7	9.5
EMBAYMENT												
EMB4	13.5	19.0	0	30.0	47	44870	9.0	15.0	6.3	7.3	2	7
EMB5	12.0	18.5	0	32.0	87	47880	9.7	14.7	6.0	7.7	3	7.5
EMB6	12.0	18.5	0	32.0	75	47880	8.5	14.8	6.1	7.8	4	6.5
SOUTH SLOUGH NECK												
SS7	15.0	24.0	0	32.0	209	41475	0.6	20.0	6.2	8.0	1	5
SS8	17.5	18.0	0	0	260	265	14.4	14.5	6.7	6.7	DRY	3
SS9	18.0	22.0	0	9.0	22	21926	9.8	14.6	5.8	7.5	DRY	5
SOUTH SLOUGH												
SS10	15.0	23.5	0	28.0	114	43134	5.0	20.0	6.5	9.4	1.5	6.5
SS11	15.0	23.5	0	31.5	115	47964	1.0	20.0	6.2	8.7	5	7
SS12	15.0	22.0	0	31.0	143	47314	1.0	20.0	6.2	9.0	2.5	7

Because the mouth remained open for most of the summer, water volume was less than if the mouth had remained closed. The measured high and low water depths at each station (to the nearest 0.5 ft) are presented in Table 8. The north slough depths did not vary much because of the controlling elevation of the slough outlet channel. Because the mouth of Redwood Creek was open, the depths in the embayment varied with the tide. The south slough neck (stations SS8 and SS9) was exposed and dry at some low tides.

Activities Conducted to Meet Long-Term Management Goals.

No formal meetings were held with adjacent landowners, other agencies, and interested parties in 1993. It appears that two of the three landowners are not amenable to selling their land; one of which definitely does not want to lose the use of any property to restoration activities. The Park has been revising and updating the Management Alternatives for the Redwood Creek Estuary (Hofstra 1983). A draft of the alternative solutions and proposed management strategy with long-term alternatives for restoring Redwood Creek estuary to a fully functioning ecosystem is enclosed (Appendix B).

The tidal gates that were to be installed in 1993 on the south slough culvert gates were not fabricated. The project is on hold, and their feasibility is being evaluated. The tidal gates were intended to increase one-way circulation through the south slough and facilitate more flushing of water volume.

Water Level Management

The water level in the estuary was monitored by a recording gage in the south slough. It ran from January 1, 1993 and continued to December 31, 1993. The recorder was not in operation between May 4 and May 11, and May 24 to June 7, 1993. The south slough water level and calculated Pacific Ocean tides at the mouth of Redwood Creek are presented in Figure 2. The tides are corrected for the coastal locality of Redwood Creek and adjusted to Mean Sea Level (MSL). Since the level of the south slough is controlled by the height of the sill at the mouth of the south slough channel, the water level in the main embayment was lower, < 2 ft. MSL, at lower tidal fluctuations when the mouth of Redwood Creek was open. However, when open, estuary water level will vary from the tides depending on the height of the sand sill at the open mouth, the discharge capacity of the mouth, river flow, and the size of the tidal prism.

Controlled Breaching

The water level exceeded 6.00 ft MSL on 19 separate incidents during the period of record (Table 9). Of those 19 incidents, 15 were for a duration of less than 5 hours. They were the result of high winter and spring stream flows coinciding with high tides when the mouth was open. Three incidents were for between 2 and 3 days, and the longest period was for 26 days, during which the controlled breach occurred.

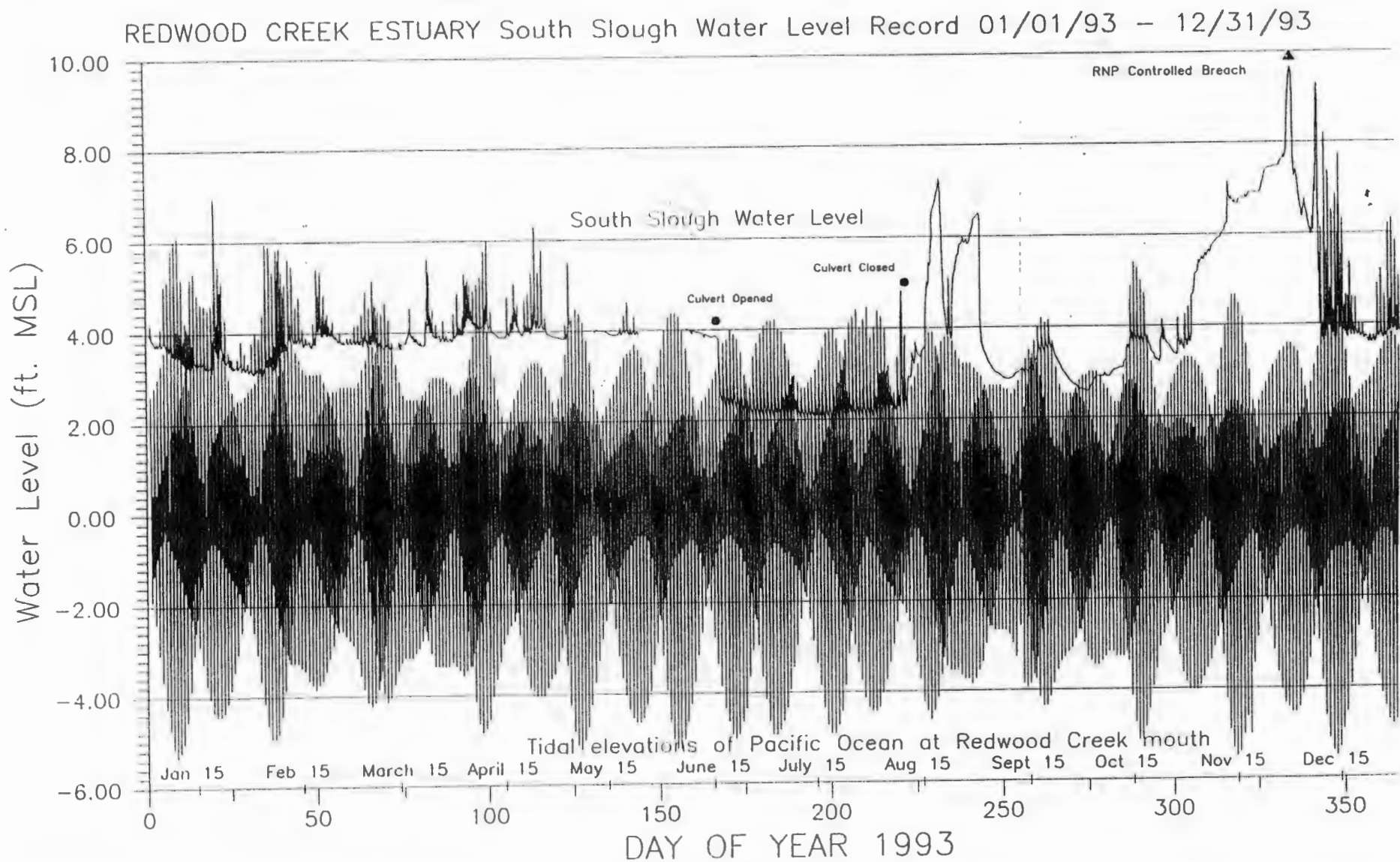


Figure 2. South slough water elevations (ft. Mean Sea Level [MSL]) and calculated tidal elevations of the Pacific Ocean at Redwood Creek for the period of January 1 to December 31, 1993, excluding May 4 to 11 and May 24 to June 7. Tidal elevations are corrected for the coastal locality of Redwood Creek and adjusted to MSL.

Table 9. Dates in 1993 where the water level of the Redwood Creek estuary exceeded 6.00 ft MSL. Record is for the periods from January 1 to May 4 (1.01 - 124.37), May 11 to May 24 (131.40 - 144.20), and June 7 to December 31, 1993 (158.35 - 365.91). Record is unavailable for other periods due to power failures of the recording equipment. Record based on equipment located in the South Slough adjacent to the end of the Redwood Information Center boardwalk.

Date	Julian Date		Maximum Elevation (ft MSL)
	From	To	
01/08/93	8.46	8.46	6.02
01/09/93	9.47	9.49	6.10
01/20/93	20.35	20.47	6.95
04/23-24/93	113.98	114.04	6.29
08/17-20/93	229.91	232.79	7.27
08/28-31/93	240.91	243.78	6.53
11/13 - 12/06/93 ^a	314.40	340.37	9.72
12/06-08/93	340.69	342.59	9.29
12/09/93	343.30	343.30	6.14
12/10/93	344.28	344.44	8.20
12/11/93	345.30	345.49	7.38
12/12/93	346.39	346.46	6.53
12/13/93	347.39	347.50	6.88
12/13/93	347.52	347.52	6.21
12/14/93	348.39	348.59	7.73
12/15/93	349.48	349.52	6.33
12/15/93	349.55	349.55	6.14
12/28/93	362.42	362.46	6.21
12/29/93	363.43	363.52	6.33

^a Estuary was artificially breached on 11/30/93 (Julian date 334).

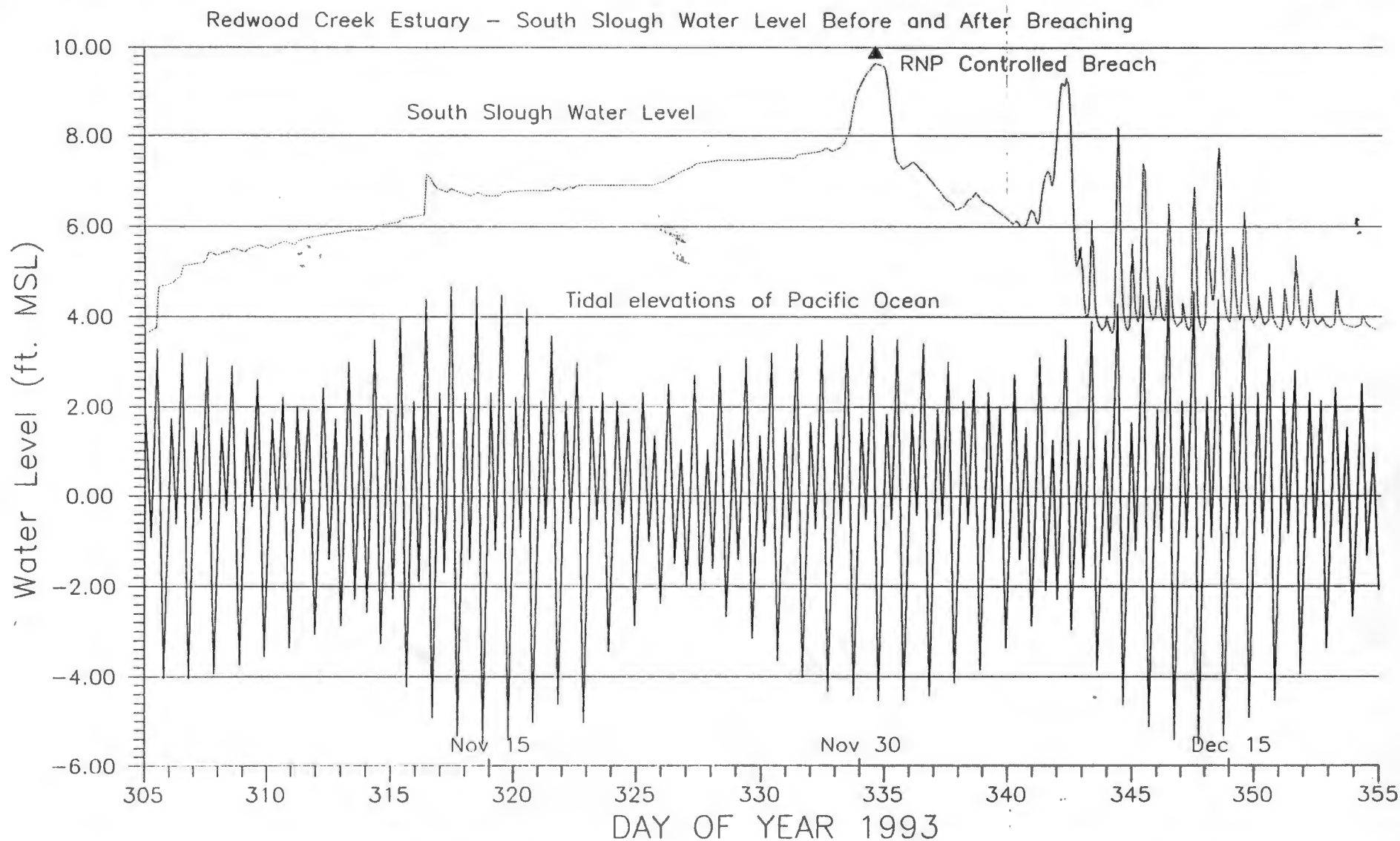


Figure 3. South slough water elevation (ft. MSL) and calculated tidal elevations, prior to, during, and after the National Park Service artificial controlled breach at the mouth of Redwood Creek on November 30, 1993.

The National Park Service artificially breached the sand berm on November 30, 1993 when the water level reached 9.72 ft. MSL, after the water elevation had exceeded 6.0 ft. MSL for 20 days. The mouth closed on November 1 and the water elevation increased, exceeding 6.0 ft MSL on November 13 (Figure 3). The sand berm was breached on Tuesday, November 30 with the Park D-4 dozer, following a storm that significantly increased the water elevation by approximately two feet. At the time of the breach, private land adjacent to the north and south sloughs and Hufford Road, a county road were underwater. From visual observations, it appeared the water elevation would have had to increase several more feet before cresting the top of the sand berm. A channel was excavated to the south, and the water level gradually declined to 6 ft. MSL over the course of 7 days. The mouth appeared to close again for a short time before opening again naturally. A fish population estimate was not done because it was assumed, from the last population estimate, most if not all juvenile salmonids had emigrated to the ocean in late September.

No evidence of any unauthorized breaching was observed, however if it did occur, the evidence (e.g., mounds of sand, tire tracks) is usually washed away when the channel widens and deepens.

South Slough Culvert Gates

The three gates of the south slough culvert were slightly opened on May 27, 1993 to allow for the gradual release of water from the south slough. The water was black in color and smelled of hydrogen sulfide. Due to a late storm, they closed five days later on June 1st to prevent sediment from entering the slough. On June 16, the gates were opened again, and remained open till they were closed on August 10, 1993 to ameliorate the adjacent landowner's concerns.

North Slough Channel

The north slough channel breached in late December, 1992 and the water level declined in the north slough. The National Park Service further modified the channel with a backhoe by deepening the area of the existing inlet on February 23, 1993. The water level declined from 7.25 ft MSL on February 22, 1993 to 6.33 ft MSL on February 25. The channel remained open all year long. During the November closure of the Redwood Creek mouth, water flowed from the embayment into the north slough and out onto the fields and adjacent county road.

References

- Farro, M. 1993. Prairie Creek Restoration: 1992-93 Season. Pacific Coast Fish, Wildlife and Wetlands Restoration Association, Arcata, California. CalTrans contract #01E026.
- Hofstra, T.D. 1983. Management Alternatives for the Redwood Creek Estuary. Redwood National Park, Arcata, California.

Youngs, W.D., and D.S. Robson. 1978. Estimation of Population Number and Mortality Rates. pp. 137 - 164. In: Methods of Assessment of Fish Production in Fresh Waters. Third Edition. T. Bagenal (ed.) Blackwell Scientific Publications, London. pp. 365.

APPENDIX A

U.S. Army Corps of Engineers Permit No. 18974N36 to Department of the Interior (Redwood National Park). Purpose: Breaching of the north and south sloughs and mouth of Redwood Creek: Flood control and habitat enhancement, In: Redwood Creek Estuary, At: Orick, County of: Humboldt County, State: California.

DEPARTMENT OF THE ARMY PERMIT

Permittee United States Department of Interior (Redwood National Park)

Permit No. 18974N36

Issuing Office San Francisco District

NOTE: The term "you" and its derivatives, as used in this permit, means the permittee or any future transferee. The term "this office" refers to the appropriate district or division office of the Corps of Engineers having jurisdiction over the permitted activity or the appropriate official of that office acting under the authority of the commanding officer.

You are authorized to perform work in accordance with the terms and conditions specified below.

Project Description: You are hereby authorized to perform water level management in the Redwood Creek Estuary including: (1) open and close the sandbar at the mouth of Redwood Creek; (2) excavate 23,000 cubic yards of sand and sediment from the south slough channel of Redwood Creek; (3) excavate 45,000 cubic yards of sand and sediment from the north slough channel of Redwood Creek; and (4) dispose of all excavated material on beach/dune areas adjacent to the excavated areas to allow removal by natural tidal currents; near the Town of Orick in Humboldt County, California, in accordance with the attached drawings:
"PURPOSE: BREACHING OF NORTH AND SOUTH SLOUGHS AND MOUTH OF REDWOOD CREEK: FLOOD CONTROL & HABITAT ENHANCEMENT, IN: REDWOOD CREEK ESTUARY, AT: ORICK, COUNTY OF: HUMBOLDT, STATE: CA, APPLICATION BY: U.S. DEPT. OF INTERIOR, REDWOOD NATIONAL PARK," in two sheets dated 31 May 1988.

Project Location: Redwood Creek Estuary, Orick, Humboldt County

Permit Conditions:

General Conditions:

1. The time limit for completing the work authorized ends on January 1, 1994. If you find that you need more time to complete the authorized activity, submit your request for a time extension to this office for consideration at least one month before the above date is reached.
2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.
3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal and state coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

4. If you sell the property associated with this permit, you must obtain the signature of the new owner in the space provided and forward a copy of the permit to this office to validate the transfer of this authorization.

5. If a conditioned water quality certification has been issued for your project, you must comply with the conditions specified in the certification as special conditions to this permit. For your convenience, a copy of the certification is attached if it contains such conditions.

6. You must allow representatives from this office to inspect the authorized activity at any time deemed necessary to ensure that it is being or has been accomplished in accordance with the terms and conditions of your permit.

Special Conditions: See attached sheet 2A for Special Conditions for Permit #18974N36

Further Information:

1. Congressional Authorities: You have been authorized to undertake the activity described above pursuant to:

(X) Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403).

(X) Section 404 of the Clean Water Act (33 U.S.C. 1344).

() Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 (33 U.S.C. 1413).

2. Limits of this authorization.

a. This permit does not obviate the need to obtain other Federal, state, or local authorizations required by law.

b. This permit does not grant any property rights or exclusive privileges.

c. This permit does not authorize any injury to the property or rights of others.

d. This permit does not authorize interference with any existing or proposed Federal project.

3. Limits of Federal Liability. In issuing this permit, the Federal Government does not assume any liability for the following:

a. Damages to the permitted project or uses thereof as a result of other permitted or unpermitted activities or from natural causes.

b. Damages to the permitted project or uses thereof as a result of current or future activities undertaken by or on behalf of the United States in the public interest.

c. Damages to persons, property, or to other permitted or unpermitted activities or structures caused by the activity authorized by this permit.

d. Design or construction deficiencies associated with the permitted work.

SPECIAL CONDITIONS FOR PERMIT NO. 18974N36

1. Authorization is given for controlled breaching at the mouth of Redwood Creek, and for dredging the mouths of the north and south sloughs, for a period not to exceed two years.
2. Within that two-year period, a long-term solution to water level management shall be established. This solution shall not include breaching the bar, but may include the set-back of levees, conservation easements, raising the county road above flood elevation or out-right land purchase.
3. Material excavated from the creek mouth and/or dredged from the slough mouths shall be disposed of on the adjacent beach/dune areas (as shown on Sheet 2 of 2 attached to the permit) where it would eventually be transported by tidal action back to the Pacific Ocean.
4. A maximum water surface elevation of no less than + 6.0 feet Mean Sea Level (MSL) shall be established. The controlled breaching proposed may not occur before that level is reached.
5. Construction of a summer diversion dam intended to divert additional water into the upstream entrance of the south slough is not authorized.
6. The National Park Service shall regularly monitor water levels and depths in the estuary and document all instances of both controlled and natural breaching, as well as any observations of unauthorized breaching. Aerial photographs showing initial and final water levels in the estuary following each event shall be taken. Fish usage of the estuary before, during and after controlled breaching events shall also be documented. This information, including a discussion of steps taken to resolve land-use conflicts and meet long-term management goals, shall be provided in an annual monitoring report distributed to the Corps, EPA, NMFS, CA Dept. of Fish and Game by December 31st.

- e. Damage claims associated with any future modification, suspension, or revocation of this permit.
4. Reliance on Applicant's Data: The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.
5. Reevaluation of Permit Decision. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:
- a. You fail to comply with the terms and conditions of this permit.
 - b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (See 4 above).
 - c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5. The referenced enforcement procedures provide for the issuance of an administrative order requiring you to comply with the terms and conditions of your permit and for the initiation of legal action where appropriate. You will be required to pay for any corrective measures ordered by this office, and if you fail to comply with such directive, this office may in certain situations (such as those specified in 33 CFR 209.170) accomplish the corrective measures by contract or otherwise and bill you for the cost.

6. Extensions. General condition 1 establishes a time limit for the completion of the activity authorized by this permit. Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give favorable consideration to a request for an extension of this time limit.

Your signature below, as permittee, indicates that you accept and agree to comply with the terms and conditions of this permit.

William H. Egan
(PERMITTEE)

12-9-91
(DATE)

This permit becomes effective when the Federal official, designated to act for the Secretary of the Army, has signed below.

Stanley G. Phernambucq
(DISTRICT ENGINEER)
STANLEY G. PHERNAMBUCQ
LTC(P) EN

1-3-92
(DATE)

When the structures or work authorized by this permit are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

(TRANSFEREE)

(DATE)

APPENDIX B

Draft of alternative solutions and proposed management strategy sections from the revised and updated report, Management Alternatives for the Redwood Creek Estuary.....

MANAGEMENT ALTERNATIVES FOR THE REDWOOD CREEK ESTUARY

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VI. ALTERNATIVE SOLUTIONS

A. Consistency with Legislation, Policies, and Park Plans

Redwood National Park's enabling legislation (P.L. 90-545) states the Park's mission is "to preserve significant examples of primeval coastal redwood forests and the streams and seashores with which they are associated for the purpose of public inspiration, enjoyment, and scientific study..." National Park Service Management Policies (USDI, NPS, 1988) state, "The National Park Service will manage the natural resources of the National Park System to maintain and perpetuate their inherent integrity."

The RNP General Management Plan (GMP)(USDI, NPS, DSC, 1980) identifies the lower portion of Redwood Creek as a natural zone. In natural zones, "shoreline processes...erosion, deposition, dune formation, etc....will be allowed to take place naturally, except where control measures, required by law or Service commitments, are necessary to protect life and property in neighboring areas." NPS Management Policies also state "fisheries management shall be specifically aimed towards preservation or restoration of the full spectrum of native species" (USDI, NPS, 1988).

Recent park planning documents have outlined considerations for management at the mouth of Redwood Creek. The ultimate goal identified in the Watershed Rehabilitation Plan (1981) is "the restoration of natural ecosystems to a condition similar to what would have existed without disturbance by man." Furthermore, it was emphasized that the estuary required research to "identify existing estuarine productivity and to propose restoration activities."

Two management objectives presented in the Resources Management Plan (USDI 1994) are to "restore and maintain the natural ecosystems of the park as they would have evolved without disturbance by human technology" and "minimize the impacts of park resources resulting from current human activity outside the park." More specifically, flooding associated with embayment formation, and the levee configuration were identified as problems and the development and implementation of alternatives to solve these problems was recommended (REDW-N-257.000).

The alternatives presented are consistent with these pieces of legislation, regulations, existing federal management policies, and Park planning documents.

B. Goals

The goal of rehabilitation and management actions in the Redwood Creek estuary is to restore natural processes and the quality of aquatic habitat. Political and legal concerns, and lack of funding complicate many of the alternatives that lead to restoration. There are both long-term major rehabilitation as well as temporary interim management alternatives. Long-term alternatives would require restructuring the lower portion of the flood control project for reestablishing slough circulation, improving water quality, and providing a means for removing

sediment that settles in the necks of the sloughs. Such measures would increase fish habitat and ensure connection between the sloughs and mainstem to improve fish accessibility to the sloughs at low water levels in the embayment. Major levee restructuring would require careful design, additional biological and engineering research, and a substantial commitment of funds. Planning and funding for such an effort may take several years to complete. Meanwhile, additional impacts to the fishery resources may be expected if active management is not undertaken.

The last Corps permit for estuary water level manipulation granted Redwood National Park, no. 18974N36, was for a period of two years (Jan 1992 to Jan 1994). Special conditions were attached after Corps consultation with other reviewing agencies (Environmental Protection Agency, National Marine Fisheries Service, U.S. Fish and Wildlife Service, California Department of Fish and Game, and California Regional Water Quality Control Board) and negotiations with the Park.

Item 2 of the special conditions read:

Within that two-year period, a long-term solution to water level management shall be established. This solution shall not include breaching the bar, but may include the set-back of levees, conservation easements, raising the county road above flood elevation or out-right land purchase.

The Park was told by the Corps that 1992 and 1993 were the last years in which breaching the berm as a manipulative measure in managing water levels in the estuary would be allowed. The Corps stated that thirteen years of water level manipulation was not a short-term interim solution, and a longer-term alternative should be actively pursued.

The following alternatives were formulated to address the two major problems, summer/fall and winter flooding of adjacent private land; and the loss of estuarine habitat from the flood control levees and agricultural practices.

C. No Action

Under this alternative, the Park would not undertake any short term estuary management actions. The permit granted by the Corps to the Park for estuary water level management expired on January 1, 1994. When this permit was granted, the understanding was that it would not be renewed by the Corps. Without the authority of a permit, the Park would not perform controlled breaching. Breaching of the berm by other parties could only occur with an approved permit (Section 404 of the Clean Water Act) from the Corps. The Corps has indicated that approval of permit applications would be denied to protect fishery resources; however it is highly probable that illegal uncontrolled breaching of the berm by other parties would occur. This no action alternative would likely result in continuing impacts and depressed fish runs. It would not achieve total protection of pasture land from flooding, and only if the existing regulatory process is adhered to would there be any protection of fishery resources.

This alternative would also result in no action to restore natural estuarine processes and the quality of aquatic habitat in the long term. The present status of fish runs, especially chinook salmon and steelhead, would likely stay at their present, depressed levels. The adult chinook salmon population could fall to a level that would no longer support a viable self-sustaining run of fish. Because of its importance to all species of anadromous fish, a compromising situation at the estuary would decrease the overall effectiveness of other fisheries and erosion-control watershed restoration efforts occurring further upstream in the Park. Restoration of the fishery resources of Redwood Creek and its tributaries, an ultimate objective of the Watershed Rehabilitation Program and a desired outcome of the combined efforts of each specific restoration project, could probably never be fully achieved. The no-action alternative would be inconsistent with the long-term goals of the Park's Watershed Rehabilitation Plan and proposed management addressed in the Resources Management Plan.

D. Interim Alternatives

1. Strict Enforcement of Park Service Management Policies

This alternative would preclude manipulation at the mouth of Redwood Creek and follow National Park Service Management Policies (USDI 1988) which indicate that natural shoreline processes will continue unimpeded unless required by law or legislation.

The embayment water level would rise unimpeded resulting in flooded pastures, and occasionally inundation of Hufford Road adjacent to the estuary. This alternative would achieve some protection of fishery resources by allowing natural processes (albeit in a modified system) to determine water levels but would also result in alienation and economic loss to landowners. Illegal attempts to open the estuary would likely increase, leading to confrontations between enforcement personnel and landowners. This alternative is an interim measure because the natural configuration of the estuary would not be restored.

2. Continued Controlled Breaching

The goal of a controlled breach is to release water at a rate that results in the maintenance of embayment integrity and a minimum number of fish being entrained in the discharge. Controlled breaching may be necessary for most of the year. In the past, controlled breaching took place only in the summer and early fall, and was only recently extended to winter. The period this manipulation remains effective depends on flow within Redwood Creek, ocean conditions, and berm formation, as the embayment can quickly rise to a level that will again require manipulation.

Manipulation involves the use of heavy equipment. When overwash of the berm deposits sand in the outflow channel, it will eventually fill in and the mouth of the creek will close. A southward migrating channel is no longer available through which a controlled breach can be accomplished. Excavation of a new channel to the south through which water can be released is necessary and requires the use of the Park bulldozer. A high water level requires a longer

channel so the gradient is not too steep and water is not released too rapidly. The notion that the discharge channel can be regulated to let out an exact amount of water is false. Once the channel is opened, it remains open until the opposing ocean conditions close it off. The method is not an exact science and rapid declines in water elevation or levels lower than intended may result. The estuary is managed for a water elevation ceiling level of no greater than 6.0 ft msl.

Authorized controlled breaching is allowable only by permits from the Corps (Section 404 of the Clean Waters Act). Additional permits, in addition to the Corps permit which allows breaching, are required from the Department of Fish and Game and the Regional Water Quality Control Board. But as previously mentioned, based on the past position of the Corps and other reviewing federal agencies, the prospects of getting another permit is doubtful.

3. Dredging

This alternative would involve dredging the embayment and necks of the north and south sloughs to historical depths. Dredging would increase the amount of available habitat for juvenile and adult salmonids and improve the water circulation between the embayment and the sloughs. For example, if the neck of the south slough were dredged, in late summer when seepage and evaporation can reduce embayment levels the slough would be connected to the mainstem. Sand deposits would no longer displace as much of the estuary volume, and summertime flooding would not be as severe.

Dredging alone would only temporarily improve conditions, as overwash and aggradation would continue. A single severe winter storm could quickly fill this area again, and dredging would have to be repeated. When an embayment is not forming, lower slough water levels could result. If the elevation of the channel within the levees is below that adjacent to it in the north or south slough, water would drain from the sloughs to the lower main channel. The slough channels would need to be dredged periodically depending upon the number and nature of winter storms that transport sand into the channels.

This interim measure would not achieve the goal of estuary restoration. As an interim measure, it would temporarily improve fish habitat until it is possible to restore the estuary. Used in conjunction with long-term rehabilitation efforts designed to reestablish historic patterns of circulation, removing accumulated sand from the necks of the sloughs would be an important component of the process.

The channel excavation alternative would interfere with present beach access north of Redwood Creek mouth via the north levee and north side of the estuary. Sport and commercial fishermen use vehicles to access the beach to fish mainly for redbait perch, surf smelt (day and night fish), and obtain sand crabs for bait. The excavated north slough channel would be deep enough to preclude four wheel drive access that exists now over the sand. People that use this route would be forced to use the route on the wave slope of the beach that was traditionally used before the north slough channel aggraded in 1972. This route would be accessible only when the mouth is closed.

4. North Slough Culvert

This alternative would involve constructing culvert gates through the north levee, similar to the culvert on the south. It would increase water circulation with the north slough, but flows probably would not be sufficient to flush out sediment accumulations in the north slough channel. The Corps proposed this project using Section 1135 of the Water Resources Development Act of 1986. This is a cost sharing program with a \$2,000,000 cap, where 25% of the project is financed by a non-federal local sponsor. The funds are available to restore habitat degraded by Corps projects. After discussion with Corps staff in July of 1992, the decision was made to terminate the Section 1135 process for this alternative because of problems with acquiring land or easements on adjacent private property, lack of a non-federal local sponsor with funds, and potential conflicts with fulfilling the Park's goal of completely removing the lower levees. Removing the levees back to the first bend in the creek east of the estuary would entail removing the culvert gates, both the existing south and proposed north intake structures. Breaching the north levee, but not building the intake structure is a variation on this interim alternative.

5. Public Education/Landowner Negotiations

Redwood National Park would provide to the visiting public information brochures on the historic and present uses and values of the Redwood Creek estuary, past and future management alternatives, and explain Park goals for preserving the estuary resources for future generations. The Park would continue to meet with adjacent landowners to negotiate an agreement for managing the embayment and to disseminate information. This alternative in conjunction with other alternatives, would facilitate the management and restoration of the Redwood Creek estuary.

E. Long-Term Alternatives

1. Flooding

a. Flood Easements

Under this alternative, the few landowners affected would receive compensation for the possibility of their property being flooded. Flooding, depending upon circumstances may or may not happen from year to year. Landowners could manage their property as they wish but would have to understand that their activities could be interrupted at any time due to flooding. It is this potential interruption of activities for which they would be compensated. Acquiring flood easements on private properties adjacent to the estuary would eliminate the need for water level manipulation by the Park and landowners. Flood easements could alleviate the problems associated with conflicting land uses without the additional expense and problems of land acquisition.

The costs of acquiring individual easements would vary with locale. Payment would be based on the acreage of land subject to flooding (approximately 54 acres), but probably would not exceed those costs associated with past controlled breaching and culvert installation. Loss of production from the potential flooded area would provide the basis for determining payments. Figure IV-18 shows the maximum potential flooded area requiring easements without elevating Hufford Road. During the public hearings in April of 1983 for the original estuary management plan (Hofstra 1983), landowners indicated flood easements as an alternative they would favor only to prevent land acquisition. Easements could decrease land value by limiting the range of uses that could realistically be conducted on such encumbered property. During the 1983 public hearings, it was stated that some land in production then was not in production 20-30 years before, as landowners did not utilize some land flooded during the summer when the mouth closed.

If the embayment is allowed to form naturally without concern for flooding (as would be expected with flood easements) it is probable that the number of fish utilizing the estuary would increase and the estuary would have greater economic and resource values. The economic benefits of preserving present fishery resources is more prudent than allowing their continued decline and eventual federal listing as additional expenditures would be incurred for restoration over and above those now required. The possibility of listing some species as threatened or endangered in the future would affect activities such as water level management in the estuary, which would create greater economic hardships for those involved. The tidewater goby which was found in the north slough in 1980 is federally listed as endangered (DOI 1994) and coho salmon is currently being considered as a threatened species. It is National Park Service policy to protect endangered, threatened, and sensitive species. Better protection could be provided to the fishery resources if water level manipulation would not be required.

b. Land Acquisition

This alternative involves placing in public ownership those private properties now affected by summer and winter flooding. By eliminating conflicting land uses, the major management consideration would be the fisheries resource. One exception would be the prevention of flooding Hufford Road, but if the road were elevated and the bridge replaced, greater fisheries protection would be achieved. In addition, substantial benefits to wildlife could occur by allowing the acquired properties to become naturally vegetated. Wetlands, marshes, and tidal flats would also be reestablished.

Acquiring land that might be affected by estuarine management would leave three landowners with a reduced land base. In two cases, the size of the remaining ranch might be insufficient to provide a major source of income to the landowner. Such effects must be carefully considered and, if necessary, the entire parcel might be purchased. The cost of land acquisition (approximately 110 acres) could be substantial, but the benefits to the natural resource over time would be equally substantial. A number of potential funding sources could be pursued if the

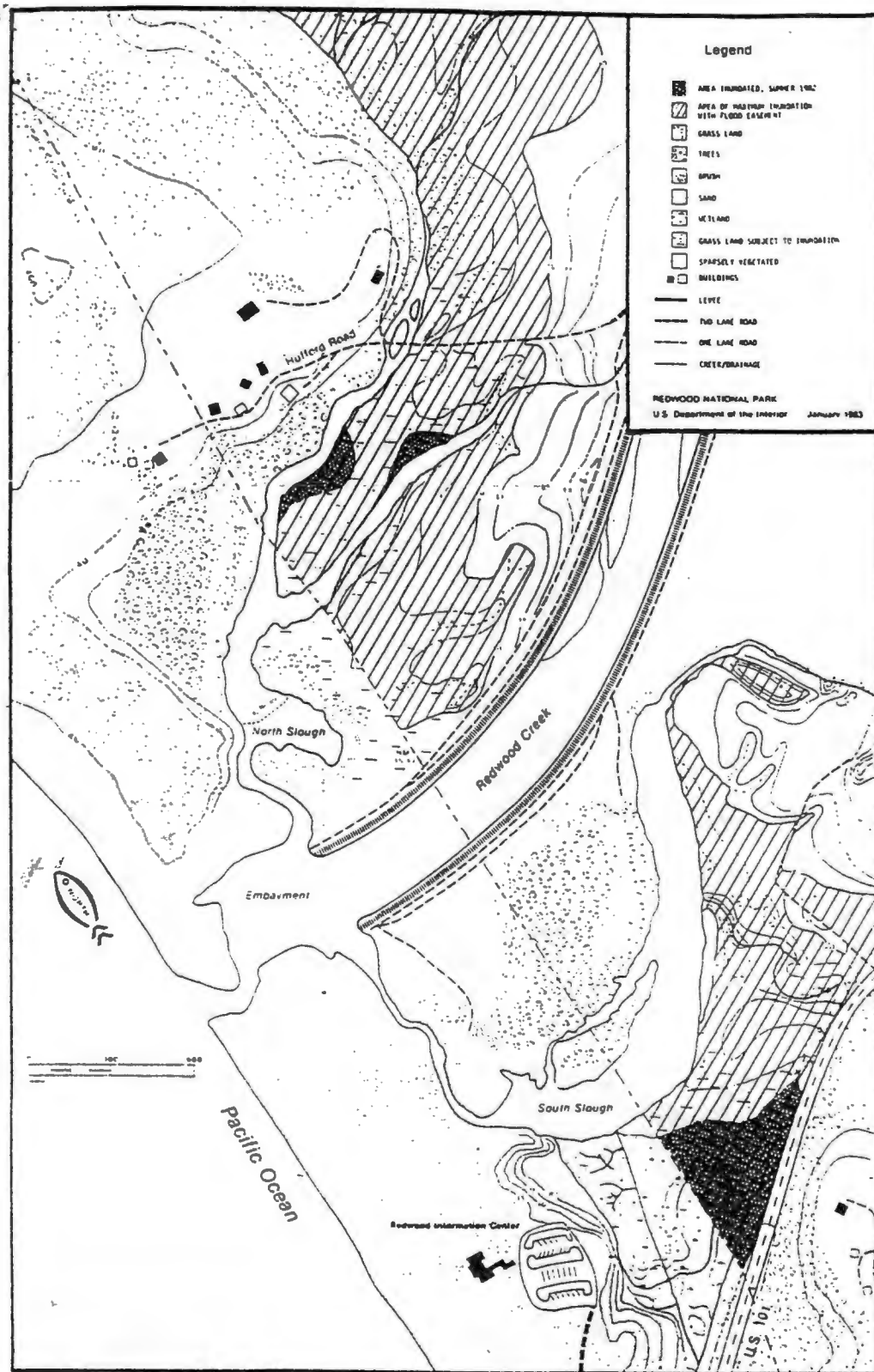


Figure VI-1. Lower Redwood Creek showing area flooded during Summer 1982 (approximately 4 acres) and maximum area potentially subject to inundation with a flood easement (approximately 54 acres). National Park lands not included in acreage estimates.

landowners were willing to sell their land or easements. During a March 1992 meeting between the three landowners and the Park, the landowners indicated they might be interested, given the right price.

c. Diking Pastures

This alternative involves diking pastures which are subject to summertime flooding. Water levels would be allowed to increase to the dike height and a larger volume of habitat could be achieved and maintained throughout the summer. This is especially important in late summer when significant evaporative losses begin to occur. Dikes would have to be well planned to ensure all points are blocked where water might enter adjacent fields. Consideration must also be given to field drainage problems as dikes would restrict drainage from the fields after rains. Tidal gates installed in the dikes would allow field drainage and prevent flooding. If properly constructed, dikes would last many years but would require regular inspection and maintenance. Benefits to the fishery would result due to a less restrictive water level regime. No estimates are available but expenses would likely be substantial due to hauling and grading.

Implementing this alternative would result in an area more artificially modified than at present. This hydrologic change would diminish existing wetlands and would likely require mitigation for those wetlands. It also may promote the conversion of any existing wetlands to uplands on private land.

d. Elevating Hufford Road

Hufford Road can be affected by winter and summer/fall flooding. Winter flooding occurs when the north slough channel is sedimented in and the water elevation of the north slough rises above the road. Summer/fall flooding occurs when closure of the mouth of Redwood Creek raises the water elevation of the north slough when the slough channel is open. The county road is used by residents to access five homes. Elevating the road and replacing the old bridge/culverts over the north fork of the north slough (Sand Cache Creek) would reduce the frequency of flooding, the need to breach the berm, and ensure the residents' safe access year round. Funding would have to be sought and permission obtained from the county for this option to occur.

2. Restoration of Historical Estuary Configuration

a. Levee Removal

If restoration of natural circulation in the estuary is a critical step toward achieving restoration goals then the first alternative to consider is removal of the levees. Levee removal back to the first bend in the creek east of the estuary, approximately 0.7 miles (1.2 km) would restore flows to the original last meander of the creek (south slough) and would allow for some additional circulation in the north slough during higher flows. Winter flows could again erode sand that had been deposited in the estuary over the summer and induce the reappearance of the deep hole adjacent to the rocks on the north side of the estuary. Initial dredging in the necks of the north

and south sloughs would also facilitate the return to historic depths in those areas. This increased depth would improve summertime water quality and increase habitat for fish even if the mouth remained open during the summer and no embayment formed. It would restore natural brackish water conditions in the sloughs, important habitat for the tidewater goby. Also, before the levees were built, the disturbance regime of floods produced an open riparian corridor. Restoring the disturbance regime by removal of the levees would restore a more natural vegetation community, rather than a climax community.

The stream presently carries an increased bedload as compared to historical characteristics. It is possible that aggradation could occur in the south slough area as winter flows recede, but a natural riffle/pool sequence would probably reestablish, and overall pool depth and volume is expected to increase in the estuary.

Increased flooding of pastures might also be expected during winter months as stormflows would no longer be confined between levees. Normally such flooding is beneficial to affected areas by depositing a layer of nutrient rich silt. However, crop and livestock losses could also occur as they might have in the past before the levees. The Corps is presently modeling areas that would be inundated under various flow regimes with the removal of the levees. These areas could be acquired or easements paid in conjunction with levee removal. Erosion of the south bank of the south slough, now lacking a riverine riparian zone because of agricultural practices, might be expected as the river naturally migrated. Bank erosion is a natural process and would not be a problem if the land is acquired. Rivers are dynamic and channels shift to account for changes in discharge and bedload. A reestablished riparian zone would afford some bank protection from erosion. This alternative would be most consistent with RNP's Watershed Rehabilitation Management Plan, which aims to restore systems to their natural configuration. The Corps estimated that costs would be \$2.9 million which exceeds the cap on Section 1135 funding. However, since the Corps were responsible for building this project, other Corps sources of funding could be sought, and from other entities. This alternative requires the willingness of the landowners to sell flood easements, or their land, or accept flooding of their land.

b. Partial Levee Removal

This would involve removing only the southern levee back to the first bend in the creek east of the estuary. The same positive effects might be expected in the south slough and embayment, but no benefits to the north slough from increased circulation would be realized. The same potential negative effects discussed under removal of both levees; flooding, erosion, and aggradation from increased bedload could occur.

c. Breaching the South Levee/Expansion of Middle Island

This alternative would remove the culvert in the south levee and adjacent portions of the levee. The mainstem channel of Redwood Creek downstream of this breach would be filled to a predetermined elevation with fill removed from the south levee to preclude all but large winter

flows. The fill would be contoured to extend the middle island to the north levee. The flow of the creek would be directed through the levee into the last meander of Redwood Creek year round, and at higher flows a portion would flow downstream between the levees. This would mimic the physical processes that existed before the construction of the levees when at high discharges, water flowed through the middle island channel. It would also solve the levee spoils disposal problem. This alternative would allow for increased circulation in the south slough without concern for erosion of the south slough southern streambank. Additional hydraulic modeling would be required for all versions of levee removal.

3. Restoration of the Estuarine Ecosystem

a. Revegetation

Before forests on lower Redwood Creek were cleared for pasture, sitka spruce (Picea sitchenses) dominated the overstory. Redwood (Sequoia sempervirens) and Douglas fir (Pseudotsuga menziesii) dominated in drier areas. This alternative would involve revegetating the lower floodplain adjacent to the estuary to mimic the historic vegetation that once existed. Native riparian habitat that was once present would be reestablished along the banks of the north and south sloughs. Also, the junked cars used for riprap on the south slough banks would be removed.

Restoration and reestablishment of native riparian habitat on the remaining lower channelized portion of Redwood Creek, the levees and areas adjacent to the levees would compliment estuary restoration downstream. Conversations with Humboldt County personnel have indicated that they would be amenable to some sort of biological enhancement plan concerning vegetation if the Park would be responsible for its maintenance and the Corps of Engineers agreed to the plan. The Corps is presently not receptive to any riparian vegetation growing between and on the levees because of consequences that could jeopardize the design capacity and structural integrity of the flood control project. The Corps also stated that once the riparian vegetation becomes established and reached maturity, public opposition would make vegetation removal difficult. However, a similar riparian vegetation project, where vegetation height and diameter is managed on the San Lorenzo River bisecting the city of Santa Cruz in northern California (Philip Williams and Associates, et. al.) has been successful.

b. Restoration of Strawberry and Sand Cache Creeks.

Restoring the two creeks that enter into the sloughs would complete estuary restoration. Nutrients from agricultural animal wastes flow into the creeks which feed directly into the estuary. Under this alternative, the creeks would be restored to include freshwater marshes as biological filters to reduce the deleterious input of nutrients that degrade water quality in the estuary. The analogous use of freshwater marshes to reduce nutrient input into bodies of water is currently used by the City of Arcata for tertiary treatment of their municipal sewage. Improved agricultural waste management at its source would reduce the amount of nutrients

entering the streams, sloughs, and estuary. Restoration of both streams would reestablish habitat for coastal cutthroat and steelhead trout, coho salmon, and wildlife.

c. Elimination of Wood Gathering

Driftwood provides nesting habitat for killdeer and other shorebirds, and perches for birds of prey. It is also an important habitat component for aquatic and terrestrial animals, shelter and substrate for plant growth, and historically was present in larger amounts. Driftwood plays an important part in erosion and deposition of beaches and dunes (Gonor, et. al 1988).

Presently wood gathering for personal use only, up to five cords, is allowed from the mouth of Redwood Creek north to Mussel Point. Unclear regulatory language, lack of and difficulty of enforcement, multiple land ownership, and violations of the regulations cause removal of large amounts of wood from the beaches surrounding the estuary. Large old growth logs, a resource that is lacking and is important to riverine and estuarine habitats, are routinely bucked up and split for firewood, rails, slabs, and commercial products. Driftwood accumulations are perceived by some to be a fire hazard as driftwood fires from abandoned campfires in the estuary have occurred in the past and have had to be suppressed. Wood collection is seen as a way to prevent these fires, but is contrary to the concept of natural resource protection. This alternative would eliminate wood collection along the Park estuary and beaches.

d. Beach Vehicle Access

Presently, off-road vehicles and all-terrain vehicles are allowed on the beach. The area designated for beach travel is below the mean high tide, on the waveslope of the beach. No vehicles are allowed on any vegetation. Access north of the Redwood Creek mouth is through the north side of the estuary, across the north slough channel.

In 1992, the route that presently exists on the north side of the estuary bisected an aggregation of pink sand verbena (*Abronia umbellata breviflora*). The pink sand verbena is defined as a candidate species for federal listing as a threatened species, but more information is needed (Federal status of species in 50 CFR Part 17, February 21, 1990 USFWS). It is listed as a rare and endangered plant in California and elsewhere by the California Native Plant Society (Smith and York 1988). The potential for its damage by off-road vehicles exists. The snowy plover, a shore bird that inhabits the north coast, is a federally listed endangered species (DOI 1993). First year snowy plover surveys of beaches in the Park show that were not found in the estuary area; which may be a result of vehicle and human traffic through its potential habitat. Estuary restoration and maintenance of native and rare vegetation is consistent with Park Service goals, whereas seasonal use by vehicles is of lower priority.

VII. Proposed Management Strategy

Three reoccurring problems need to be addressed for the Redwood Creek estuary to be restored to a naturally functioning ecosystem with natural processes benefitting fish, wildlife, and visitors; (1), the effects of flood control for adjacent land that occurs with embayment formation during summer and fall, and winter storms; (2), the effects of the Corps flood control levee configuration which has degraded estuarine habitat; and (3), the effects of adjacent land uses on creeks, water quality, wetlands, and vegetation. The interim alternatives discussed in the previous section (VI.D.) address the symptoms but do not solve the conditions causing the problems nor do they alleviate the continuing negative impacts and degradation on the fish runs and other aquatic and wildlife resources. Continued use of only these alternatives would not resolve the issues, but may eventually cost more time and money than a long-term permanent solution.

In retrospect, the long-term alternatives are initially expensive and politically sensitive, but would provide the estuary restoration needed to reestablish a more natural estuarine ecosystem. Resolution would include a combination of long term alternatives and the initial use of dredging.

The following sections outline a restoration scenario that would help to restore the Redwood Creek estuary.

A. Flooding

Land acquisition (VI.E.1.b.) would provide the greatest benefit over the long-term period in allowing embayment formation to occur unhindered by any concern for flooding of private land and allowing the greatest amount of fish habitat and stability. This alternative would also restore riparian vegetation and historical wetlands. However, landowners would need to be willing sellers. Redwood National Park would seek funds for land acquisition, resource management, and protection of the new park resources if other agencies and private landowners agreed to this option.

Flood easements (VI.E.1.a.) would be a less preferable alternative over land acquisition, but one that may be more agreeable to affected landowners. This alternative would not completely allow restoration of riparian vegetation or wetlands, and would be dependent upon cooperation of the landowner. This alternative would be pursued if land acquisition is not possible.

The Park would seek funding to elevate Hufford Road and the bridge over Sand Cache Creek (VI.E.1.d.). This alternative would further preclude the need to breach the berm to lower the water level of the estuary embayment. If the Corps awards an emergency permit when the road is flooded, artificial breaching of the mouth may still occur, but much less frequently, because the berm would most likely breach naturally when the water level reached the top of the berm, an elevation that would generally be below the level of the elevated county road. The Park would seek funding to remove the levees as discussed in alternative VI.E.2.a. This would allow

scouring of the north slough outlet, thereby alleviating winter flooding caused by aggradation of the north slough channel.

B. Restoration of Historical Estuary Configuration

Both lower levees (VI.E.2.a.) would be removed so their influence on the estuary is lessened and historical circulation patterns are restored (i.e. restoration of flows into the original last meander of the creek, the south slough). This alternative is the most complete and natural of the levee modification options. Land would be acquired, negating the need to protect adjacent land from winter or summer flooding. The slough necks would no longer aggrade over long periods of time, as the return of the historical circulation patterns would seasonally scour the channels and prevent backwater areas where marine sediments are currently deposited. Additional water circulation in the sloughs would improve water quality above its present conditions. The Park would initially dredge (VI.D.3.) the necks of the north and south sloughs to accelerate the return of historic depths and circulation patterns.

C. Restoration of Estuarine Ecosystem

Alternatives that would complete the restoration of the estuary ecosystem are:

1. Revegetation

The Park would revegetate (VI.E.3.a.) riparian zones along the banks of the sloughs and areas of lower Redwood Creek, and the lower floodplain pastures to reestablish spruce forests that once existed. This alternative could be accomplished if land acquisition occurred. Restoration and reestablishment of native riparian habitat on the remaining lower channelized portion of Redwood Creek, in the channel, on the levees, and areas adjacent to the levees would compliment downstream estuary restoration efforts. Beach vehicle access (VI.E.3.d.) would be restricted to improve revegetation efforts, and wood gathering would be eliminated (VI.E.3.c.). Driftwood would stabilize the dunes and vegetation, and provide habitat diversity for both aquatic and terrestrial species.

2. Stream and Wetland Restoration

The Park and other interested parties would restore Strawberry and Sand Cache Creeks (VI.E.3.b.) and establish freshwater marshes. This could reduce potential nutrient introduction from agricultural animal wastes into the estuary. Non-natural riprap (rock, rusted car bodies, and wood deflection structures) presently in the south slough would be removed. The Park would restore former wetlands and reestablish the historic slough channels in the lower floodplain and tidal flats that were filled in by levee construction materials and agricultural practices. Redwood National Park would continue to provide information to the visiting public of the Redwood Creek estuary (VI.D.5.). Together all these management actions would restore the biological functions and dynamics of the estuary.