# Technical Appendices

# Watsonville Sloughs Watershed

## Resource Conservation & Enhancement Plan

*prepared for*

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**Technical Appendix A: Hydrology and Water Quality**

Swanson Hydrology & Geomorphology of Santa Cruz prepared the hydrology and water quality sections presented below.

The degradation of wetland habitats in the Watsonville Slough system can be largely attributed to land development and ongoing uses in urban, agricultural, industrial and rural residential areas. Improving the drainage infrastructure that serves all of the land uses in the watershed will facilitate enhancement of the natural waterways within the Watsonville Sloughs System by diversifying aquatic habitat and improving circulation. The present drainage system was developed in a piecemeal fashion during the reclamation era that occurred between the 1850s and 1940s. Since the 1940s there has been an increase in urban land development that has increased stormwater runoff contributions to the drainage system downstream. The current drainage system requires a high level of maintenance to function as designed and since the early 1980s maintenance has been dramatically reduced, hampered by funding resources and regulatory controls. Many of the sloughs are in areas of natural or expected sediment deposition due to hydraulic structures (dams, levees, roads, culverts and bridges) and the lack of channel dredging in the current system has become detrimental to the agricultural uses and has had significant economic impact.

The following section is an assessment of the present hydrology and drainage system in the Watsonville Sloughs Watershed. The assessment resulted from data collection and analysis geared toward understanding the unique hydrology of each Slough and its attributes that are problematic to aquatic and wetland habitats and water quality. A key outcome of this assessment was to identify potential opportunities to improve drainage, water quality and habitat.

## A.1 Drainage and Waterway System

The purpose of drainage mapping was to acquire an understanding of the hydrologic function of individual sloughs as it relates to wetland quality, water quality and circulation and drainage. The investigation was conducted between January and June of 2001 and consisted of three

main components:

1. An assessment of individual subwatershed area land use cover and hydrologic characteristics;
2. Descriptions of individual stream channel reaches by channel type, hydrology, stability and vegetation cover; and
3. Documentation of hydraulic control structures (bridges, culverts, fill, etc), and their influence on water circulation, flooding and drainage.

### *A.1.1 Methods*

The Watsonville Sloughs Watershed was divided into morphologically similar subwatershed units determined by topography, channel morphology, land use coverage, and watershed position. USGS topographic maps, and aerial photography were used in conjunction with field visits to determine drainage area boundaries. Channel morphology characteristics for each reach were documented by estimates of average channel depth, average channel width, average reach length, riparian vegetation, and degree of circulation. The Santa Cruz County assessors parcel GIS database and aerial photographs were used to determine land use coverage. The information was compiled into maps and tables for presentation.

The network of waterways in the Watsonville Slough Watershed was divided into reaches of similar geomorphic, hydrologic, and vegetation conditions. Geomorphic similarity of each reach was determined by channel width and depth, flood plain characteristics, entrenchment, gradient and channel pattern. For each reach, these features were measured in the field at locations representative of the average dimensions. Hydrologic conditions were evaluated by stream type and degree of water circulation by visual inspection of current velocity, signs of stagnation (floating debris, flotsam), baseflow and storm response. Using historical aerial photographs and field surveys, the hydrology of individual stream reaches were classified as:

1) Perennial: Flow all year with seasonal base flow maximum occurs late winter/early spring; peak flows in winter rainfall.
2) Intermittent: Baseflow expended between late winter and fall, peak flows.
3) Ephemeral: Only flows during winter rainfall events.
4) Winter Ponding and inundation (i.e. Seasonal Lake): Areas of open water during winter and spring.
5) Agricultural drainage: streams dominated by runoff from agricultural lands and tile drain/sump discharge; includes main agricultural ditches.

6) Urban Drainage: Drains or watercourses dominated by urban runoff during rainfall events.

Visual assessments of water circulation within each reach were repeated and documented from December 2000 to June 2001. A descriptive inventory of riparian vegetation surrounding the individual waterway reaches was conducted to indicate the relative degree of vegetative cover and the general vegetation type (e.g. woody vs. grassy; scrub, grassland or forest; native vs. invasive exotic.)

Field surveys of hydraulic control structures were conducted from winter flood through spring recession in order to assess their influence on circulation. Control structures are culverts, bridges, road fill and dams that effect water surface elevations and the degree of circulation. They are often associated with road crossings and drainage control structures and may constrict water flow and circulation, or may cause backwater conditions during flooding and reduce hydraulic capacity. Most of the control structures in Watsonville Sloughs Watershed were constructed during the early to mid-1900s. A table of all major hydraulic control structures was compiled for the watershed indicating location, physical description, and present conditions. Each structure was rated for its present structural condition, the degree of flow constriction, whether it is clogged or inoperable, and whether the structure appears adequately sized. The extent of flooding was mapped during the winter season of 2001 by repeated visual inspections and mapping on aerial photographs between January and March, 2001

### *A.1.2 Results and Discussion*

The map of subwatershed areas (**Figure A-1**.) was used to calculate drainage areas and areas of various land use cover types (**Table A-1 and Figures A-2**). The upper watersheds are a mix of land coverages while the lower watersheds west of Highway One are predominately agriculture, which accounts for 32% of the overall land area coverage. Rural residential (20%), grazed areas (18%), urban residential (9%), commercial (8%), and industrial (2%) round out the other active land uses. Undeveloped land accounts for approximately 10%.

The land coverage data for each subwatershed generally indicates the types of problems and conflicts that arise between land use and natural resources, and the types of management approaches that can be applied. Agricultural uses usually involve drainage problems and their proximity to waterways allows inflow of nutrients, eroded soils and residual pesticides into the Sloughs. Urban and industrial uses generate non-point source pollution such as nutrients, pesticides and herbicides, heavy metals, oils and grease. Rural residential and grazing areas are a source of nutrients from septic systems and manure.

The hydrologic, geomorphic and water circulation characteristics of individual stream reaches (**Figure A-3**) are shown in **Table A-2** and **Figure A-4**. Two general trends are notable:

- Circulation is high in the upper watershed areas, including Larkin Valley and urban storm drain systems in urban areas, which discharge into the lower watershed areas that display low circulation, winter inundation and stagnant waters. It is apparent that the expanded urban areas of Watsonville have increased urban stormwater runoff within an efficient storm drain system while little has been done in the lower reaches of the Watsonville Slough to expand capacity.
- Each stream reach characterized by winter inundation has a circulation rating of low or stagnant and is generally within areas affected by inoperable culverts and/or in areas where channels were designed for a high level of maintenance that has not recently been conducted.

**Figure A-4** illustrates the location of the hydraulic control structures in the Watsonville Sloughs Watershed and the extent of winter inundation identified during the observation period of January through March 2001. **Table A-3** presents description and performance rating for each control structure. Ten of the 42 control structures identified were observed to be major drainage constrictions during the storm runoff events in the Winter of 2001.

The significant winter inundations observed in Struve and Watsonville Sloughs, above UPRR crossing, are attributable to channel constrictions, inoperable control structures and the minimal elevation gradient over very significant distances. Land subsidence may also be contributing to the sluggish water drainage observed in Struve and Watsonville Slough during the Winter and Spring of 2001. Historic depletion of the shallow groundwater table, coupled with the compaction and decomposition of surface peat soils, are most likely the main causes of potential land subsidence. In addition, the weight of water masses atop these locations during sustained winter inundation may further exacerbate subsidence.

Subsidence is observed in Upper Watsonville Slough and possibly surrounding the Ford Street crossing (the Ford Street driveway is seen in **Figure A-5**) in Watsonville Slough below Lee Road and upstream of the UPRR, and in Harkins Slough upstream of the UPRR. The Ford Street driveway, and the fill crossings of Lee Road over Struve Slough and of Harkins Slough Road over Harkins Slough are examples of subsided roadways now closed or intermittently open due to flooding. Subsidence of the crossings is explained by the placement of road fill over compressible peat soils. These structures present major hydraulic controls that further exacerbate seasonal and perennial inundation.

The apparent land subsidence and winter inundation downstream of Lee Road on Struve Slough appears to have accelerated during the winter of 2001. In winter of 2000, the seasonal pond receded by the end of February. Given that the annual rainfall in 2001 was approximately 20% less than that of 2000, this land was still inundated in April of 2001.

Other drainage problems include Upper Struve Slough north of Main Street where winter inundation and stagnation is caused by the improper placement of culvert CS # 18 beneath Main Street. The culvert CS#18 is located at an elevation too high to efficiently drain the waters north of Main Street. This creates poor circulation north of Main Street, and the discharge from the elevated outlet has resulted in a 3-foot deep head cut in the channel on the south side of Main Street. CS # 7, #11, #36, and #37 all contribute to the sluggish drainage of Struve Slough (between the railroad tract and Harkins Slough Road) (**Figure A-6**) and to the lower portions of Watsonville Slough. The combined effect of drainage

constrictions and a minimal elevation gradient from Harkins Slough Road to the railroad trestle is the primary cause for winter inundation.

Winter flooding in Upper and Middle Harkins Slough is due to similar causes described above for Upper Struve Slough. Structures #3, #13, and #40 all have a backwater influence creating significant expanses of freshwater observed in Harkins Slough. When 2000/2001 field observations were made, installation of the Pajaro Valley Water Management Agency (PVWMA) groundwater recharge project was delaying the usual operation of the pump station at the confluence of Harkins and Watsonville Slough (CS#2) during the winter season. A continuous depth recorder was installed in Harkins Slough on April 20, 2001 and from installation to June 15, 2001, the water depth decreased from 4.2 feet to 2.0 ft. However, a significant expanse of water was still present in Harkins Slough in mid-June.

The middle portion of Gallighan Slough suffers from the encroachment of Buena Vista Road between the County Landfill and San Andreas Road. Buena Vista Road from Hacienda Road to San Andreas Road courses through highly erodible soils and road ditches have become gullies. Excess sediment clogs the ditches around the Santa Cruz County landfill. From the landfill westward, Buena Vista Road is situated on the floodplain of Gallighan Slough and the waterway is usually a roadside ditch. The road cuts often fail during storm events, causing road closure and sediment discharge directly to the creek. Spoils from the emergency road grading are left to erode along the banks of Gallighan Slough and become a chronic source of fine sediments.

Upper Harkins Slough in Larkin Valley serves as the main drainage conduit for Larkin Valley. Due to a variety of private land uses along multiple properties and the public road, the condition of the stream varies considerably. Often where habitat is dense and rich, drainage is inadequate, but where the channel is maintained as a drainage ditch, habitat is sparse. Numerous culverts, bridge crossings and road embankments impinge on the riparian corridor and affect drainage condition. Erosion is a significant problem, especially where headcuts have formed and migrated upstream, widening and deepening the channel in the

process. Some landowners report several feet of channel incision in one winter season (1998).

## A.2 Water Quality

### *A.2.1 Previous Water Quality Studies*

The Watsonville Sloughs Watershed has been the subject of several water quality studies over the past three decades. The studies included different methods of data collection at multiple sites (**Figure A-8**) including grab samples for water chemistry, analysis of sediments in the slough channels for residual pesticides, and bioassay/tissue analysis. The information was compiled through the review of published reports by consulting firms, university researchers, and state and local government agencies in **Table A-4**, and organized by the sample site location, the time of year, and the type of data collected. The purpose of the assessment of historical water quality data is to demonstrate the type of data previously collected, display the sampling locations and describe the relevant conclusions affecting the CEP. For specific details of the previous studies, see the text of the individual reports. The results are summarized here and references are provided in Chapter 8 for further information.

We have provided a brief summary of the results of the most important and relevant water quality studies below. However, we must note that the sampling procedures and reported units of measurements are not consistent across studies, making comparisons and general conclusions from the results difficult. In addition, we have reservations concerning the applicability and validity of some of the previous water quality studies for a number of reasons. First, spot sampling of water chemistry constituents provides only a minute snapshot of the nutrient, trace metal, or organic pesticide values at an instant in time. This information is useful in providing an order of magnitude approximation of the concentration of these constituents at these locations at that particular time. However, in aquatic systems such as Watsonville Slough, where extreme biological productivity is present, the daily and seasonal variability may be extreme. Therefore, instantaneous water chemistry values do not provide any information on the biological effects or ecological health resulting from these reported values. This fact is supported by the inconsistent trace metal water column results found by Questa in 1994 and SCC in 1997 (see water quality study summaries below)

Swanson Hydrology's greatest concern is the water column trace metal values reported by other researchers. Accurate and representative trace metal sample collection and analysis require extremely rigorous sample handling techniques to avoid contamination. None of the previous studies report using trace metal clean techniques. Another concern is the applicability and relevance of the particular analyses to biological health. The Questa report (1995) conducted total water column trace metal analyses. From these results, Questa concludes that the trace metal concentrations of Cu, Pb, Ni and Zn exceed EPA water quality criteria. However, if the point of these studies is to understand the interaction and influence of these metals on the biota, Questa's data is completely misinterpreted. It is a small fraction of the dissolved fraction of the trace metal concentrations in the water column that are available for biological uptake. The Questa analyses have reported all of the trace metal concentrations present in the water column, including the metals absorbed to particles and contained in any other forms (biota, leaves, etc) floating within the water column.

The reasonable conclusions to be made from previous water quality studies are:

1. Trace metal and organic pesticide concentrations in the sediments of the lower Sloughs areas are elevated and should be monitored prior to and during any earth moving activities in areas where buried sediments may be in prolonged contact with surface waters. DDT resuspension from buried sediments is most likely the primary concern.
2. Nutrient concentrations (N, P) are extremely high in much of the Watsonville Sloughs Watershed as a result of urban runoff and agricultural practices. Stagnant waters and surface waters exposed to sunlight for lack of vegetative cover (i.e. little circulation and warm water temperatures) exacerbate the eutrophic conditions observed in Watsonville Slough.
3. Toxicity studies on resident crustaceans (Hunt et al 1999) illustrated the waters within Beach Road agricultural ditch (concentrated agricultural tailings) are toxic to the crustaceans following storm events.
4. No conclusions can be made on the ecological interaction and effects of trace metal concentrations within the Watsonville Slough water column.

**Summary of individual water quality studies**

**Figure A-8** shows the sampling locations of the previous water quality studies. The locations were determined using the site descriptions in the published reports. When vague,

an approximate location was made using a topographic map of the Watsonville Slough Watershed, a street map of Santa Cruz County, and/or our personal knowledge of the area.

The majority of the water quality studies of the Watsonville Slough Watershed have been performed in the lower portion of the watershed, from the intersections of Harkins Slough Road with Harkins Slough, Struve Slough, and Watsonville Slough downstream to the mouth of the estuary (Sample Sites 1-13, 20 and 21; **Figure A-8**). These studies have concentrated on the presence of organochlorines (i.e. pesticides) and trace metals in the water column and in the tissues of aquatic organisms exposed to the slough water. Water quality studies in the upper watershed have been more sporadic, with the majority of the data produced by the Santa Cruz County Department of Environmental Health's testing for fecal coliform bacteria in Struve Slough.

- SCC Local Coastal Program, 1980.
  "Pesticide Tests in the South County Sloughs"

In May/June 1980, the Santa Cruz County Local Coastal Program took sediment samples for pesticides from seven sites in the watershed. Of particular concern, DDT was found to be above the EPA's allowed limit and was in the greatest concentration in the uppermost sediment layer, where it could most affect the aquatic wildlife. We must note that this study was performed 21 years ago and may not be representative of the conditions today.

- Questa Engineering Corporation, 1995
  "Water Resources Management for Watsonville Slough System, Santa Cruz County"
  *includes Pajaro Valley Water Management Agency Water Quality Sampling

Monitored water quality (physical parameters, nutrients, metals, pesticides) at ten sampling stations during fall/winter of 1994. The physical parameters suggested adequate conditions existed for warm water fisheries, but concentrations of copper, lead, zinc, and nickel were found to exceed the short and/or long term water quality limit for either freshwater or saltwater aquatic life, or both. Struve Slough had particularly high levels of ammonia and,

during run-off events, there were increased amounts of pesticides found, specifically at those sites bordering or downstream of an agricultural area.

- SCC Environmental Health Service 1997
  "Summary and Conclusions of Water Quality Sampling for Toxic Substances in Watsonville Sloughs"
  *includes Toxic Substances Monitoring Program and State Mussel Watch

This report measured the levels of toxic synthetic organic compounds in transplanted freshwater clams, as well as the total trace metals in the water and in the clams' tissues. No water quality problems due to total metals concentration in the water were found. Although high levels of trace metals have been reported previously (Questa 1995), no such amounts were found during the tissue monitoring and therefore are not of concern. Dangerous levels of organic compounds, however, were found throughout the watershed, with the highest concentrations being at the confluence of Harkins and Watsonville Sloughs. These levels were down from the mid-1980s levels, but still pose a significant threat to the quality of the Slough habitat. This report also included nutrient concentration data from grab samples performed in various locations in the Watsonville Sloughs Watershed in 1996 and 1997. Their results show the following: (1) $NO_3$ is the primary N species found in Watsonville Slough, (2) $NO_3$ concentrations are higher in low flow months when dilution by storm runoff is not occurring (**Figure A-8.1**), and (3) NO3 concentrations increase as more agricultural runoff enter the Slough system (**Figure A-8.2**).

- SCC Department of Environmental Health, "Recent Coliform Bacteria Testing"

Levels of fecal coliform varied from 0 to 11,750 throughout time and location in the watershed.

- Hunt, J.W., B.S. Anderson, B.M. Phillips, R.S. Tjeerdema, H.M. Puckett, V. deVlaming. 1999.
  "Pattern of aquatic toxicity in an agriculturally dominated coastal watershed in California"

Four sites in the lower portion of the Watsonville Sloughs Watershed were sampled monthly

for eighteen months and tested for toxicity to resident crustaceans. Results showed the agricultural drainage ditch to be the most frequently toxic, and the estuary's toxicity was highly correlated to rainfall and river flow due to the resuspension of metal/pesticide rich sediments during storm runoff. Therefore, decreased crustacean survival rates corresponded to increased river flow and rainfall. Multiple compounds were found to be the source of the toxicity.

**Synopsis**

Generally it has been found that the physical parameter data suggest adequate conditions for warm water fisheries (Questa 1995) and there are elevated nutrient (nitrate and phosphate) levels, especially downstream of farmland (Questa 1995). The results of trace metal studies vary. The Questa report is commonly cited for their reporting of alarming levels of metal toxicity (copper, lead, zinc, nickel) in the water column. However, there are the previously mentioned concerns with their findings. Another report (Santa Cruz County 1996) reported the dissolved levels to be within an acceptable range and found no evidence of metal toxicity during tissue sampling of transplanted freshwater clams (Santa Cruz County 1996). All studies found elevated levels of pesticides, specifically DDT, especially in the agricultural drainage ditches (Hunt 1999), in the uppermost layers of the sediment (LCP 1980), at the confluence of Harkins Slough and Watsonville Slough (Santa Cruz County 1996), and at sites bordering or downstream of agricultural fields after run-off events (Questa 1995).

Instantaneous concentrations of nutrients and trace metals provide a 'snapshot' of the degree of contamination within the water column, but these data do not provide information regarding the fate or availability of these constituents to the resident ecology. Previous studies on the aquatic toxicity of the Watsonville Sloughs Watershed have observed high mortality rates in agricultural drainage ditches where agricultural runoff is concentrated. Lower degrees of toxicity were observed within the Pajaro River and lower tidal slough waters presumably due to the dilution of the agricultural and urban runoff in these locations (SMW, Hunt et al, 1999)

### *A.2.2 SH&G Water Quality Studies 2001*

The focus of this water quality study is water circulation, quantification of nutrient loading, and biotic productivity that leads to eutrophication (water with highly productive phyto

plankton and algal growth, reducing dissolved oxygen levels). Swanson Hydrology implemented a continuous monitoring approach of basic water quality parameters (depth, water temperature, pH, and dissolved oxygen) coupled with vertical water quality profile measurements to address the interaction of circulation and biological activity at the base of the food chain. The viability of interpreting trends, duration and mass loading from spot sampling data suffers due to the inherent extreme daily variability of both nutrients and trace metals within eutrophic (nutrient-enriched, highly productive) systems (Beck and Bruland, 2000). The advantage of continuous data collection is the capacity to observe the stability of basic water quality parameters in the water column on short (daily) time scales and to judge the effect of stormwater runoff and tidal fluctuations on flow and water quality in individual events. The vertical profiles expand our understanding of how the continuous data collected at one location fits into the vertical context of the entire water column. Daily chemical stratification of these waters may result in very different chemical compositions between the surface and bottom waters at any particular site, in addition to compromised water quality in the bottom waters where redox-sensitive trace metals and $H_2S$ gas production occur. The spatial and temporal variation observed within the water column adds detail to illustrate the present, baseline biogeochemical dynamics present in Harkins, Watsonville, and Struve Sloughs.

The simplest way to assess the health of a wetland is to use daily (or "diel") dissolved oxygen (DO) variations as a proxy for biological activity at the base of the food chain. Photosynthesis by aquatic plants (algae) in the water column during sunlight hours is a net production of $O_2$ in the water column. Heterotrophic bacteria respire the organic matter created by daytime photosynthesis during the nighttime hours, removing $O_2$ from the water column. A healthy biogeochemical environment, capable of supporting invertebrate and fish communities, would have minor daily variations in DO fluctuating around 100%, as well as sufficient water circulation, water clarity, moderate pH, and relatively low water temperatures. Locations that display chronic levels of extremely low dissolved oxygen values, are most likely locations that posses compromised water quality, ecological health, and minimal biological diversity and survival.

### *A.2.2.1 Continuous Data Collection*

**Methods**

Two YSI-6000XLM multi-parameter data loggers (designated YSIA and YSIB) (**Figure A-9**) (http:/www.ysi.com) were used to gather real-time water quality data, including water temperature, depth, DO, salinity and pH. Four Global Water's WL14X water depth recorders were used to continuously monitor water depth variations (designated D#1 through D#5) within the Watsonville Sloughs Watershed (**Figure A-10**).

The YSI probes were situated between 0.5 and 2 ft above the channel bed in the lower portion of the water column where water quality conditions reflect excess microbial respiration and DO removal. The instruments were set to record each parameter every 30-minutes including: water temperature, salinity, conductivity, dissolved oxygen, and water depth. The four Global Water electronic pressure transducer data loggers were programmed to record water depth on the same 30-minute intervals. All of the instruments were installed concurrently with a staff plate, which relates water surface elevation to the recorders readings. Outside staff plates were surveyed relative to U.S. Geological Survey National Geodetic Vertical Datum (NGVD) using local benchmark elevations provided by Santa Cruz County Public Works; this ties the recorded elevations of water surface at each recorder site and elevations across the watershed to tidal elevations.

The locations of the instruments are indicated on **Figure A-10**, which also includes the maximum extent of flooding within the Watsonville Slough Watershed observed by SH&G field personnel during the Winter of 2001. The study was limited to use of the two YSIs and these were relocated approximately every 6 weeks to expand data collection in the watershed to broaden the basic understanding of water quality and circulation. This report includes the first 60 days of data collection from YSIA1, YSIB1, D#1, and D#3. D#2 was vandalized and all of the initial data was lost. D#2 was reinstalled on April 20, 2001 and data from April 20th through June 1st are included. D#5 was installed at the request of the PVWMA and collected data from May 29th through June 1st, 2001.

The data from the YSI's and depth recorders were downloaded in the field onto a laptop computer every 45 days. The instruments were calibrated and serviced prior to redeployment. The data stored on laptop computer was downloaded in the office and entered into an MS Excel spreadsheet. Quality control examination was conducted to ensure the integrity of the data. Any suspicious individual 30- minute readings were normalized, averaging the readings of the time intervals previous and subsequent to that reading. All water depth data was verified against the staff plate readings by SH&G personnel.

Precipitation, air temperature, and short-wave irradiance (sunlight intensity) data was obtained from a Real-time Environmental Information Network and Analysis System meteorological station which is located in Santa Cruz, CA (approx. 10 miles NW of Watsonville Sloughs) and maintained by the University of California at Santa Cruz. Unfortunately, the station's air temperature gauge was inoperable from March 8 to 23, 2001, creating a gap in our data. The daily tidal variations were provided by the WXTide32 program, using data from Moss Landing, CA (approx. 5 miles south of WS). Both sets of data were downloaded on 30-minute intervals into an Excel spreadsheet. The real-time water quality data and local weather and tide data were plotted to examine hydrologic behavior, response to the tidal cycle, runoff events, and biogeochemical cycling. Specifically, we looked at the water circulation as a function of the tidal cycle and precipitation events, and the water quality and biological activity responses to the local climate.

**Results**

*Water Quality Instruments YSIA and YSIB (Instrument Location Map: Figure A-10)*

**YSIA1: Beach Road**

YSIA1 is located in Watsonville Slough immediately downstream of Beach Road. This site is located within the tidally influenced reach of the lower Slough behind Pajaro Dunes development (see **Figure A-10**). Circulation is influenced by tidal elevations at the mouth of Watsonville Slough and the Pajaro River, as well as discharges from the Beach Road Ditch, which collects agricultural runoff, and tile drain discharge from fields south of Beach Road. It is anticipated that this site will possess greater circulation when the Pajaro River mouth is open to seawater inflow, however no data has been recorded when the mouth is closed

(usually in the late summer and early fall) in order to confirm our assumptions. The discharge from the Beach Road ditch contains high levels of nutrients and pesticides from tailwater and sump discharge from fertilized agricultural fields and toxicity studies have illustrated toxic responses of resident crustaceans during high runoff events (Hunt et al. 1999). The discharge of this water directly into the Watsonville Slough Estuary exacerbates eutrophication problems and contaminant loading in the Estuary.

Data was collected at Beach Road between February 15 and March 30, 2001 (**Figure A-11 through A-13**).

The water depth within the Watsonville Slough Estuary is compared to the tidal cycle, salinity, and the precipitation records. Tidal influence is apparent on water depth plot showing diurnal water depth changes corresponding to tidal fluctuation (Note: the Moss Landing readings are predicted tides meaning to represent open ocean conditions outside the mouth of the Pajaro River; the barrier beach sandbar which is usually around 0.0 feet MSL, restricts the lower half of the open ocean tidal cycle.) Saltwater did not migrate all the way upstream to Beach Road during this data collection period indicating that freshwater inflows from Watsonville Slough and Beach Road were adequate to maintain the saltwater/freshwater interface some distance downstream of Beach Road. However, high tidal events did cause a backwater effect and raised freshwater levels at Beach Road. Stormwater runoff from precipitation events, reflected by an increase in the minimum depths, is superimposed on the depth variation resulting from the tidal cycles. The salinity spike recorded in late March (**Figure A-13F**) suggests a salt pulse from agricultural field runoff following an isolated storm event.

From February 15$^{th}$ to March 16$^{th}$, a significant increase in the average temperature ($T_w$) was observed (≈ 6° C) as well as an increase in the maximum daily light intensities. During the cooler winter months, DO values at this site fluctuated around 100% saturation. However, the occurrence of warm, dry weather (March 16$^{th}$ through March 30$^{th}$) resulted in extreme DO variations with daily maximum values reaching 300% saturation and minimum values near 50%. The concurrent diel pH variations (another proxy for biological activity as the

carbonate chemistry in the water column is strongly influenced by photosynthesis and respiration) reflect a change to warmer weather as well. The observation of these extreme DO variations during late winter/early spring season suggests that in the subsequent summer and fall seasons, when circulation is lower or the mouth of the Pajaro River is closed, minimum daily DO values may possess chronically low levels at this location.

**YSIA2: Shell Road Pump Station**

YSIA2 collected data at Shell Road Pump Station from March 31st through April 16th, 2001, at which time the instrument experienced technical problems and was no longer operable. **Figure A-14c** illustrates a steady decline in the water depth at the pump station from early April through April 10th, followed by a rapid rise in the water level. As anticipated, the tidal cycle has been successfully disconnected from the water levels recorded upstream of the pump station. The interpretation of this data could be expanded by comparing the depth data to the Santa Cruz County Public Works pump operation schedule.

DO variations recorded at Shell Road display daily variations fluctuating about atmospheric saturation. Swanson Hydrology assumes that the water at the Shell Road pump station does contain elevated levels of nutrients and pesticides due to significant agricultural runoff. However, the circulation and water mixing induced by the pump operation appears to maintain stable DO levels. Visual observation of the water quality at Shell Road pump station suggest very turbid, polluted waters with very little habitat value.

**YSIB1: Upper Watsonville Slough**

YSIB1 is located 20 ft downstream of the inundated wetland area between Harkins Slough Road and the driveway at Ford Street (see **Figure A-10**). Water from the freshwater wetland drains through two 3.5 ft culverts and into a well-defined trapezoidal channel that essentially extends from this point to the Shell Road pumping station.

Data was recorded at this location from February 15th to March 30th, 2001 (**Figures A-16 through A-18**). Very little depth variation was recorded except for several abrupt increases in depth caused by stormwater precipitation events.

The DO recorded at YSIB1 is well below atmospheric equilibrium for the entire observation period. This is not surprising when the location of the instrument is understood. The site has little to no water circulation, no vegetation, and receives runoff from industrial, urban, and agricultural uses. On January 24, 2001, SH&G field personnel observed over 30 dead fish in this channel at Errington Road, approximately 600 ft downstream from the location of YSIB1 (**Figure A-15**). The fish were later identified as a bottom dwelling carp species, which are usually well adapted for low DO conditions. While the direct cause of this fish kill is unknown, during the warm weather in late March 2001, numerous suboxic events (DO values < 5%) were recorded and maximum daily DO values rarely exceed 20%. These chronic, extremely low DO levels (i.e. reducing conditions) are alarming. Reducing conditions are not only characterized by low DO levels but also result in high concentrations of redox sensitive trace metals and $H_2S$ (hydrogen sulfide) in the water column. As the occurrence of warm weather continues through the late spring and summer, the health of this system will most likely continue to decline.

**YSIB2: Struve Slough**

YSIB2 recorded data in Struve Slough, slightly east of Highway 1 (**Figure A-10**) from March 30th – May 8th, 2001. The water depth in Struve Slough over the duration of data collection showed relatively little decline (**Figure A-19c and A-20c**) despite the warm spring climate, suggesting minimal surface water flow. The YSIB2 was located in the bottom waters, approximately 0.8 ft from the sediments. Due to this submerged location the data does not display the pronounced daily variability observed in Harkins Slough, where the YSI recorded data much closer to the water surface. Dissolved oxygen values progress from suboxic (< 20%) to perhaps anoxic (sustained DO < 0%) conditions within the bottom waters of Struve Slough. High amounts of cattails and algae were observed in Struve Slough (**Figure A-21**) and the compromised DO levels are the result of excessive respiration of the high amount of biomass loading in this stagnant water body.

**YSIB3: Harkins Slough**

YSIB3 recorded data in Harkins Slough, 100 ft west of Harkins Slough Road, from May 8th through May 31st, 2001 (**Figure A-22**). In contrast to the other YSI locations, the YSI in Harkins Slough was located in the middle of the water column at a depth of 1.8 ft. Water depth decreased from 3.6 ft to 2.7 ft over the time of observation, most likely due to the onset of the PVWMA water removal downstream at the mouth of Harkins Slough. Daily variations of over 1.5 pH units were recorded concurrently with extreme DO variations during observation made in late May, 2001. These extreme pH variations are correlated to daily variations in water temperature and the high biological metabolism (daily DO variations) observed in the water column.

Interesting conclusions can be made from the DO observations in Struve and Harkins Sloughs. Both of the water columns have similar water depths during the times of observation, 3-4 ft. Struve Slough has a high amount of vegetation and algae present in the water column. In contrast, Harkins Slough is predominantly open water and subjected to daily mixing by wind stress alone. The data from Struve Slough was collected in the bottom of the water column, where we would expect to observed the most compromised DO values due to extreme respiratory activity. While Struve Slough bottom waters display extremely low DO levels, the high levels of biomass in these waters may actually be treating and improving the water quality as it travels downstream. The YSI in Harkins Slough collected data in the middle of the water column and displays a delicate cyclic balance of DO supply in the water column, where the DO produced during the day is nearly consumed that night. We assume that if the YSI in Harkins Slough was placed closer to the sediments, similar suboxic/anoxic conditions would likely be recorded. These data sets provide interesting insight into the differences in DO dynamics as a function of physical conditions and locations in the water column, in addition to providing valuable baseline data by which the effects and success of future restoration efforts may be quantified.

***Water Level Recorders D#1-D#5 (Instrument Location Map: Figure A-10)***

The precipitation record for the 2001 water year to date is presented in **Figure A-23**.

**D#1: Mouth of Watsonville Slough**

D#1 was installed on February 28, 2001, approximately 100 ft. from the confluence of Watsonville Slough and the Pajaro River (see **Figure A-10**). This site would reflect conditions at the Pajaro River mouth and would record the influence of the sandbar to tidal inflows to the Watsonville Slough Estuary. As expected, the depth at the mouth of Watsonville Slough Estuary is a function of the tidal cycle and sandbar condition. Superimposed on the water depth response to the fluctuating tides is the influence of the antecedent rainfall and the subsequent runoff from the upper watershed. For example, the storm event from March 3rd to March 5th (**Figure A-23**) produced 26 mm of rainfall and resulted in the elevated minimum depth levels observed at the mouth from March 5th through March 9th (**Figure A-24). Figure A-24B and C** illustrate the strong influence of the tides on water depth variations in Watsonville Slough Estuary during the dry spring and summer months. Water circulation appears to be dramatically reduced during neap tidal cycles relative to spring tides. This decreased mixing trend during neap tidal cycles most likely has implications on the degree of water circulation upstream at locations near Beach Road.

**D#2: Harkins Slough Railroad Trestle**

D#2 is located at the intersection of Harkins Slough and Union Pacific Railroad Trestle (UPRR). D#2 was initially vandalized and depth data did not become available until April 20th, 2001 **(Figure A-25)**. A steady decline in water depth was observed from 4.5 ft on April 20th to 2.8 ft on May 31st, corresponding to a decreasing water depth rate on the order of 0.5 in/day.

**D#3 Watsonville Slough Railroad Trestle**

D#3 was installed on March 7, 2001 and is located in Watsonville Slough at the UPRR (see **Figure A-10**). The winter rainfall of 2001 (**Figure A-23**) resulted in the extensive inundation of Struve Slough, West Branch Struve Slough, and the mouth of Hanson Slough (see **Figure A-4** for the extent of flooding). The overall decreasing depth trend observed in

this record is the draining of the pond after the maximum inundation (**Figure A-26A**). Following the storm events of late February, the water depth decreased from 4.32 ft on March 7th to 2.39 ft on March 30th, appearing to stabilize at 2.39 ft. On March 30th there remained a significant amount of inundation upstream of the D#3 site with very little inflow observed from Struve, West Branch Struve or Watsonville Sloughs. Watsonville Slough was only about 50% full at San Andreas Road on March 30th, indicating a constriction and suggesting significant drainage constrictions and/or land subsidence. From April 1st through May 31st, the water depth only decreased from 2.4ft to 2.0 ft, corresponding to a decreasing water depth rate of < 0.1in/day. In April 2001, the stagnant Slough was becoming clogged with an emergent plant, as well as some cattail growth. The observed late spring pond between Lee Road and UPRR has persisted for at least two months longer than the previous year, even though the year 2000 recorded 25% more annual precipitation.

**D#4: Shell Road Pump Station**

D#4 was installed at Shell Road pump station on March 13th, 2001 (**Figure A-27**). Water depths were over 4 ft during late March and early April. In mid April, it appears that the water pumping activities successfully lowered and maintained water depths at approximately 1.5 ft for the remainder of the data collection period.

**D#5: Harkins Slough at Harkins Slough Road**

D#5 was installed in Harkins Slough, 100 ft west of Harkins Slough Road on April 20th, 2001. Following the onset of the PVWMA groundwater recharge project in late April, the water depths decreased from 4.3 ft to 2.7 ft (**Figure A-28**), corresponding to a decreasing water depth rate of 0.5 in/day.

The rates of decreasing water depths, while they have not been constrained for the respective surface area of exposed water, are close to daily evaporation estimates that would be calculated for warm sunny days along the central coast.

### *A.2.2.2 Vertical Water Quality Profile Measurements*

#### Methods

The vertical sampling procedure is designed to capture one daily vertical profile study representative of each seasonal weather conditions in each key aquatic habitat of interest. **Table A-5** summarizes the sampling procedure. Ancillary water chemistry parameters (water temperature, DO, salinity) were collected with a hand-held YSI-85 multi-parameter probe from a canoe at a number of depth intervals (five to eight, depending on total depth of water column at each site) by securing the YSI probe to a PVC pipe marked with depth increments. Three water samples were collected from the canoe (surface, bottom, and mid water column) using a hand-held peristaltic pump attached to a PVC pipe marked with depth increments. Bev-a-line tubing was attached to the PVC pipe and all tubing was thoroughly rinsed with deionized water in between each sampling event. Water samples to be analyzed for dissolved nutrients were filtered during collection through an Aqua Prep 250 0.45 μM filter. The samples collected in March 2001 were frozen at the offices of SH&G and then sent to a certified and reliable analytical laboratory, Santa Cruz County Lab, for subsequent nutrient analyses. The location of the first vertical profile within each environment was documented using photographs and written descriptions of nearby landmarks to ensure subsequent data collection occurs at the same location.

#### Results

Afternoon vertical profiles were conducted on March 20th and morning profiles were conducted on March 28th, 2001. See Figure A-10 for vertical profile sampling locations.

**Upper and Lower Harkins Slough** sites are located 200 ft. upstream and 100 ft. downstream of Harkins Slough Road, respectively. Harkins Slough is a freshwater marsh with water depths of 4.5 to 5.0 ft in late March, 2001. Water circulation appears to be primarily wind-driven as very little current was observed. At both sites, the early morning studies illustrate a well-mixed water column with uniform temperature and DO values (**Figure A-29**). The afternoon studies suggest slight afternoon thermocline (temperature stratification) with fairly dramatic DO differences between the surface and bottom waters. The low DO levels in the afternoon bottom waters indicate respiration in excess of the DO

**Table A-5**: Vertical Profile Sampling Summary

| Site ID | Location | When (2001) | | | | What |
|---|---|---|---|---|---|---|
| | | Mar - Apr | May - June | June - Aug | Aug - Oct | |
| HS | Harkins Slough above and below Harkins Slough Road | c | * | * | * | 2 Vertical Profiles per sampling event<br>1 @ sunrise<br>1 @ mid-day |
| SS | Struve Slough above and below West Marine | c | * | * | * | |
| EST | Watsonville Slough Estuary at Beach Road and at mouth | c | * | * | * | |
| c = completed; * = dependent on funding | | | | | | |

supply. The excess DO in the surface counteracts the low values in the bottom waters. These values appear to balance and result in uniform DO profiles in the morning, at levels near 50%. The character of these profiles is fairly typical of a freshwater lake, but progression of the water chemistry should be monitored through the warmer summer months. The nutrient analysis showed the limiting factor for biological activity was nitrate ($NO_3$). The landfill and septic systems upstream in Larkin Valley contribute large levels of phosphate ($HPO_4$), explaining its elevated levels in Harkins Slough (**Table A-6**).

The **Upper Struve Slough** site is located 100 ft downstream of Harkins Slough Road and Lower Struve Slough is located approximately 1000 ft downstream of Harkins Slough Road, near the location of YSIB2. Similar to Harkins, this portion of Struve Slough is a freshwater marsh, with maximum observed water depths between 3 and 4 ft in late March, 2001. The water in Struve Slough, east of Highway One, appeared to be fairly stagnant with significant amount of visible algal growth in the surface waters (**see Figure A-21**). Water temperatures were fairly uniform during the morning and afternoon studies. The DO morning values, following the nighttime DO consumption through respiration, were observed to be extremely low, with most values below 25% saturation (**Figure A-30**). The shallower water

column in Upper Struve appears to be able to replenish some DO as a function of photosynthesis, but maximum levels recorded remained < 60%. These DO values are not surprising given the minimal amount of water circulation and high nutrient loading to this system, but again, the continuation of these studies throughout the summer would provide a more complete understanding of the vertical water chemistry within Struve Slough. Like Harkins Slough, the nutrient analysis of Struve Slough found nitrate to be the limiting factor. Industrial and residential uses upstream most likely contribute the higher levels of $HPO_4$ (**Table A-6**).

The **Watsonville Slough** vertical profiles were measured at Beach Road near the location of YSIA1 and downstream at a point ≈ 150 ft upstream of D#1 (see **Figure A-10** for locations). Tides influenced the water depth variations at this location, but salinity readings indicate that saltwater did not migrate inland to Beach Road (**Figure A-31**); as discussed above this could change as freshwater inflows from upstream decrease in the summer season. The water column at Beach Road is well mixed, indicating good circulation caused by tidal action. The afternoon readings were in excess of 200% saturation (the limits of the water quality handheld meter used) and the high degree of fluctuation in biochemical activity is indicative of a response to high nutrient input from the direct discharge from the Beach Road ditch. The morning readings suggest that water circulation is adequate to balance DO inputs and removal from biological activity, as DO readings were near normal 100%.

The water column at the mouth of Watsonville Slough displays stratification with a salinity gradient indicating dense saltwater overlain by freshwater. The low DO levels recorded in the bottom saline water for both morning and afternoon readings indicate that respiratory activity exceeds DO supply, and is compounded by the stagnation due to a lack of mixing caused by denser and less mobile saltwater. These low DO levels are surprising since the area should be well circulated with an open sandbar and river mouth. With the mouth closed and circulation decreased, this site would receive all nutrient-rich runoff from the entire watershed during the summer months, which may cause far worse water quality problems. As expected, due to the intense agricultural activity in the area, Watsonville Slough nutrient

analysis revealed high concentrations of nitrate throughout the water column, while here $HPO_4$ is the limiting factor (**Table A-6**).

**Table A-6:** Results of Vertical Profile Nutrient Analysis

| Site | Location in water column | NO3 | | PO4 | |
|---|---|---|---|---|---|
| | | am | pm | am | pm |
| **Harkins Slough** | Surface | 0 | 0 | 0.67 | 0.49 |
| | Middle | 0 | 0 | 0.54 | 0.52 |
| | Bottom | 0 | 0 | 0.57 | 0.51 |
| **Struve Slough** | Surface | 0 | 0 | 0.31 | 0.19 |
| | Middle | n/a | 0 | n/a | 0.45 |
| | Bottom | 0 | 0 | 0.37 | 1.84 |
| **Watsonville Slough** | Surface | 39.6 | 59.7 | 0.24 | 0 |
| | Middle | 51.6 | 59.2 | 0.26 | 0 |
| | Bottom | 76.9 | 59.2 | 0.19 | 0 |

### *A.2.3 Water Quality Summary*

During the winter of 2001 significant and prolonged inundation occurred in the upper reaches of 3 different Slough locations (see Extent of Flooding; **Figure A-4**). The winter precipitation totals for 2001 on the Coast were approximately 40 cm of rain, well below the Watsonville annual average of nearly 60 cm/year. Considering that 2001 was a below average winter with respect to rainfall, a tremendous amount of surface water persisted in upper Harkins and Struve Sloughs in mid June 2001. The lack of drainage from these areas suggests the acceleration of land subsidence due to historic shallow groundwater removal and decomposition of organic soil may be exacerbated by the sustained weight of water atop these areas. It is difficult to predict whether or not the land surface is now at steady state, or if subsidence may continue to increase during upcoming winters.

Healthy water quality is essential for aquatic life, fish and food production for waterfowl. Dissolved oxygen data from the continuous recording and the vertical profile studies presents a disturbing picture of conditions in the Watsonville Slough Watershed resulting from poor circulation and excessively high nutrient inputs. At the site of YSIA1 (Beach Road) one week of warm weather in early spring resulted in a rapid transition to from relatively stable DO values to extreme daily DO variations. This suggests the further progression of minimum DO levels towards suboxic or even anoxic conditions as the warm weather persists through the warmer months of the year. A fish kill was observed during the end of January (**Figure A-15**) in Watsonville Slough during times of significant freshwater runoff and relatively greater water circulation. This provides evidence that Watsonville Slough is a highly polluted and compromised waterway. The overall conditions of the Sloughs stagnant waters, high algal production, and hydrogen sulfide build up could be much worse during warm summer months.

## References

Beck, N.G. and K.W. Bruland. 2000. Diel biogeochemical cycling in a hyperventilating shallow estuarine environment. Estuaries. 23(2): 177-187.

Hunt, J.W., B. S. Anderson, B. M. Phillips, R. S. Tjeerdema, H. M. Puckett, V. deVlaming. 1999. "Patterns of aquatic toxicity in an agriculturally dominated coastal watershed in California." Agriculture, Ecosystems, and Environment **75**: 75-91.

Questa Engineering Corporation. 1995. Draft Water Resources Management Plan for Watsonville Slough System, Santa Cruz County, prepared for Association of Monterey Bay Area Governments**:** Section 6, Appendix D.

Santa Cruz County Environmental Health Service. 1996. Summary and Conclusions of Water Quality Sampling for Toxic Substances in Watsonville Sloughs. Santa Cruz County, Santa Cruz County Environmental Health Service Water Quality Laboratory.

Santa Cruz County Local Coastal Programs. 1980. Pesticide Tests in the South County Sloughs. 1-2, 31.

**Technical Appendix B: Vegetation Resources**

The following vegetation section was prepared by Kathy Lyons of the Biotic Resources Group, located in Soquel, California.

The Watsonville Sloughs Watershed is situated in the Aptos and Watsonville region of Santa Cruz County. The watershed supports both developed and undeveloped lands and, collectively, supports twenty-two principal plant community types. This diverse assemblage of plant community types result from the vast differences in the watershed's topography, substrate, flooding regime, fire history, and current and past land uses.

The upper watershed lands, such as in the White Road and Larkin Valley area, support a mosaic of woodland vegetation. Dominant plant community types include coast live oak woodland, central maritime chaparral and coastal scrub. Riparian woodland occurs along the several creeks that traverse this mountainous terrain. Since the turn of the century the planting of non-native trees, most notably blue gum eucalyptus and Monterey pine, has altered large expanses of the historic oak and chaparral landscape. These trees now form dense groves throughout the upper watershed. This portion of the watershed is dominated by rural residential land uses, small-scale agriculture, and animal husbandry (e.g., horse stabling). Rural residential and agricultural activities as well as public facilities (i.e., roadways) have altered the historic (pre-European) distribution of both the woodlands and grasslands within the upper watershed. This has occurred through the direct alteration of habitat (i.e., conversion of historic vegetation type to other land uses) and through indirect means (i.e., relocation, filling or other alterations of natural drainage features). As a result of these human activities, the upper watershed supports numerous non-native plant species, including some species that are considered to be invasive pests. The upper watershed also supports several sensitive upland habitats and special status plant species. These species are found and well adapted to the Aromas red sand deposits. The central maritime chaparral and some areas of coastal live oak woodland support two rare species unique to this region of the world: Hooker's manzanita, an evergreen shrub and robust spineflower, an annual plant. The occurrence of these two species, as well as other locally unique plant species, underscores the importance of these habitats to the region's botanical

diversity.

The lower watershed lands are characterized by the south county slough system. Drainage from the upper watershed, as well as local runoff, supports a series of five freshwater sloughs. Gallighan and Harkins Sloughs occupy the westernmost portion of the watershed; Hanson, Struve and Watsonville Sloughs occur in the central and eastern portions of the watershed. These sloughs are dominated by freshwater marsh vegetation, which are intermingled with willow riparian woodland and upland grassland. The slough system is recognized as the largest and most significant wetland habitat between Pescadero Marsh (San Mateo County) and Elkhorn Slough (Monterey County). Like the upper watershed lands, the natural resources of this low-lying region have changed dramatically since pre-Spanish and pre-European colonization. Agricultural activities, including peat farming, and public facilities (i.e., County landfill, roadways, railroad) have significantly altered the historic (pre-European) distribution of both the brackish and freshwater marshes within the lower watershed. This has occurred through the direst alteration of habitat (i.e., conversion of historic vegetation type to other land uses) and through indirect means (i.e., relocation, filling or other alterations of natural drainage features). In most instances, the upland areas that historically supported grasslands and coast live oak woodland have become agricultural lands, and more recently, urban lands. In some areas where the historic grasslands have been retained, special status plant species are known to occur, such as the endangered plant species, Santa Cruz tarplant. Although reduced in size compared to historical conditions, the lower watershed slough system still provides a high level of plant community and species diversity.

### Methods

Biotic Resources Group conducted the botanical resources analysis. Study methodology included literature review, aerial photograph interpretation, and field reconnaissance surveys. Literature and data base searches included the California Natural Diversity Data Base (CNDDB) "RareFind" (2001), California Native Plant Society (CNPS) Rare Plant Electronic Inventory (2000); and reports on file with the County of Santa Cruz for some properties within the watershed. A potential list of special status or sensitive plant species and/or habitats was prepared, utilizing species recognized by California Department of Fish and Game (CDFG 2001), US Fish and Wildlife Service (2000) and California Native Plant Society (CNPS 2000).

The occurrence and spatial distribution of special status species was obtained from previous data. Due to access limitations on private property, no rare plant surveys on these watershed lands during the study. Field surveys to document rare plant species were conducted within Spring 2001 (April-May) on publicly owned lands in the watershed.

Reconnaissance-level surveys were conducted in December 2000 and February, March, April and May 2001 to document the botanical resources within the watershed. Biotic Resources Group used aerial photo interpretation (photos dated June 2000 and October 2000) and field reconnaissance surveys to prepare a map of the principal plant communities within the watershed. In most instances, field checking was limited to public roads and access points in consideration of private property rights. Public lands were accessed to field check these areas. The *Jepson Manual* (Hickman 1993) was the principal taxonomic references used for the botanical work. The habitat polygons were then digitized into ArcView and the habitat distribution within Watsonville Sloughs Watershed is depicted in WSCEP Figure 3-5.

The information gathered from literature review, aerial photo interpretation and field reconnaissance surveys was used to describe the existing conditions of the botanical resources and present planning-level opportunities and constraints for resource management.

### Plant Community Descriptions

*Redwood Tree Groves*

Groves of coast redwood trees (*Sequoia sempervirens*) occur within the upper watershed lands. The trees occur as distinct groves amid coast live oak woodland dominated slopes in the White Road and Larkin Valley Road areas. The trees are most prevalent on the moist north and east-facing slopes of the watershed lands, encompassing approximately 21 acres. The majority of the redwoods appear to be second-growth trees originating on historically larger forested lands and/or recent landscape plantings by landowners.

Within these redwood tree groves, the soil profile is well developed and rich in organic matter, with a thick layer of redwood duff. Other tree species are also present but occur in lesser amounts, including tan oak (*Lithocarpus densiflorus*), madrone (*Arbutus menziesii*) and coast live oak

(*Quercus agrifolia*). The tree canopy is dense (>80% cover), which creates an understory suitable for shade tolerant plants. Hazelnut (*Corylus cornuta*), flowering currant (*Ribes sanguineum*) and young tan oaks were observed to dominate the understory. Although the tree groves are relatively small (in comparison to larger redwood forests), the herbaceous layer is comprised of shade tolerant plant species. Plant species observed in the redwood groves include western sword fern (*Polystichum munitum*), redwood violet (*Viola sempervirens*), California hedge nettle (*Stachys bullata*), California strawberry (*Fragaria californica*), starflower (*Trientalis arvensis*), trail plant (*Adenocaulon bicolor*), bedstraw (*Gallium* sp.) and yerba de selva (*Whiplea modesta*).

The occurrence of invasive, non-native plant species is limited within the redwood groves (in comparison to other habitat types). Based on the field surveys, the principal invasive plants are English ivy (*Hedera helix*) and periwinkle (*Vinca major*). These fast-growing perennial plant species thrive in the shady conditions and successfully compete with the native plants. Both the ivy and periwinkle are capable of growing into dense thickets, at the exclusion of the native plant species, thereby reducing plant diversity of the habitat. The redwood groves within the watershed lands offer opportunities to remove and/or control the spread of these invasive pest plant species and to revegetate the woodlands with native understory species.

*Monterey Pine Tree Groves*

This forest type consists of planted trees of Monterey pine (*Pinus radiata*). These stands primarily occur along Highway 1 (planted by CalTrans) and in smaller groves amid residential development along Larkin Valley Road. Although the Monterey pine is native to California, these tree stands occur outside the range of the native stands and are considered non-native. The majority of these trees were likely planted from non-native planting stock from Australia. The pines occur amid and interdigitate with the native coast live oak woodland; in several areas in the watershed, young trees of Monterey pine were observed encroaching into the woodland. The watershed supports approximately 52 acres of Monterey Pine.

In most areas, the Monterey pine stands were observed to be devoid of other tree species. In some areas, such as along Highway 1, the non-native blue gum eucalyptus (*Eucalyptus globulus*) intermixes with the pines. In some portions of the watershed, such as along Trabing Road, the Monterey pines intermix with coast redwood. Understory plant species are limited, in

comparison to native forests and woodlands. The understory in this area includes native shrubs, such as coyote brush (*Baccharis pilularis)*, coffeeberry (*Rhamnus californica)* and poison oak (*Toxicodendron diversilobum)* in addition to invasive, non-native plants. Species such as French broom (*Genista monspessulanus)*, iceplant (*Carpobrotus edulis)* and pampas grass (*Cortederia jubata)* were observed within the Monterey pine tree groves in the watershed. These fast-growing perennial plant species thrive in the sunny conditions and previously disturbed soils within the pine groves. The broom, iceplant and pampas grass growing into dense stands and exclude the growth of most native plant species, thereby reducing plant diversity of the habitat. The Monterey pine tree groves within the watershed lands offer opportunities to remove and/or control the spread of these invasive understory plant species.

In natural pine forests, the pines are subject to frequent fires, perhaps once every 30 to 50 years, resulting in even-aged stands. The pine groves in the watershed also appear even-aged; presumably most were planted following construction of Highway 1 and residential development in the upper watershed (circa 1950's). The tree's early senescence and its susceptibility to pine pitch canker, leads to favorable conditions for fire. The Monterey pine's cones release large quantities of seed following a fire, adapting it well to germinating in open, fire-scorched soils. In recognition of the fire danger these trees pose to nearby residential areas and the fact that these groves are non-native, there are opportunities to remove or modify these tree groves to reduce fire hazard and to re-establish native woodlands (e.g., oak woodland).

*Eucalyptus Tree Groves*

The eucalyptus tree groves within the watershed, covering approximately 754 acres are dominated by blue gum eucalyptus. These tree groves are non-native, with most planted in the early-mid 1900's for firewood and as landscape trees. The eucalyptus tree groves occur in areas that historically were vegetated with coast live oak woodland and central maritime chaparral. Although the blue gum eucalyptus is the dominant tree species, other trees were also observed within these groves, such as scattered occurrences of acacia (*Acacia* sp.) (another non-native tree), young coast live oaks and Douglas firs (*Pseudotsuga menziesii).* Non-native occurrences of Monterey pine are also found in the tree stands, particularly at the edge near scrub or grass openings. Open areas that have been previously disturbed, such as old roads and clearings, have naturally revegetated with non-native plants, most notably French broom and pampas grass.

Other associated understory species observed in the eucalyptus tree groves are California mugwort (*Artemisia douglasiana*), California blackberry (*Rubus ursinus*), coffeeberry and cotoneaster (*Cotoneaster* sp.). In some areas of the watershed, such as in the Mar Monte Avenue area, Hooker's manzanita (*Arctostaphylos hookeri*) (a rare plant species) occurs within the eucalyptus understory. Due to the dense shade and tree litter from the eucalyptus trees, however, the manzanita shrubs display a relatively sparse growth habit compared to the Hooker's manzanita plants occurring in the chaparral and oak woodland areas of the watershed.

Large expanses of eucalyptus groves occur along the ridge between Highway 1 and Larkin Valley Road and north of White Road. In many instances, residential areas abut these tree groves. Smaller groves of eucalyptus occur in the lower watershed. These trees occur as small tree groves amid grasslands or within the riparian corridors.

The non-native eucalyptus tree is adapted to natural fire. In their native habitat (i.e., Australia), eucalyptus tree forests are subject to natural fires. The tree's seed is released from its cap after a fire and, like the Monterey pine seed discussed above, is adapted to germinating in open, fire scorched soil. The thick duff beneath the trees (comprised of leaf and bark litter) as well as the numerous bark peels on the tree trunk, provides favorable conditions for crown fires. In recognition of the fire danger these trees pose to nearby residential areas and the fact that these groves are non-native, there are opportunities to remove these trees and re-establish native woodlands (e.g., oak woodland) (where the trees are not supporting overwintering habitat for Monarch butterflies – see Technical Appendix C).

*Coast Live Oak Woodland*

The watershed contains approximately 1,067 acres of forest dominated by coast live oak. The woodland primarily occurs on north and west-facing slopes. The overstory is dominated by coast live oak, however there are also occurrences of tan oak, California bay (*Umbellularia californica*) and madrone. The canopy cover is dense (> 50 %) and the woodland occurs in areas supporting deeper soil profiles and duff. In some areas, like Larkin Valley, the woodland intergrades with stands of redwood and groves of Monterey pine and eucalyptus. On the west and south-facing slopes, the oak woodland is probably the dominant pre-European settlement habitat type within the upper watershed lands.

The understory within oak woodlands is diverse. Commonly observed shrub species are poison oak, California blackberry, blue blossom ceanothus (*Ceanothus thyrsiflorus*), coffeeberry, and huckleberry (*Vaccinium ovatum*). The climbing vine, hairy honeysuckle (*Lonicera hispidula*), and the groundcover yerba buena (*Satureja douglasii*) were also observed throughout the watershed. Oak woodlands within the watershed are also known (and were observed) to support several rare and/or locally unique plant species. Special status plant species include robust spineflower (*Chorizanthe robusta* var. *robusta*), Monterey spineflower (*Chorizanthe pungens* var. pungens*)*, Kellogg's horkelia (*Horkelia kelloggii*) and Hooker's manzanita have been documented in the watershed lands. Two locally unique species (i.e., species with limited distribution in the County, but more widespread elsewhere) have also been documented, small-leaved lomatium (*Lomatium parviflorum*) and California bottlebrush grass (*Elymus californicus*). California bottlebrush grass was observed within the watershed lands during this survey.

Invasive, non-native plant species, such as French broom and pampas grass (*Cortederia jubata)* were observed within the coast live oak woodlands in the watershed. These perennial plants thrive in sunny, previously disturbed soils within the oak woodlands, such as along roads, cut slopes and in other previously altered areas. The broom and pampas grass growing into dense stands and exclude the growth of most native plant species, thereby reducing plant diversity of the habitat. The oak woodland within the watershed lands offers opportunities to remove and/or control the spread of these invasive understory plant species.

According to the CNDDB, oak woodland is considered a "threatened" community by the CNDDB (CNDDB 1999), due to the dominance of native species in the habitat, the potential for rare or endangered species, and its overall value to wildlife.

*San Andreas Live Oak Woodland*

This woodland type is a subset of the large classification of oak woodland, with the overstory dominated by mature live oak and madrone. The understory includes shrubs that also occur in the central maritime chaparral. Hooker's manzanita and brittle-leaved manzanita (*Arctostaphylos tomentosa crustacea)* are known (and were observed) within the San Andreas live oak woodland of the watershed. Other chaparral plants were also observed, including black sage (*Salvia mellifera*),

sticky monkey flower (*Mimulus aurantiacus*), and coffeeberry. The moist north and west-facing slopes of the woodland support a dense understory of moisture-dependent plant species. Plant species observed in these areas include hazelnut (*Corylus cornuta*), mugwort, California blackberry, blue elderberry (*Sambucus mexicana),* flowering currant (*Ribes californicum*), snowberry *(Symphoricarpos alba*), hedge nettle (*Stachys bullata*), California bottlebrush grass and poison oak. The San Andreas Live Oak Woodland community covers approximately 682 acres of the watershed area.

Openings within the woodland were also observed. In these areas, herbaceous plant species, such as soft chess (*Bromus hordeaceus*), hedge nettle, star lily (*Zigadenus fremontii*), yerba buena (*Satureja douglasii*), blue-eyed grass (*Sisyrinchium bellum*), and English plantain (*Plantago lanceolata*) were observed. Other herbaceous species observed in the woodland include Douglas iris (*Iris douglasiana)*, Pacific pea (*Lathyrus vestitus)*, wild rye (*Elymus glaucus*) and melic (*Melica torreyana*). Scattered occurrences of California bottlebrush grass, a locally unique plant species, have been previously documented within the watershed in previous biotic reports (and were observed during this study). Robust spineflower (a rare plant species) has also been previously documented within the watershed and was observed during this study. This species is known from relatively open areas within oak woodlands; its seeds can lie dormant in the soil and sprout in open disturbed areas. Other special status plant species documented from the oak woodland in the watershed are Monterey spineflower, Kellogg's horkelia and Hooker's manzanita.

As discussed for oak woodlands, above, the San Andreas coast live oak woodland supports occurrences of invasive, non-native plant species, most notably French broom and pampas grass. These perennial plants thrive in sunny, previously disturbed soils within the oak woodlands, such as along roads, cut slopes and in other previously disturbed areas. As the broom and pampas grass grow into dense stands and exclude the growth of most native plant species, their presence reduces the plant diversity of the habitat. The San Andreas coast live oak woodland within the watershed lands offer opportunities to remove and/or control the spread of these invasive understory plant species. The oak woodland also offers opportunities for the preservation and management of special status plant species (e.g., Hooker's manzanita and robust spineflower).

This woodland type occurs within the Aromas red sand deposits in the upper watershed, such as near Fiesta Way, Mar Monte and the Calabazas Road area. The San Andreas live oak woodland/central maritime chaparral complex is identified as a "special forest" in the County of Santa Cruz County Code.

*Central Maritime Chaparral*

This habitat type occurs within the upper portion of the watershed property and intergrades with the adjacent coast live oak woodland. The chaparral is characterized by the presence of evergreen shrubs occurring on the Aromas red sand deposits. The watershed contains approximately 200 acres of chaparral, primarily along the south-facing slopes and uppermost ridges in the Buena Vista and Larkin Valley areas.

Chaparral supports a manzanita community, including the common brittle-leaved manzanita and the rare and locally unique Hooker's manzanita. Associated species that were observed in the chaparral coffeeberry, sticky monkey flower, blue blossom, deerweed (*Lotus scoparius)*, huckleberry, and warty-leaved ceanothus (*Ceanothus pappilosus)*. Other plants observed include poison oak, bracken fern (*Pteridium aquilinum* var. *pubescens)*, mock heather (*Ericameria* sp.), peak rush-rose (*Helianthemum scoparium*), yerba santa (*Eriodictyon californica*) and globose sedge (*Carex globosa*). Special status plant species endemic to the Aromas sands, such as robust spineflower are also known (and were observed) within this plant community type.

Where the maritime chaparral intergrades with the adjacent oak woodland, manzanita and other shrubs occur within the understory of coast live oaks. These areas represent the San Andreas live oak woodland/maritime chaparral complex, as described earlier and depicted on Figure 3-5 of the WSCEP.

Plant species growing in the chaparral have adaptations to survive dry, sandy soils. Their long root systems obtain moisture from deep in the sands and in fractures of more consolidated substrates. The central maritime chaparral includes stump (or crown)-sprouting shrubs that grow new stems from buds on the root crown and are adapted to periodic wildfires. Stump (crown)-sprouting shrubs that occur in the watershed lands include chamise (*Adenostoma fasciculatum*), brittle-leaved manzanita, toyon (*Heteromeles arbutifolia*), poison oak and buck brush.

These plants re-sprout from the crown after a fire, thereby quickly revegetating the burned area. Other plant species, such as Hooker's manzanita, has seeds that are well adapted to periodic burning. After a fire, rainwater easily penetrates the fire-charred seed coat, resulting in abundant germination. The Hooker's manzanita also re-seeds itself in previously disturbed soils in the absence of fire. Roughened and nicked seeds (as a result of ground disturbances) quickly germinate and can re-colonize the disturbed sites. The watershed supports areas where this manzanita has re-colonized disturbed chaparral areas. Other plant species, such as deerweed and sticky monkey flower, are shallow-rooted and shorter lived than other shrubs. These plant seeds lie dormant underground from one fire (or ground disturbance) to the next, sprouting in the open areas of the shrublands. Robust spineflower (a rare species) is also known to grow in disturbed chaparral areas. Its seeds are capable of persisting in the soil until the conditions are favorable for its growth (i.e., open, slightly disturbed soil conditions).

The old roads and trails that traverse through the chaparral habitat within the watershed create open areas. As discussed above, some of these areas have been colonized by special status species (e.g., Hooker's manzanita, Monterey spineflower and robust spineflower). A locally unique plant species, Michael's rein orchid (*Piperia michaelii*) has also been observed amid the Hookers manzanita in the Fiesta Way area. Some areas have been colonized by other native and non-native plant species, including bush lupine (*Lupinus chamissonis)*, star lily , sanicle (*Sanicula* sp.), French broom, eucalyptus saplings and pampas grass. Patches of native grasses are also observed in these openings, such as purple needlegrass (*Nassella pulchra).*

As discussed for oak woodlands, the maritime chaparral supports occurrences of invasive, non-native plant species, most notably French broom and pampas grass. The chaparral within the watershed lands offers opportunities to remove and/or control the spread of these invasive understory plant species. The chaparral also offers opportunities for the preservation and management of special status plant species (e.g., Hooker's manzanita and robust spineflower).

According to the CNDDB, central maritime chaparral is considered a "threatened" community by the CNDDB (CNDDB 1999), due to the predominance of rare or endangered species. Central maritime chaparral is also identified as a "special forest" in the County of Santa Cruz County Code (as a component of the San Andreas live oak woodland/maritime chaparral

complex). Hooker's manzanita, is considered a rare species (i.e., List 1B) by the CNPS. Robust spineflower and Monterey spineflower, two rare plants that occur in the chaparral of the watershed, are federally designated as endangered (USFWS 2001).

*Coastal Scrub*

The watershed supports areas of scrub habitat that are dominated by evergreen shrubs. These areas occur as scattered patches in previously disturbed areas and along the south-facing slopes in the watershed (see WSCEP Figure 3-5). The property contains approximately 299 acres of coastal scrub.

Shrubs of coyote brush (*Baccharis pilularis*), black sage, poison oak, interspersed with California blackberry, bracken fern and coffeeberry (*Rhamnus californica*) are the dominant plant species that were observed in the scrub habitat of the watershed. Scattered individuals of brittle-leaved manzanita were observed amid other shrubs where the scrub abuts central maritime chaparral and San Andreas coast live oak woodland, such as in the Mar Monte and Calabazas Road areas of the watershed.

Grasses and forbs are not prevalent within the coastal scrub. However, plants such as pearly everlasting (*Gnaphalium bicolor*), hedge nettle (*Stachys bullata*), Fremont's star lily and sanicle (*Sanicula bipinnatafida*) were observed in scattered locations during the field surveys. The scrub areas within the watershed are subject to infestation from invasive, non-native plant species. In the lower watershed areas where scrub has naturally colonized fallow agricultural lands or previously grazed side slopes, perennial plants of poison hemlock (*Conium maculatum)* and fennel (*Foeniculum vulgare*) are prevalent. Other perennial pest plants, such as velvet grass (*Holcus lanatus*) and canary grass (*Phalaris* spp.) were observed in moist areas closer to the sloughs. Invasive annual plants were also observed in the scrub habitats, including wild mustard (*Brassica* spp.) and wild radish (*Raphanus sativus*). These plants grow well in the previously disturbed soils. As these plants grow into dense stands, they successfully compete with, and over time, exclude the growth of the native plant species, such that their presence reduces the plant diversity of the habitat. The coastal scrub areas within the watershed lands offer opportunities to remove and/or control the spread of these invasive plant species.

*Coastal Dune Scrub*

The coastal section of the watershed study area (north of Pajaro Dunes residential area) contains patches of central dune scrub. This habitat type is characterized by an assemblage of low growing to prostrate annual and perennial plants. Within the watershed area the dune scrub is dominated by beach bur (*Ambrosia chamissonis*), mock heather (*Ericameria ericoides*) and silver bush lupine (*Lupinus chamissonis*). Yellow sand verbena (*Abronia latifolia*), pink sand verbena (*A. umbellata*), sea rocket (*Cakile maritima*)and beach primrose (*Camissonia cheiranthifolia*) were observed in the more open sandy areas. Other species that occur in the dune scrub include wild cucumber (*Marah fabaceus*), sea fig [ice plant] (*Carpobrotus edulis*), salt grass (*Distichlis spicata*)and European beach grass (*Ammophila arenaria*). The dune scrub, with its open sandy soils, is suitable habitat for several special status plant species, such as Monterey spineflower (*Chorizanthe pungens var. pungens)*, sand gilia (*Gilia tenuiflora ssp. arenaria),* and coast wallflower (*Erysimum ammophilum*). Although not occurring in the watershed boundary, these species occur immediately north of the Pajaro Dunes development at Sunset State Beach (see WSCEP Figure 3.6). Less than one acre of coastal dune scrub habitat exists in the watershed. The dune scrub areas within the watershed are subject to infestation from invasive, non-native plant species. Perennial plants of iceplant, ripgut brome (*Bromus diandrus*), poison hemlock were observed in the dune scrub of the watershed. The dune scrub areas within the watershed lands offer opportunities to remove and/or control the spread of these invasive plant species.

According to the CNDDB, central dune scrub is considered a "threatened" community by the CNDDB (CNDDB 1999), due to the predominance of rare or endangered species. Dune habitats are also identified as “sensitive habitats” in the County of Santa Cruz County Code. Monterey spineflower, which may occur in the scrub, is federally designated as endangered (USFWS 2001). The small scrub areas within the watershed offer suitable habitat for colonization by the Monterey spineflower.

*Grasslands*

Several areas within the watershed are comprised of grassland. Based on the review of the aerial photographs and field reconnaissance surveys, approximately 1535 acres of grassland occur in the watershed. For many of the private lands (i.e., where previous surveys/reports are not available from the County of santa Cruz or City of Watsonville), these occurrences are mapped

as "unknown species composition". Due to private property considerations the site was not field checked and the composition of plant species (native vs. non-native) could not be determined from nearby roads or from aerial photographs. Some of these grasslands are expected to be comprised of native grasses, however, more detailed surveys on private land would be necessary to determine this.

The grassland community within the lower watershed lands has been modified by historical land uses. Where these grasslands are situated on coastal marine terraces, they historically supported a dense growth of native perennial bunchgrasses and other native herbaceous species. Termed "coastal terrace prairie", these grasslands were characterized by the presence of California oatgrass (*Danthonia californica)*, a native perennial grass that is considered by many botanists to be indicative of coastal terrace prairie. In most locations, these historic prairie grasslands were converted to agricultural land uses. Most areas were subject to intensive cattle grazing during the rancho/land grant period, and then a gradual conversion to row crops and orchards on the terrace-tops during the post-European period. Currently, the grasslands in the lower watershed occur on fallow agricultural fields on the terrace-tops and on previously grazed side-slopes (above the sloughs). A small proportion of the existing grassland is believed to occur on land that historically supported riparian woodland or oak woodland, such as along the hillsides east of Hanson Slough. The previous land uses significantly altered the plant composition of the historic prairie such that the grasslands now support only pockets of native perennial grasses or forbs that would be typical of an intact coastal terrace prairie. The existing grasslands are now dominated by annual, non-native grass species (primarily of European origin). Although the lower watershed areas may have historically supported a native prairie, the grasslands would be considered California annual grassland (CDFG 1997), or non-native grassland. Approximately 39 acres of this community occurs within the lower watershed, as depicted on Figure 3-5 of the WSCEP.

The lower watershed grasslands are dominated by non-native grass species, such as wild oat (*Avena fatua)*, soft chess (*Bromus hordeaceus)*, Harding/canary grass (*Phalaris* spp.), rattail fescue (*Vulpia myuros*) and Italian ryegrass (*Lolium multiflorum)*. Other non-native species observed within the grasslands include wild mustard (*Brassica sp.),* wild radish (*Raphanus sativa)*, ripgut brome (*Bromus diandrus)*, bindweed (*Convolulus arvensis)*, sheep sorrel (*Rumex acetosella*), redstem

filaree (*Erodium cicutarium)*, cut-leaved geranium (*Geranium dissectum)*, English plantain, rattlesnake grass (*Briza maxima)*, bristly ox-tongue (*Picris ecioides*), narrow-leaved clover (*Trifolium angustifolium*), sow thistle (*Sonchus asper*), Italian thistle (*Carduus pynocephalus*), bull thistle (*Cirsium vulgare*), fennel, cat's ear (*Hypochaeris* sp.), and dandelion (*Taraxacum officinale*). Scattered throughout the grassland are some native plants; species observed include California poppy (*Eschscholtzia californica)*, hairy vetch (*Vicia villosa*), coyote brush, California rose (*Rosa californicum*), wild rye (*Elymus glaucus*), blue elderberry, coffeeberry, and remnant orchard trees. Some areas within the lower watershed still support plants typical of remnant coastal terrace prairie. A large area of prairie occurs at the Watsonville Airport. This large grassland area was observed to support dense stands of California oatgrass and purple needlegrass (*Nassella pulchra)*. Some of the other native plant species typical of intact coastal prairie habitat also occur her, including Artists popcorn flower and Santa Cruz tarplant. Other plant species typical of prairie habitats may also occur, such as slender rush (*Juncus tenuis*), bi-color lupine (*Lupinus bicolor),* owl's clover (*Castilleja densiflora*), suncups (*Camisonia ovata*), horkelia (*Horkelia sp.*), goldfields (*Lasthenia californica*), Kellogg's yampah (*P. kelloggii*) and footsteps of spring (*Sanicula arctopoides)*.

The grassland community within the upper watershed lands has also been modified by historical land uses. As discussed for the lower watershed, historic prairie grasslands were believed to be present, however, the wooded character of the area suggests that the grasslands were smaller and intermixed with the historic oak woodland and chaparral. The flatter areas in the upper watershed, such as along Larkin Valley Road, probably supported riparian and oak woodland that were converted to agriculture during the post-European period. While the majority of these grasslands now support non-native grasses, stands of native grasses have persisted in many areas. The dominant native grass species are purple needlegrass (*Nassella pulchra)*, nodding needlegrass (*Nassella cernua*) and occasionally, California oatgrass. Associated species are primarily non-native and include Italian ryegrass (*Lolium multiflorum*), soft chess, ripgut brome, wild oat, European hairgrass (*Aira caryophylla)* and rattail fescue (*Vulpia myuros*). Non-native forbs (i.e., non-grass herbaceous plants) are also prevalent and include English plantain, filaree (*Erodium spp.)*and scarlet pimpernel (*Anagallis arvensis)*. Native forbs were also prevalent in some of these grasslands; farewell-to-spring (*Clarkia purpurea*), common yarrow (*Achillea millefolium*), California poppy, blue dicks (*Dichelostemma capitatum*), sun cups (*Camissonia ovata)*, blue-eyed grass (*Sisyrinchium bellum*) and lupine (*Lupinus nanus*) were observed.

All of the grasslands within the watershed are subject to infestation from invasive, non-native plant species. In areas left fallow, perennial plants, such as poison hemlock, fennel, velvet grass and Harding grass are commonly observed. Invasive annual plants were also observed, including yellow star thistle (*Centaurea soltitialis*), wild mustard and wild radish. The grasslands within the watershed lands offer opportunities to remove and/or control the spread of these invasive plant species.

Some of the grasslands within the watershed are known (and were observed) to support special status plant species. The Santa Cruz tarplant (a State endangered and Federal threatened species) is known to occur in several locations within the watershed. The grasslands are also potential habitat for other rare species, including San Francisco popcorn flower, Gairdner's yampah and Santa Cruz clover (see additional discussion on these species under Special Status Plant Species). The grasslands offer opportunities for the preservation and management of both native species and special status plant species (e.g., Santa Cruz tarplant).

Grasslands supporting special status species as well as all grasslands within the coastal zone are identified as "sensitive habitat" in the County of Santa Cruz County Code.

*Riparian Forests*

Riparian forests occur along stream channels and the edges of the sloughs. This streamside vegetation typically grows up to the bankfull flow line and may extend above this line in the wet winter months when soil moisture levels are high. Characteristic woody vegetation species could include (but are not limited to): various types of willow (*Salix* sp.), box elder (*Acer negundo*), black cottonwood (*Populus balsamifera* ssp. *tricocarpa*), and big leaf maple (*Acer macrophyllum*). Three types of riparian habitat were observed in the watershed, as described below. The stream channels usually exhibit some evidence of scour and/or deposition. The high water regime of a stream is an important component in the species composition along a watercourse, as most riparian plant species are adapted to colonizing recently disturbed (i.e., flooded, scoured or depositional areas) portions of a stream.

These deciduous forests typically occur along perennial streams (depicted as a solid or dashed blue line on USGS 1:24,000 scale topographical maps) and some ephemeral streams with well-defined channels. Figure 3-5 of the WSCEP displays the occurrences of riparian plant communities based on the aerial photo mapping and reconnaissance surveys. Approximately a total of 630 acres of riparian vegetation (e.g., willow-cottonwood forest, willow scrub and herbaceous riparian) occurs on the watershed lands.

All riparian corridors are identified as "sensitive habitat" in the County of Santa Cruz County Code.

**Willow Scrub.** This riparian type is prevalent within the watershed lands. The scrub is characterized by the dominance of young willows; arroyo willow (*Salix lasiolepis*) and yellow willow (*Salix lucida* ssp. *lasiandra*). The scrub occurs along intermittent and perennial streams both in the upper watershed (such as along small tributaries leading to Larkin Valley Road), along the edges of the sloughs and at hillside seeps/springs. Although the willows are most prevalent, other plant species occur (and were observed), such as California blackberry, water smartweed (*Polygonum emersum*), stinging nettle (*Urtica dioica*), spreading rush (*Juncus patens*), nut sedge (*Cyperus eragrostis*) and poison oak.

The presence of willow scrub vegetation is indicative of high soil moisture during most times of the year. Where the willows occur at hillside seeps/springs, such as observed in the Larkin Valley area, or at the headwaters of the sloughs tributaries (such as along portions of Harkins Slough), the vegetation persists as a dense thicket of willows. Other riparian tree species are absent due to inadequate soil moisture or other hydrological conditions. Where willow scrub was observed along intermittent or perennial waterways, such as along portions of upper Harkins Slough (east of Highway 1), the absence of mature, large-sized willows and other riparian tree species indicates either natural or man-induced disturbances. Stream bank erosion can result in the loss of riparian vegetation from the streambanks, such that a site is continually vegetated with young willows. Similarly, stream bank disturbances and domestic animal browsing can also result in the maintenance of young willow growth (verses the development of mature trees).

In areas subject to repeated disturbances, invasive non-native plant species were observed. The most prevalent within the willow scrub areas within the watershed is poison hemlock. This perennial plant is prevalent along the edges of the willow scrub and intermixes with the willow. The growth of the hemlock retards the growth of native understory plant species. The watershed lands offer opportunities for the management of willow scrub areas through the removal of invasive, non-native plant species. Additionally, in areas capable of supporting more diverse and mature riparian woodland (see willow-cottonwood riparian woodland, below), the watershed offers opportunities for riparian revegetation and management.

**Willow – Cottonwood Riparian Woodland.** This forest type is prevalent along portions of Upper Harkins Slough (in the Larkin Valley area), along Upper Watsonville Slough and along portions of Hanson Slough. Willow is the dominant tree species, however other trees are evident, such as black cottonwood and box elder. Understory plant species include California blackberry, thimbleberry (*Rubus parviflorus*), stinging nettle and creek dogwood (*Cornus glabrata*).

In areas where the riparian vegetation is naturally re-colonizing previously disturbed areas, such as along portions of Hanson Slough (e.g., from the slough confluence with Watsonville Slough to Harkins Slough Road), the riparian area includes dense thickets of poison hemlock, an invasive, non-native plant species. A review of aerial photos from the 1930 and 1940's reveals that most of this riparian area was under cultivation; only narrow band of riparian woodland was evident. Currently a wide riparian area grows along the drainage; the naturally revegetating willow stands are intermixed with the poison hemlock. The slough upstream of Harkins Slough Road is a narrow drainage swale. Grazing in and around the drainage has resulted in little to no woody riparian plant cover in this area.

The riparian woodland within the watershed has been significantly reduced in distribution since pre-European settlement. The watershed lands offer opportunities for the management of willow –cottonwood woodlands through the removal of invasive, non-native plant species. The watershed also offers opportunities for riparian revegetation and management.

**Herbaceous Riparian.** This riparian type occurs along several of the streams in the watershed. The vegetation is dominated by herbaceous (i.e., non-woody) plant species. Plant species of

common rush (*Juncus effusus*), Santa Barbara sedge (*Carex barbarae*), brown-headed rush (*Juncus pynocephalus*) and cattail (*Typha* spp.) were observed. The herbaceous areas typically occur in areas subject to animal grazing or other land disturbances where the woody riparian cover (usually willow) has been browsed or otherwise removed. Examples of herbaceous riparian areas occur in the Larkin Valley Road area and in the upper reaches of Watsonville Slough, where the watercourses display discontinuous patches of woody willow patches amid herbaceous-dominated areas.

As discussed under willow-cottonwood riparian woodland, many of the drainages currently supporting herbaceous riparian vegetation historically supported mature riparian woodland. The watershed offers several opportunities for restoration of these areas through the establishment of setback areas that can be revegetated with willow scrub or willow-cottonwood riparian woodland. There are also opportunities to remove occurrences of invasive, non-native plant species.

*Freshwater Marsh*

This vegetation type consists of areas dominated by perennial, non-woody plant species that are adapted to growing in wet conditions. The plants grow in permanently saturated soil, along the edges of the sloughs and other waterbodies. In some instances, confined slough channels are also dominated by freshwater marsh vegetation, such as the lower portions of Watsonville Slough. Winter inundations, creek flows and spring/seeps have resulted in fresh water marsh species growing along the edges and within Harkins, Struve, Galighan, and Upper Watsonville Sloughs.

Within the watershed, the sloughs support a dense cattail/bulrush habitat. The most common bulrush is California bulrush (*Scirpus californicus*), however; other species are also present, including small-fruited bulrush (*S. microcarpus*) and Olney's bulrush (*S. olneyi*). Cattail (*Typha latifolia*) is also commonly observed where it forms dense stands within the slough as well as intermixing with the bulrush. The distribution of these plant species is primarily a function of historical land uses, source of water (i.e., groundwater, surface runoff) and water depth. The west branch of Struve Slough, for example, supports a dense growth of both bulrush and cattail along the shallow water edges, extending into the deeper open water areas (to approximately a

3 foot water-depth). Distinct stands of bulrush can be seen growing on shallower sediment deposits. The occurrence of other plant species also varies by water depth and the duration of inundation. Along the edges of the bulrush/cattail stands where periodic flooding often occurs, other wetland plant species are present. Common monkey flower (*Mimulus glutattus*), Pacific silverweed (*Potentilla anserina*), creeping buttercup (*Ranunculus repens*), watercress (*Rorippa nasturtium-aquaticum*), western goldenrod (*Euthamia occidentialis*), brown-headed rush and waterweed (*Polygonum lapathifolium*) are commonly observed in these areas. In open water areas pondweed (*Lemna* sp.) is also prevalent. A non-native marsh marigold (*Caltha* sp.?) was observed within the lower reaches of Watsonville Slough.

Approximately 269 acres of this community occurs within the watershed. All areas supporting freshwater marsh vegetation are identified as "sensitive habitat" in the County of Santa Cruz County Code (wetlands). CDFG maintains a reserve along the West Branch of Struve Slough. Encompassing approximately 132 acres, the reserve's purpose is to preserve the wetland habitat and sensitive species in this freshwater marsh.

The freshwater marshes within the watershed have been significantly reduced in distribution since pre-European settlement. A review of aerial photos from the 1930's and 40's reveals that many of the wetland areas in/adjacent to the sloughs were under agricultural cultivation and the historic slough vegetation was absent. In most instances within the lower watershed, the existing freshwater marsh habitat exceeds the amount present at the turn of the 20$^{th}$ century. This trend is evident along Harkins Slough, which was harvested for peat. Since the cessation of peat farming, these areas have re-colonized with native marsh vegetation (e.g., cattail and tules). Many areas in/around the Struve Slough were also in agricultural production in the 1930's. As these areas have been taken out of agriculture, thickets of freshwater marsh have naturally recolonized.

In areas where the freshwater marsh vegetation is naturally re-colonizing (e.g., along Harkins Slough and Struve Slough), the freshwater marsh areas are ringed by dense thickets of poison hemlock, wild mustard and wild radish, three invasive, non-native plant species. The watershed offers several opportunities for restoration of the freshwater marsh areas through the removal of occurrences of invasive, non-native plant species and management of water levels to increase

habitat diversity.

***Ruderal Grassland and Scrub***

The hillsides around the sloughs are dominated by non-native plant species, creating ruderal (or weedy) grassland and ruderal scrub. These hillsides were historically vegetated with native grassland, coastal scrub or oak woodland. As described earlier, many of these hillsides were farmed or grazed, thus altering these historic vegetation types. Currently most of the hillside are vegetated with dense thickets of annual, non-native grasses with invasive plants of poison hemlock, wild mustard, wild radish, Himalayan blackberry (*Rubus procerus*) and, in some areas periwinkle (*Vinca major).*

The watershed offers opportunities to restore these ruderal areas to an historic vegetation types. All areas would benefit by the removal/control of the invasive, non-native plant species.

*Brackish/Coastal Salt Marsh*

The brackish/coastal salt marsh occurs at the mouth of Watsonville Slough Estuary, downstream of the Shell Road pumping station and covers approximately 89 acres. The marsh is dominated by plant species tolerant of high salinity, such as pickleweed (*Salicornia virginica*), fleshy jaumea (*Jaumea carnosa*), alkali heath (*Frankenia grandiflora*), coastal gumplant (*Grindelia latifolia*) and salt grass (*Distichlis spicata*). This marsh receives seawater inflows from the Pacific Ocean and the Pajaro River lagoon (when the river is open to the ocean). Depending upon the tidal inundation level, mud flats may be visible adjacent to the marsh plain. Pickleweed is adept at colonizing these open areas, and its extent depends upon the duration and magnitude of tidal inundation.

The brackish/coastal salt marsh within the watershed has been significantly reduced in distribution since pre-European settlement. Historically, the marsh occupied a large area at the confluence of Watsonville Slough and the Pajaro River. Agricultural uses and construction of a levee confined the eastern extent slough; development of the Pajaro Dunes residential area confines its western extent. Other land uses in the wetland areas have also affected the area; an old racetrack occurred in the marsh areas in the mid 1900's.

The marsh plain was observed to support some occurrences of invasive, non-native plant species. Iceplant was observed in several locations opposite the Pajaro Dunes development. The levee slopes were observed to support stands of poison hemlock, wild mustard and wild radish. Non-native plantings of myoporum (*Myoporum*sp.) and Monterey cypress (*Cupressus macrocarpa*) were also observed adjacent to the marsh. The watershed offers several opportunities for restoration of the brackish/salt water marsh areas through the removal of occurrences of invasive, non-native plant species, creation of lower marsh plain areas to increase habitat diversity and expansion of the marsh through the modification of the existing levees.

All brackish/salt marsh areas are identified as "sensitive habitat" in the County of Santa Cruz County Code.

*Seasonal Wetlands*

The small seasonal wetlands and hillside seeps within the watershed create microhabitats where subsurface water is available for plant growth during most of the growing season. This hydrologic regime supports a dense growth of plant species typical of a wet meadow or seasonal wetland. These conditions include periods of ponded water, saturated soil conditions and dominance by hydrophytic (i.e., "water-loving") plant species**.**

Typical plant species observed in the seasonally wet areas include spreading rush (*Juncus patens*), rabbittsfoot grass (*Polypogon monspeliensis*), curly dock, common monkey flower (*Mimulus glutattus*), pennyroyal (*Mentha pulegium*), brown-headed rush (*Juncus pynocephalus*), sedge (*Carex* sp.), common rush (*Juncus effusus)* and meadow barley (*Hordeum branchyantherum*). Seasonal wetlands were observed amid the grasslands in the Larkin Valley Road area and in some areas abutting the sloughs. Seasonal wetlands area also known from the terrace tops in the Airport Road area. The City of Watsonville owns land that supports seasonal wetlands.

Invasive, non-native plant species are not prevalent in the seasonal wetlands, however, the wetlands were observed to support patches of velvet grass (*Holcus lanatus*) and Harding/canary grass.

Seasonal wetlands are identified as "sensitive habitat" in the County of Santa Cruz County Code.

### Sensitive Plant Communities

Sensitive habitats are defined by local, State, or Federal agencies as those habitats that support special status species, provide important habitat values for wildlife, represent areas of unusual or regionally restricted habitat types, and/or provide high biological diversity. Seven of the principal plant communities on the Watsonville Sloughs Watershed lands – riparian woodland, coast live oak woodland, freshwater marsh, seasonal wetlands, coastal salt marsh, central dune scrub and central maritime chaparral – are designated as a high priority in the CNDDB (CDFG 2000). This category contains native plant communities that are regarded by CDFG as having special significance under the California Environmental Quality Act (CDFG 1995a). Riparian and wetland habitats, as well as the San Andreas live oak woodland and central maritime chaparral, are also considered sensitive under County of Santa Cruz Code.

**Riparian Forests.** The riparian forests are all considered sensitive habitats according to the City of Santa Cruz and CDFG. This status is due to the value of these forests to wildlife and the relatively limited (and declining) distribution of this habitat at the local and statewide level. These habitat types are considered to be areas of high biological quality, warranting preservation and management.

**Freshwater Marsh, Coastal Salt Marsh and Seasonal Wetlands.** The wetlands within the watershed are typical of similar areas in California. Due to the large size of the Watsonville Slough complex, however, this wetland feature is a significantly important in wetland areas. Since land uses have reduced the distribution and habitat quality of most wetlands in the region, the State, County of Santa Cruz, CDFG and the COE consider wetlands of all types sensitive.

**Central Maritime Chaparral.** The central maritime chaparral is an uncommon plant community found only in Southern Santa Cruz County and Northern Monterey County. Central maritime chaparral is considered a "threatened" plant community by the California Department of Fish and Game (CNDDB 2000). The chaparral may also support special status species endemic to sandy soil conditions, such as robust spineflower and Hooker's manzanita.

According to the CNDDB, Hooker's manzanita–dominated chaparral is more restricted in its distribution within the central maritime chaparral; this manzanita is restricted to the greater San Andreas region of Santa Cruz County and portions of north Monterey County. Due to the presence of Hooker's manzanita (and/or other rare species), the County of Santa Cruz considers this plant community a "special forest". The County's designation is intended to recognize the unique habitat qualities (including rare species) of the woodland/chaparral mosaic and limit disturbances to the habitat type through restrictions on land uses.

**San Andreas Live Oak Woodland.** The County of Santa Cruz considers this woodland a "special forest". This status is due to the unique habitat structure of the woodland, the presence of central maritime chaparral species within the understory and the known or potential for the woodland mosaic to support special status plant species (i.e., Hooker's manzanita and robust spineflower). The County's designation is intended to recognize the unique habitat qualities (including rare species) of the woodland/chaparral mosaic and limit disturbances to the habitat type through restrictions on land uses.

### Special Status Plant Species

Some of the watershed lands provide habitat for plant species of concern, including those listed by the USFWS, CDFG and/or CNPS as rare, threatened or endangered. In addition, some of the lands provide habitat for plants recognized as rare or locally unique by CDFG or CNPS.

There are several special status plant species known or with potential to occur in the vicinity of the watershed. Three of these, the robust spineflower, Monterey spineflower, and Santa Cruz tarplant are federally listed species (listed as endangered and threatened, respectively) and are known to occur in the watershed. The Santa Cruz tarplant is also listed as endangered by the State of California. As discussed under the plant community descriptions, the Hooker's manzanita (CNPS List 1B, no State or Federal listing) has also been documented (and was observed) in the watershed area. Special status species also occur immediately adjacent to the watershed in the Sunset State Beach area (e.g.,. coast wallflower, Monterey spineflower and sand gilia) and in the Ellicott pond area on San Andreas Road (e.g., Kellogg's horkelia and robust spineflower).

In addition to listing at the State and Federal level or on CNPS List 1B, there are species that local botanists and local chapters of the California Native Plant Society consider to be specialty plants of the region. Such species may have limited occurrences within the Santa Cruz Mountains (locally rare), or may be endemic to the watershed land area. These plants are typically on CNPS List 4, a watch list. Artist's popcorn flower (*Plagiobothrys chorianus*) is known to occur in the grasslands at Watsonville Airport.

Plant species of concern include those listed by either the Federal or State resource agencies as well as those identified as rare by CNPS (Skinner & Pavlik 1994). The search of the CNPS and CNDDB inventories, as well as the review of previous reports, resulted in several special status species of concern with potential to occur in the watershed area.

**Santa Cruz tarplant** (*Holocarpha macradenia*). The Santa Cruz tarplant is State-listed as endangered and Federally listed as threatened. The species is currently known from 12 native populations and 6 experimental seedings. Six of the native populations occur around the City of Santa Cruz (USFWS 1998). Seven populations are currently known to occur within the Watsonville Sloughs Watershed.

Historically, the species occurred amid a coastal terrace prairie and grew in openings amid the perennial bunch grasses and native forbs. Although there is no historical documentation on the pre-European era distribution of the species, many botanists believe the species was more widespread and occurred on both the terrace tops and side slopes in the lower watershed. With the advent of intensive cattle grazing during the land grant/rancho period and subsequent conversion of the flat terrace grasslands to agriculture, it can be speculated that the prairie grasses declined and the tarplant was relegated to the terrace side slopes, where most of the colonies are found today. In recent history (1900's), cattle grazed these sites, which was a beneficial management regime for the tarplant. As land use patterns changed in the project area and cattle grazing was terminated at most sites, population size decreased due to competition with non-native grasses. The exception is at Watsonville Airport where the grassland has been consistently mowed and the species is thriving.

To date, the consultants are not aware of any significant active management actions having occurred at the other tarplant areas. Management is currently proposed for the Struve Slough population (occurrence #34) as part of a residential development agreement. Historically this site supported over 400,000 plants (1989). While only one tarplant was observed at this site in 1994, viable seed is expected to be present in the soil. Recent studies have suggested that the seed bank may be viable for as much as 10 to 15 years. Experimental grassland management actions conducted by the City of Santa Cruz at Arana Gulch have yielded positive results. At this location, scraping, burning and mowing of the grassland have been shown to create a microhabitat suitable for the germination of the soil seed bank and a revival of the tarplant colony.

Since the Santa Cruz tarplant is an annual species, the size of the population is dynamic with slight shifts in location according to the environmental conditions of a given year.

The watershed offers several opportunities for the management and preservation of this species. Funds to implement these actions may also be available from State, federal and private sources due to the protected status of the species and the agencies' interest in species recovery.

The tarplant populations are known by their CNDDB occurrence number; each of these colonies is described below:

- Occ. #5: This population is located between the Apple Hills Condominiums and Highway 152. Historically comprised of three colonies; the population is now reduced to one after the other two were destroyed by the housing development in the mid 1980's. The last census of this area revealed 700 plants (1995), down from a high of 4,000 plants in 1986. The current threats at this locality are non-native grasses and disturbances from nearby land uses.
- Occ. #9: This is a historical record from along Freedom Boulevard. These occurrences are believed to be extirpated.
- Occ. #13: This occurrence is located at Westgate and Anna Street and historically supported 3 or 4 subpopulations. The population was partially destroyed in the mid 1980's for construction of an industrial park. The last census of this area revealed

plants in 1992, the seed bank is expected to be intact. The current threat at this locality is non-native grasses and disturbances from nearby land uses.

- Occ. #22: This occurrence is in the Clifford and Arthur Road area. Tarplants were last observed in 1986; most of the population was destroyed by a housing development in the mid 1980's.
- Occ. #34: This population is located along a hillside along Struve Slough. Historically this site supported over 400,000 plants (1989). While only one tarplant was observed at this site in 1994, viable seed is expected to be present in the soil. The current threat at this locality is non-native grasses and disturbances from nearby land uses.
- Occ. #40: This is a population along the east side of Harkins Slough, just south of Harkins Slough Road. Historically this site supported over 15,000 plants (1993); 40 plants were observed in 1990. The current threat at this locality is non-native grasses
- Occ. #45: This locality is at Watsonville Airport. At this location the tarplant grows amid a coastal terrace prairie dominated by California oatgrass and purple needlegrass. Approximately 28 million plants within approximately 150-acre area were observed in 1998. This site is being mowed and grazed.

**Hooker's manzanita (*Arctostaphylos hookeri*).** This species of manzanita grows in sandy substrate in southern Santa Cruz and northern Monterey Counties. It is often associated with San Andreas live oak woodland/central maritime chaparral mosaic, where it forms dense thickets in the understory and adjacent to the woodland. This species is listed as rare (List 1B) by the California Native Plant Society and is considered rare by the County of Santa Cruz and California Department of Fish and Game. The species is not listed under either the California Endangered Species Act or the Federal Endangered Species Act. As discussed previously, the species is known to occur within along the ridge between Highway 1 and Larkin Valley Road (several populations/subpopulations) and in the Fiesta Way/Ranch Road area of the watershed. The watershed is believed to support several thousand plants.

**Robust spineflower (*Chorizanthe robusta* var. *robusta*)**. This species is federally listed as endangered. This species is also listed as rare (List 1B) by the California Native Plant Society

and is considered rare by the County of Santa Cruz and California Department of Fish and Game. The species is not listed under the California Endangered Species Act. The plant grows in sandy soils within this portion of Santa Cruz County; the species is known to occur within the East Del Mar Avenue and Fiesta Way regions of the watershed. The species is also known from areas that abut the watershed, such as near Freedom Boulevard (Aptos), Sunset State Beach, San Andreas Road (Ellicott Pond area) and Freedom Boulevard (USFWS 2000). A member of the Polygonaceae family, the species is characterized by its low-growing habit and spiny bracts surrounding the flowers. The species tends to occur in open areas. Open areas within the live oak woodland and maritime chaparral provide habitat for this species.

**Monterey spineflower.** The Monterey spineflower (*Chorizanthe pungens* var. *pungens)* is in the same family as the robust spineflower. It too grows in sandy soils, however, is more typically found closer to the ocean, growing on back dune areas and coastal dune scrub. There are four records of this species occurrence in the watershed lands. Three occurrences are east of Highway 1 in the Mar Monte and East Del Mar Road area and south and east of Freedom Boulevard. Another known occurrence is in the Fiesta Road area where the plant grows with Hooker's manzanita. Other known records for this species are in the Sunset State Beach area (CNDDB 2001)(just north of the watershed boundary) and near Ellicot Pond, which is outside the watershed area.

**Sand Gilia.** This plant grows in the dunes and dune scrub habitat. It is known from Sunset State Beach (just outside the watershed). The small dune scrub areas in the watershed offer potential habitat, yet no gilia plants have been observed here.

**Kellogg's Horkelia.** This member of the rose family is known from the Fiesta Way region of the watershed. It was recorded from areas supporting robust spineflower and Hooker's manzanita.

**Coast Wallflower.** This plant grows in the dunes and dune scrub habitat. It is known from Sunset State Beach (just outside the watershed) growing with sand gilia and robust spineflower. The small dune scrub areas in the watershed offer potential habitat, yet no wallflower plants have been observed here.

### Invasive, Non-Native Plant Species And Pathogens

Several invasive non-native species have become established in several of the plant community types with the watershed. Invasive, non-native plant species observed within the watershed include:

- French broom (Genista monspessulana),
- pampas grass (Cortederia jubata),
- periwinkle (*Vinca major*),
- poison hemlock (*Conium maculatum*)
- German ivy (Senecia mikanoides),
- English ivy (*Hedera helix*),
- Italian thistle (*Carduus pynocephalus*),
- yellow star thistle (Centaurea soltitialis),
- Acacia *(Acacia* sp.),
- Monterey pine (*Pinus radiata*), and
- eucalyptus (Eucalyptus globulus)
- ice plant (sea fig) (*Carpobrotus edulis*)
- wild mustard (*Brassica* spp.)
- wild radish (*Raphanus sativus*)
- teasel (*Dipsacus fullonum* and *D. sativus*)
- Harding and canary grass (*Phalaris* spp.)

### Role Of Fire For Biodiversity

The upper watershed lands support plant communities that are adapted to natural fire. The disturbance of the community by fire creates openings in the woodland or scrub for both herbaceous and woody plants to grow, facilitates the release of seeds from some woody plant species and rejuvenates the habitat. The central maritime chaparral, the San Andreas live oak woodland/maritime chaparral complex and grasslands are native plant communities specifically adapted to natural fire. The Eucalyptus tree groves and Monterey pine tree groves are two non-native plant communities that are also adapted to natural fire.

The County of Santa Cruz Code recommends that a prescribed fire program be implemented within the central maritime chaparral community. This recommendation acknowledges that chaparral communities are adapted to periodic fire and that the effects of fire are important in the evolution and health of the chaparral plant species. Sclerophyll shrubs (e.g., chamise and manzanitas) have small, thick evergreen leaves as an adaptation to Mediterranean type climates. Fire is an environmental stress factor and has a leading role in determining the species composition within shrublands. Non-stump sprouting manzanitas (e.g., Hooker's manzanita) reproduce by seeds that require heat or other disturbance to germinate. Fire mechanically damages the seed coat or breaks down the seed's oils, making it permeable to water and germination. Crown (or root)-sprouting shrubs (such as chamise and some manzanitas) readily re-grow following a fire. Fire also benefits the chaparral by clearing an area, allowing light to enter and nutrients to be returned to the soil. Many "fire-following" annual plant species and short-lived subshrubs also benefit as open areas are created for seed germination and plant growth. Open areas are favored by the robust spineflower for colonization. In the absence of fire, fuel lands accumulate beyond the "ready to burn" point, and the inevitable fire may severely damage the vegetation. Prescribed burning has not been practiced within the watershed and the most recent fires have been accidental occurrences (man-induced). The fire suppression activities used to combat these unplanned events can result in unplanned ecological effects. For example, bulldozer-created firebreaks result in relatively large landscape alterations or open ground scars, which may become infested by dense stands of invasive species, such as French broom.

Native eucalyptus and Monterrey pine forests are also adapted to periodic fire. The pine tree's early senescence and its susceptibility to pine pitch canker, leads to favorable conditions for fire. As a result, the Monterey pine has adapted to this regime by having cones release large quantities of seed following a fire, enabling the seeds to germinating in open areas. Native eucalyptus forests are also accustomed to periodic fire. The bark peels and thick litter beneath the canopy create conditions conducive to large, crown fires. Like the Monterey pine, the blue gum eucalyptus seeds are adapted to this regime and are capable of germinating in the open, fire-scorched soil.

### Pathogens

A fungus responsible for California Oak Mortality (COM), formerly known as Sudden Oak Death (SOD) is a water mold fungus in the genus *Phytophthora*. This fungus has been reported from northern Santa Cruz County and may occur in the watershed. Although no trees were observed with obvious signs of COM during the 2000/2001 field surveys, it may occur in the oak woodland, especially in areas frequented by vehicles.

If COM becomes prevalent within the watershed area in the future, significant areas of oak woodland would be susceptible to death. Opportunities exist in the watershed to inform property owners on measures to prevent/control the spread of this fungus.

### References

California Department of Fish and Game. 1995-2001. California Natural Diversity Database. http://www.dfg.ca.gov/whdab/html/cnddb.html

California Native Plant Society. 2000. Rare Plant Electronic Inventory. http://www.cnps.org/rareplants/inventory/inventory.htm

Hickman, J.C. 1993. *The Jepson Manual: Higher Plants of California*. University of California Press: Berkeley, CA.

Skinner, M.W. and B.M. Pavlik (eds.). 1994. Inventory of Rare and Endangered Vascular Plants of Calif. CNPS Special Publication No. 1 (5th Ed.), California Native Plant Society, Sacramento, California.

U.S. Fish and Wildlife Service. 1998. Federal Register Vol. 63, No. 60: March 30, 1998.

U.S. Fish and Wildlife Service. 2000. Federal Register Vol. 65. http://www.gpo.gov/su_docs/aces/aces140.html

U.S. Fish and Wildlife Service. 2001. Federal Register Vol. 66, No. 32: February 15, 2001.

**Technical Appendix C: Wildlife Resources**

Dana Bland of Dana Bland and Associates prepared the following section on Wildlife Resources.

On a regional basis, the marshes of the Watsonville Sloughs Watershed are extremely important to wildlife. This area is the largest complex of freshwater marsh habitat between Pescadero Marsh on the north and Elkhorn Slough on the south (Busch 2000). The centerpiece of the Watsonville Sloughs Watershed for wildlife resources is the freshwater marsh portion of the Sloughs, and includes the marsh areas fringed by willow riparian woodland. These are the most biologically productive areas of the watershed with the highest abundance and diversity of wildlife. The marshes are important to resident wildlife and also support migrating species by providing plentiful food, cover and open water-resting areas, critical for species' success in reaching their breeding/wintering grounds. The abundant food sources within the marshes and open water areas of the Sloughs support a wide variety of wintering birds in preparation for their upcoming breeding season.

The marshes and associated grassland/scrub habitats also attract a number of foraging animals that are residents of nearby woodlands and chaparral. The Slough channels, with their adjacent riparian habitats, provide natural movement and dispersal corridors for resident wildlife. The value of contiguous habitat continues to increase as highways and urban development dissect portions of the landscape.

The demands and impacts of nearby urban and agricultural land uses adversely affect the wildlife of the Watsonville Sloughs Watershed. Draining and diverting water can leave marsh areas too dry for wintering waterfowl during critical times of year and can result in poor water circulation. Nutrient enrichment from urban and agricultural inputs, coupled with stagnant water, can result in extreme eutrophication of these waters. Eutrophic conditions, characterized by dense algal mats, can result in the depletion of dissolved oxygen in the water column and the die off of aquatic fauna. Pesticides and herbicides from agricultural runoff can be toxic to local invertebrates and aquatic species and can

bioaccumulate up the food chain, adversely affecting higher trophic levels. Encroachment of urban development around the edges of the Sloughs can present barriers to wildlife movement, and often leads to the proliferation of more aggressive, urban tolerant, invasive wildlife species. Fragmented habitat areas may be too small to support wide-ranging top predators. This can lead to a rise in the number of meso-predators and increase the predation pressure on smaller animals, beyond the level their population can normally sustain.

The following chapters discuss the existing conditions of wildlife resources in the Slough watershed, opportunities and constraints to sustaining and improving wildlife resources, and specific wildlife resource management recommendations with priorities for implementation.

**Methods**

Dana Bland & Associates conducted the wildlife resources analysis. Study methodology included field reconnaissance surveys to assess current habitat values for wildlife, literature review, aerial photograph interpretation to map existing conditions for wildlife, and searches of electronic databases. Literature and data base searches included the California Natural Diversity Data Base (CNDDB) "RareFind" (2001), and previous reports prepared for the Slough watershed. Reconnaissance field assessments of the wildlife resources within the Watsonville Sloughs Watershed were conducted by Dana Bland, wildlife biologist, in the winter 2000 and spring 2001, after which a draft existing conditions report was prepared.

Additional information on the bird resources of the project area was prepared by David Suddjian, local ornithologist, and are presented in Technical Appendix G.

Prior to conducting field surveys, a potential list of special status wildlife species was prepared, which included species with special protected status under California Department of Fish and Game and/or U.S. Fish and Wildlife Service The occurrence and distribution of special status species was recorded from previous data and updated, based on reconnaissance-level 2000 and 2001 observations. No focused species surveys were conducted for wildlife for this report, as this report intends to summarize over 200 species from four major taxa (amphibians, reptiles, birds, and mammals). It was not within the scope of this study to conduct focused species

surveys for this wide variety of wildlife. Each species, or group of species, requires special survey techniques, and to cover each of the 8 slough systems over all the ideal time periods needed to detect these species was not within the time line or scope of this project, i.e., was not practical. However, opportunities to coordinate with local schools, colleges and universities for assistance in conducting long-term monitoring are discussed below.

### Special Status Wildlife Species and their Predicted Occurrence in the Watsonville Sloughs Watershed, Santa Cruz County, CA

The information gathered from literature review, consultations with experts, and field reconnaissance surveys was used to describe the existing conditions of the wildlife resources and recommendations for resource management. Previous reports for the study area that were reviewed included: *Draft Water Resources Management Plan for the Watsonville Sloughs Wetland System* (Questa Engineering Corp. 1995), *Revised Draft Environmental Impact Report, Proposed Third High School Site at Harkins Slough Road, Watsonville, California* (Envicom Corp. 1998), *Final Report, Conceptual Wetland Restoration Plan for MF Farming Property* (John Gilchrist & Assoc. 2001), *Draft Watsonville Slough Planning Study* (Busch 1986), *Waterfowl Habitat Use in Three Coastal Freshwater Sloughs* (Busch 1985), and *Santa Cruz Kangaroo Rat Survey, Buena Vista Country Club Site, Santa Cruz County, California* (Biosearch Wildlife Surveys 1996).

### General Habitat Descriptions

A general description of the wildlife by habitat type is given below. The fishery resources are discussed in a separate section.

**Coastal Dune Scrub:** The wildlife that inhabit the coastal dune scrub are able to tolerate the arid climate, sandy soil and salt spray. Common species such as white-crowned sparrow (*Zonotrichia leucophrys*) and deer mouse (*Peromyscus maniculatus*) may forage for seeds in this habitat, Anna's hummingbird (*Calypte anna*) may find nectar on some plants, and western fence lizard (*Sceloporus occidentalis*) may forage on insects.

**Coastal Salt Marsh:** The coastal salt marsh is a biologically productive habitat, and consequently, a wide variety of wildlife species utilize this habitat type. Snakes hunt for small mammals at the edges of salt marsh, shorebirds forage for invertebrates in the exposed mud of the salt marsh at low tide, herons and egrets forage for fish in the channels, secretive rails may inhabit the denser stands of salt grass, and raccoons may hunt along the shorelines at night. The overall value to wildlife of the coastal salt marsh of Watsonville Slough Estuary is adversely affected by pesticide runoff from adjacent agricultural lands, reducing the invertebrate fauna on which many vertebrates forage. The narrow width of the vegetated channel also places a constraint on the available habitat within the estuarine portion of the watershed. Common wildlife in this habitat include gopher snake (*Pituophis melanoleucus*), western aquatic garter snake (*Thamnophis couchii*), great blue heron (*Ardea herodias*), snowy egret (*Egretta thula*), mallard *(Anas platyrhynchos*), willet (*Catoptrophorus semipalmatus*), black-necked stilt (*Himantopus mexicanus*), Virginia rail (*Rallus limicola*), belted kingfisher (*Ceryle alcyon*), cliff swallow (*Hirundo pyrrhonota*), ornate shrew (*Sorex ornatus*), harvest mouse (*Reithrodontomys megalotis*), and raccoon (*Procyon lotor*).

**Fresh Water Marsh/Open Water:** The freshwater marshes and ponds of the Sloughs provide important foraging and breeding areas for a variety of wildlife species. The presence of wetland plants such as cattails, bulrush, and willows directly increase the wildlife value of the marsh. Wetland vegetation provides cover, breeding sites and a food base of a diversified aquatic invertebrate fauna, the basis of many food webs. The Sloughs provide important wintering (Busch 1986) and breeding habitat (Busch 1985) for a number of waterfowl. The abundance of waterfowl attracts predators such as hawks and falcons. Wildlife from adjacent upland habitats are attracted to the marsh areas for drinking water and foraging opportunities. The wildlife value of the freshwater marsh habitats can be impaired by periods of oxygen depletion, artificial lowering of water levels by pumping, the build up of pesticides that may limit invertebrate fauna, and the presence of non-native predator species. The overall health of the Sloughs is constrained by the close proximity to urban and agricultural development.

Common native wildlife species that are known to utilize the freshwater marsh habitat of the Watsonville Sloughs Watershed include Pacific tree frog *(Hyla regilla)*, western toad (*Bufo boreas*), western aquatic garter snake (*Thamnophis couchii*), green heron (*Butorides striatus*), black-

crowned night-heron (*Nycticorax nycticorax*), mallard *(Anas platyrhynchos)*, ruddy duck *(Oxyura jamaicensis)*, cinnamon teal (*Anas cyanoptera*), northern shoveler (*Anas clypeata*), gadwall (*Anas strepera*), American coot (*Fulica americana*), Virginia rail (*Rallus limicola*), red-winged blackbird *(Agelaius phoeniceus)*, black phoebe *(Sayornis nigricans)*, cliff swallow *(Hirundo pyrrhonota)*, raccoon (*Procyon lotor*),Virginia opossum (*Didelphis virginiana*), and several species of bats.

**Seasonal Wetlands:** The seasonal wetlands in the watershed are mostly small hillside seeps, like Larkin Valley. They provide seasonal surface water for wildlife, breeding sites for some amphibians, and aquatic invertebrate fauna as a food base for several vertebrates. Common wildlife species that may utilize seasonal wetlands in the watershed include Pacific tree frog *(Hyla regilla)*, western toad (*Bufo boreas*), western aquatic garter snake (*Thamnophis couchii*), black phoebe *(Sayornis nigricans)*, cliff swallow *(Hirundo pyrrhonota)*, raccoon (*Procyon lotor*), and several species of bats.

**Willow Riparian Scrub:** The riparian habitat is one of the highest valued habitats for wildlife species diversity and abundance in California. Factors that contribute to the high wildlife value include seasonal presence of surface water, variety of niches provided by the high structural complexity of the habitat, and abundance of plant growth. Riparian habitat along the Sloughs may be used by a diversity of wildlife species for food, water, escape cover, nesting, and thermal cover. The willow thickets along the Sloughs also provide a buffer for wildlife from adjacent urban and agricultural uses.

Common wildlife species that are expected to inhabit the riparian habitat include Pacific treefrog *(Hyla regilla),* western aquatic garter snake (*Thamnophis couchii*), Wilson's warbler *(Wilsonia pusilla),* Bewick's wren (*Thryomanes bewickii*), several swallows, raccoon (*Procyon lotor*), Virginia opossum (*Didelphis virginiana*), and California myotis (*Myotis californicus*).

**Coastal Maritime Chaparral:** The berries of shrubs and the seeds of herbaceous plants in the coastal scrub habitat provide important forage for wildlife. Wildlife may perch on the outer perimeter of mixed scrub to take advantage of hunting opportunities in adjacent openings or take cover in the denser shrub patches as needed. Common wildlife species

found in coastal scrub include western fence lizard, California towhee *(Pipilo crissalis)*, white-crowned sparrow (*Zonotrichia leucophrys*), and coyote (*Canis latrans)*.

**Coast Live Oak Woodland:** The wildlife value of oak woodland varies with the degree of canopy cover and the density and diversity of understory plants. Acorns from oaks provide important food resources for many wildlife species and natural cavities in the oaks provide nesting opportunities for some birds and mammals. Snags are an important component of oak woodlands for some wildlife, such as woodpeckers, which excavate nests in snags and holes for storing acorns. Downed decaying logs and limbs add to the structural complexity of the habitat and are an important cover, nesting, roosting, and foraging substrate for species, such as newts, which are attracted to the moist microclimate and invertebrate food supply. The denser oak woodlands also provide escape cover during the day for species such as deer.

Common wildlife species expected to occur in oak woodlands in the watershed include California slender salamander (*Batrachoseps attenuatus*), Ensatina (*Ensatina eschscholtzi*), western fence lizard (*Sceloporus occidentalis*), scrub jay (*Aphelocoma coerulescens*), California quail *(Callipepla californica*), red-tailed hawk *(Buteo jamaicensis*), western gray squirrel (*Sciurus griseus*), woodrat (*Neotoma fuscipes annectens*), and deer *(Odocoileus hemionus*).

**Grassland/Ruderal:** Grasslands provide an important foraging resource for a wide variety of wildlife species. The grasses and forbs produce an abundance of seeds and attract numerous insects, providing food for granivorous and insectivorous wildlife. Sparrows, rabbits and rodents are commonly found in this habitat. Consequently, grasslands are valuable foraging sites for raptors such as hawks and owls, and other predators including coyote, fox, skunk and snakes. Aerial foraging species flying over grasslands include bats and swallows.

Common wildlife species that utilize grassland habitat in the watershed include western fence lizard (*Sceloporus occidentalis*), gopher snake (*Pituophis melanoleucus*), house finch *(Carpodacus mexicanus)*, western meadowlark *(Sturnella neglecta)*, cliff swallow *(Hirundo pyrrhonota)*, red-tailed hawk *(Buteo jamaicensis)*, California ground squirrel *(Spermophilus beecheyi)*, and Botta's pocket gopher (*Thomomys bottae*).

**Landscaping:** Wildlife use of the landscaping plants is expected to be low because many are non-native plants not frequented by native wildlife species. Most are single shrubs or trees interspersed among an otherwise urbanized or developed area, providing little vegetative cover for wildlife. Urban adapted species such as scrub jay (*Aphelocoma coerulescens*) and European starling (*Sturnus vulgaris*) may use the landscaped areas as perches, and these, as well as other birds, may occasionally forage on berries or nectar of some plants.

**Agricultural:** The agricultural lands in the watershed provide limited habitat for native wildlife. The discing of the soil for row crops reduces habitat for ground burrowing animals and the application of pesticides may reduce the invertebrate fauna several types of wildlife depend upon for forage. Agricultural fields also often attract non-native wildlife such as European starling (*Sturnus vulgaris*), Norway rat (*Rattus norvegicus*), and feral pigs (*Sus scrofa*).

**Eucalyptus/Monterey Pine Groves:** Eucalyptus is a non-native species to California. Common wildlife species that utilize eucalyptus and Monterey pine groves include alligator lizard (*Gerrhonotus multicarinatus*), Anna's hummingbird (*Calypte anna*) and woodrat. Eucalyptus trees are locally important as they provide potential wintering habitat for monarch butterflies (*Danaus plexippus*). The eucalyptus and Monterey pine groves in the watershed also provide potential roosting and nesting habitat for raptors such as red-tailed hawk, red-shouldered hawk (*Buteo lineatus*) and great horned owl (*Bubo virginianus*).

### Special Status Wildlife Species

Special status wildlife species include candidate species for listing, those formally proposed for listing, or those listed as threatened or endangered under either state or federal endangered species laws. Species listed by the State as California Species of Special Concern also receive special protection under CEQA review standards. Migratory birds are protected under the Migratory Bird Treaty Act and all raptor nests are protected by CDFG Code. Wildlife species identified as sensitive by the Santa Cruz Mountains Bioregional Council (1999) are also included here. Below is a brief summary of the ecology of each species, their special status, their primary habitat requirements, and known or expected occurrence within the watershed.

Several special status wildlife species with habitat ranges that include the Watsonville Sloughs Watershed were evaluated for their potential occurrence on site. However, the critical habitat features for these species were not found on the watershed lands to-date, and thus the following species are not presently considered potential inhabitants of the watershed lands: Common loon (expected as winter resident, but not as nesting), white-faced ibis (expected as occasional winter transients, but no breeding or rookery habitat present), Snowy plover (known to nest in dunes on beach to west of mouth of Watsonville Slough, but no habitat within the slough watershed project), California least tern (nesting only now known at south end of San Francisco Bay), long-billed curlew (nesting not known along this coast, but may be winter resident), Black tern (extirpated from breeding in the central coast), and Santa Cruz kangaroo rat (area lacks sandy soils required by this species for burrows)

Monarch butterflies (*Danaus plexippus*) migrate to central California and overwinter in Eucalyptus, pine and acacia trees. They are present in Santa Cruz County between September 1 and March 1 and prefer dense stands of trees that provide protection from the wind. The California Department of Fish and Game (CDFG) recognizes monarchs as a "Special Status Animal" because their winter residence in California represents a critical stage in their life cycle and habitat continues to decline as a result of land development.

Monarchs inhabit some Eucalyptus/pine groves with adequate wind protection within the study area, but recent surveys to establish occupied groves have not been conducted (CDFG 2001).

Santa Cruz long-toed salamanders spend most of the year in upland refugia. They use small mammal burrows or hide under dense leaf litter and rotting logs. This salamander prefers riparian, oak woodland and coastal scrub for upland habitat. During rainy winter nights, adult salamanders travel from their upland refugia to temporary or semi-permanent ponds to breed. Santa Cruz long-toed salamanders have been documented to travel as far as 0.6 mile from upland habitat to breeding ponds (Ruth 1989). Females lay eggs singly on stalks of submerged vegetation and the eggs hatch within 30 days. Larvae take up to 6 months to transform into juveniles, depending upon pond conditions. The juveniles then typically remain in the moist pond environs until the first fall rains, when they begin their dispersal to upland areas.

Santa Cruz long-toed salamanders are known to breed at the Buena Vista, Calabasas, and Gillette Road ponds within the Watsonville Sloughs Watershed (CNDDB 2001, A. Orten-palmer, pers. comm.). At the time of this report, they had not been observed within any of the Sloughs (S. Ruth, pers. comm.). Intensive surveys for Santa Cruz long-toed salamander were conducted at the West Branch Struve Slough in 1998-99 and again in 2001, but found no adults, juveniles or larvae (Dana Bland & Associates 1999, 2001). The presence of several non-native predators (e.g., bullfrog, signal crawfish, mosquitofish, etc.) and the limited amount of upland habitat adjacent to the lower Sloughs reduce the potential for occurrence of this very rare species within the main Sloughs. Upland habitat for this salamander around the known breeding ponds is considered a priority for conservation; corridors for salamander movement between known and/or potential breeding ponds is considered a priority for conservation. Areas within the watershed that need further study to determine presence/absence of this species include ponds and streams above Calabasas Pond, tributary to Gallighan Slough along Rancho Road, and stock ponds on the Tai property.

The California tiger salamander is a federal candidate for listing as endangered and a State species of special concern. This tiger salamander is a permanent resident of annual grasslands, foothill-valley woodlands, and is occasionally found along streams. Adults spend most of the year underground in mammal burrows, coming out at night to forage. The first heavy rains of winter initiate the migration of adults to permanent and temporary ponds, where breeding takes place from December to February (Stebbins 1985). Agricultural and urban development has reduced much of the former habitat of this species. Introduction of non-native fish, which prey on the salamander larvae, has devastated local populations (Shaffer et al. 1993).

California tiger salamanders are known to breed at the Buena Vista pond. Potential habitat for this species exists along portions of Struve, Harkins and Hanson Sloughs, although the abundance of non-native fish, bullfrog, and crawfish predators along with the limited amount of upland habitat reduces the value of these areas for this species.

The California red-legged frog is a State Species of Special Concern and Federally listed as threatened. This species is found in quiet pools along streams, in marshes, and ponds. Red-legged frogs are closely tied to aquatic environments and favor intermittent streams, including

some areas with water at least 2.5 ft. deep, a largely intact emergent or shoreline vegetation, and a lack of introduced bullfrogs and non-native fishes. This species' breeding season spans January to April (Stebbins 1985). Females deposit large egg masses on submerged vegetation at or near the surface. Embryonic stages require a salinity of $\leq$ 4.5 parts per thousand (Jennings and Hayes 1994). They are generally found on streams having a small drainage area and low gradient (Hayes and Jennings 1988). Recent studies have shown that although only a small percentage of red-legged frogs from a pond population disperse, they are capable of moving distances of up to 2 miles (Bulger 1999). The red-legged frog occurs west of the Sierra Nevada-Cascade crest and in the Coast Ranges along the entire length of the state. Much of its habitat has undergone significant alterations in recent years, leading to extirpation of many populations. Other factors contributing to its decline include its former exploitation as food, water pollution, and predation and competition by the introduced bullfrog and green sunfish (Moyle 1973, Hayes and Jennings 1988).

California red-legged frogs are known to occur in West Branch Struve Slough, Hanson Slough, Harkins Slough, Upper Harkins Slough at Calabasas pond (CNDDB 2001), and probably occur in Gallighan Slough, main branch Struve Slough and scattered ponds in Larkin Valley. Most of the Watsonville Sloughs Watershed is within the recently designated "critical habitat" for the California red-legged frog (USFWS 2001). Because this species occurs in areas both west of Highway 1 and northern portions of Harkins Slough, it should be considered a resident of all portions of the slough during certain times of year, except for the lower reach of Watsonville Slough that is too saline. California red-legged frogs probably breed in ponded or slow-moving waters of Watsonville Slough, Hanson Slough, Struve Slough, Harkins Slough and Gallighan Slough.

The southwestern pond turtle is a Federal and State Species of Special Concern. This aquatic turtle inhabits ponds, lakes, streams, marshes, and other permanent waters located in woodland, grassland, and open forests below 6,000 ft (Stebbins 1985). Pond turtles can often be seen basking in the sun on partially submerged logs, rocks, mats of floating vegetation or mud banks. During cold weather, they hibernate in bottom mud. The diet of these turtles consists of aquatic vegetation, insects, fish, worms, and carrion. Females dig soil nests in or near stream banks (Nussbaum et *al.* 1983). Eggs are deposited between April and August. One factor in

the decline of this species is the introduction of non-native fish, which prey on hatchlings and juveniles.

Pond turtles have not been documented in the area, but suitable habitat for the species exists in the deeper water portions of all the Sloughs. Nesting habitat for pond turtles is limited in the slough area to the grasslands/agricultural areas on the west side of Highway 1.

The black legless lizard is a California species of special concern. It was proposed for federal listing as endangered in 1995 (USFWS 1995), but it was subsequently determined that listing was not warranted as a large section of the former Fort Ord where this lizard occurs was preserved (USFWS 1998). The black legless lizard inhabits coastal dunes in Monterey County between the Salinas and Carmel Rivers (USFWS 1998). This lizard burrows into loose sand under plants including bush lupine, mock heather, and mock aster (Jennings and Hayes 1994). It hunts for its insect prey while concealed in the leaf litter below the plants.

The watershed's coastal scrub habitat adjacent to Sunset State Beach provides suitable habitat for black legless lizard, although the area has not to-date been surveyed for this species

California horned lizard is a California Species of Special Concern. This lizard is active between April and October, with mating occurring during April (Jennings and Hayes 1994). The young hatch in July and August. California horned lizards primary prey on ants, in addition to other insects. This lizard occurs in areas with exposed loose soils and scattered shrubs, including riparian habitat (e.g., cobble areas along rivers), chaparral habitat, annual grasslands, and alkali flats. During hibernation, this lizard uses small mammal burrows or burrows into loose soils under rocks or surface debris (Jennings and Hayes 1994). Habitat loss is believed to be the primary cause for decline in this species numbers (Jennings and Hayes 1994).

California horned lizard habitat within the watershed area includes the very short grassland areas west of Highway 1 that are grazed, although the area has not been extensively surveyed for this species

Double-crested cormorant rookery is listed as a California Species of Special Concern. This cormorant typically nests on offshore rocks or small islands, and occasionally on coastal cliffs (Roberson and Tenney 1993). They need nesting areas that are completely isolated from land predators such as raccoons. During non-nesting season, they roost on rock pilings at river mouths, such as at the Pajaro River/Watsonville Slough estuary. Double-crested cormorant are known as summer residents in Hanson Slough (Suddjian unpubl. field notes), and were observed roosting among the rock rip-rap and wooden post debris at the mouth of the Watsonville Slough during spring reconnaissance surveys

The black-crowned night heron (breeding populations only) is listed by the Santa Cruz Mountains Bioregional Council as a "sensitive fauna". Black-crowned night herons build nests in trees, and often favor Eucalyptus trees perhaps because the smooth bark discourages predators such as raccoons (Robison and Tenney 1993).

Black-crowned night herons are known be both winter and summer residents in Hanson Slough, and presumably breed where suitable trees are present in the sloughs (Suddjian unpubl. field notes).

The white-tailed kite does not have any special status, but is listed as a fully protected species by the CDFG for its nest sites. This bird usually nests in trees along riparian areas, willows and live oaks, and in oak savannah. The male parent does all the hunting while the female kite incubates the eggs and broods the nestings. They prefer nest trees with adjacent open fields for hunting. They build their large stick nests atop dead trees, large closed canopy trees such as live oak, or on poles, and will readily use artificial platforms. Nesting ospreys have declined in California because of the removal of nesting trees, degradation of river and lake environments, boating, and shooting (Remsen 1978). The favored prey of white-tailed kites is voles and mice. Nesting occurs from April through July. During fall and winter, kites form communal roosts (Roberson and Tenney 1993).

Known nesting habitat for white-tailed kite exists in the lower Harkins Slough and Watsonville Sloughs west of Highway 1 in the riparian habitat. Other areas with suitable habitat include Gallighan Slough and Hanson Slough, both west of Highway 1.

The osprey is a California Species of Special Concern for nesting sites. Most ospreys seen in the county are flying over, with few seen foraging. They build their large stick nests atop dead trees or poles, and will readily use artificial platforms. Nesting ospreys have declined in California because of the removal of nesting trees, degradation of river and lake environments, boating, and shooting (Remsen 1978).Osprey are known to winter in Hanson Slough (Suddjian unpubl. field notes), and with proposed restoration of slough habitat, the construction of nesting platforms at the confluence of Struve Slough and Watsonville Slough may enhance habitat for this species.

The northern harrier is a State Species of Special Concern. This bird is an uncommon permanent resident in open grasslands, marshy areas, and edges of estuaries in Monterey County (Roberson and Tenney 1993). Nesting begins in late March with young fledged during June and July. They build nests of sticks and grass on the ground hidden by tall grass or reeds. Harriers hunt a wide variety of prey, including other birds and small mammals. Primary threats to this species include loss of habitat, egg predation by non-native red fox, and poisoning by rodenticides and pesticides (Roberson and Tenney 1993).

Northern harriers do use the grasslands and Sloughs for foraging, and are expected to nest on the west side of Highway 1 where grasses are tall and dense.

The Cooper's hawk is a State species of special concern. Like the sharp-shinned hawk, this species is a rare breeder in the Santa Cruz Mountains, though somewhat more numerous than the former. Cooper's hawks prefer forested habitats in mountainous regions, but also use riparian woodlands. Cooper's hawks feed primarily on small birds, but also take small mammals, reptiles, and amphibians. Foraging occurs in both dense cover and open habitats. Nests are constructed in a variety of trees, but stands of live oaks may be preferred (Zeiner et al. 1990). Cooper's hawks build stick nests in similar situations as the sharp-shinned hawk and the nest site is vigorously defended by the adults. The local breeding season probably spans March/April through July (Suddjian 1990). Cooper's hawks are uncommon migrants and winter visitors. Migrant and wintering individuals occur in a variety of habitats, including oak woodland, conifer and mixed broadleaf forests, grasslands, residential areas and riparian

woodland. Habitat destruction and falconry practices have been attributed to this species' decline in California (Remsen 1978).

The Cooper's hawk is expected to nest in the riparian woodlands and oak woodlands along the Sloughs and winter along the Sloughs.

The sharp-shinned hawk is a State species of special concern. This species may be the rarest breeding raptor in the Santa Cruz Mountains (Suddjian 1990). Potentially suitable breeding habitat occurs over much of the forested mountainous terrain of the Santa Cruz Mountains. Sharp-shinned hawks prefer to build their stick nests in conifers in thick cover (Zeiner *et al.* 1990; Ehrlich *et al.* 1988). Migrant and wintering individuals frequent a variety of habitats, but favor edges of wooded habitats. Sharp-shinned Hawks prey mostly on small songbirds. The local breeding season spans April to July. This species is uncommon throughout the study region from September to early May. Sharp-shinned hawks are not expected to nest in the Watsonville Sloughs Watershed, but are expected to winter along the Sloughs.

Ferruginous hawk is a California Species of Special Concern for wintering populations. This species is a winter resident of the Central California Coast, and feeds primarily on small mammals. Ferruginous hawk are known to winter in Hanson Slough (Suddjian unpubl. field notes), and there is suitable wintering habitat for this species along Harkins Slough, West Branch Struve Sloughs and portions of Gallighan Slough.

The golden eagle is a State species of special concern. Golden eagles require large expanses of habitat as territory for feeding and nesting. Grasslands and open wooded habitats are needed for hunting, with ground squirrels and jackrabbits being the primary prey species of golden eagles. Nests are built at sites with a good view of the surrounding area, and are usually placed on cliffs, in trees, or occasionally on transmission towers. Golden eagles are very sensitive to human disturbance at nest sites. Agricultural and urban development of grasslands, as well as human persecution, has led to this species' decline in California (Remsen 1978, Clark and Wheeler 1987). Golden eagles are not expected to nest in the Watsonville Sloughs Watershed, but are expected to winter along the Sloughs.

Merlin is a State Species of Special Concern. This bird is a rare to uncommon spring and fall transient and winter visitor, occurring in California between late September to mid-April (Small 1994). They do not nest in California. Wintering individuals occur in a variety of habitats, including riparian, open woodlands, grasslands and agricultural fields, tidal estuaries, marshes, and developed areas. Merlins prey primarily on small birds, but also take small mammals and insects. Because they prey mostly on birds, merlins may be threatened by the use of pesticides (Remsen 1978). Merlins do winter along the Sloughs.

Prairie falcons are a State Species of Special Concern. This falcon nests on ledges of very tall cliffs, with open grasslands and open oak savannah for hunting nearby. Prairie falcons also take a wide variety of prey, including other birds, ground squirrels and jackrabbits. Nesting occurs from April to mid-June (Roberson and Tenney 1993). The local resident falcons are joined by migrants from further north during winter. Primary threats to this species include loss of foraging habitat adjacent to nest sites and pesticides (Roberson and Tenney 1993). Prairie falcons are winter residents in Hanson Slough (Suddjian upubl. field notes).

Peregrine falcons are State listed as an endangered species. Peregrines were removed from the federal endangered species list in 1999 because captive breeding, reintroduction, and banning of certain pesticides has resulted in recovery of the species over much of its former range. Peregrines are rare breeders on the central coast, currently known only to nest on inaccessible coastal cliffs between February and August (Roberson and Tenney 1993). During the non-breeding season, Peregrines forage for shorebirds and ducks at lakes, rivers and estuaries (Roberson and Tenney 1993). Peregrine falcons have been observed wintering along the Sloughs, but the Watsonville Sloughs Watershed area lacks the tall cliffs this species uses for nesting. Peregrine falcons are expected to be winter transients in the watershed area.

The California gull is a California Species of Special Concern for nesting colonies. This gull has historically nested at the salt ponds at Elkhorn slough, and probably nest along portions of Hanson and Harkins Sloughs. This is a ground nesting species and thus subject to egg and nestling predation. California gull are both winter and summer visitors to Hanson Slough (Suddjian unpubl. field notes), and suitable habitat for this species exists at Harkins Slough.

Burrowing owls are a California species of special concern and are also protected under the Migratory Bird Treaty Act. They inhabit annual or perennial grasslands or areas with less than 30 percent canopy coverage as a resting site during migration, as feeding habitat, and as a breeding ground. The nesting season for burrowing owls occurs between February 1 and August 31 and peaks around April 15-July 15 (California Burrowing Owl Consortium 1993). Burrowing owls nest in single pairs, or more often, in small colonies and make their nests in burrows created by fossorial mammals, artificial burrows (i.e. pipes), or crevices in piles of rubble (CDFG 1995). They forage nocturnally and crepuscularly for insects and small rodents. During the daylight hours burrowing owls may perch conspicuously either at the entrance to their burrow or on a nearby post or shrub (Zeiner et al. 1990). Burrowing owls have declined in recent decades throughout California. The primary cause of decline is attributed to habitat loss due to development (CDFG 1995). Burrowing owls historically occupied the grasslands surrounding the Sloughs, but may now be extirpated (Busch 2000).

Western kingbird is considered a sensitive species in the Santa Cruz Mountains Bioregion. This bird prefers open oak savannah habitats, feeding on insects from a variety of perches (Robison and Tenney 1993). The local breeding season spans April to July, with nests placed 8-40 feet above ground, usually on a horizontal branch or in the crotch between branches (Robison and Tenney 1993). Western kingbird may be extirpated as a breeding species in this part of Santa Cruz County.

The loggerhead shrike is a Federal and State species of special concern. Common residents of lowlands and foothills, this species prefers open habitats with scattered shrubs, trees, fences, or other lookout posts. Loggerhead shrikes occur only rarely in heavily urbanized areas. They hunt insects, snakes, small birds, and rodents that they often impale on thorns or barbed wire to hold it while they eat. Eggs are laid from March to May, with a clutch size of 4-7 eggs, in shrubs and trees with dense vegetation for concealment. The breeding season in Santa Cruz County spans April to late July (Suddjian 1990). Suitable breeding habitat for the loggerhead shrike exists in the dense shrubs of the scrub habitat along Harkins Slough and portions of West Branch Struve Slough and suitable foraging habitat exists in the adjacent grasslands along the Sloughs.

The California horned lark is a California Species of Special Concern. These larks are common permanent residents of grasslands with short vegetation. The build a shallow cup nest in very short grass or on bare ground, and breeding takes place from mid-March to mid-May. The primary threat to this species is loss of habitat due to urbanization (Roberson and Tenney 1993). Horned larks may be extirpated as a breeding species in this part of Santa Cruz County.

Saltmarsh common yellowthroat is a California Species of Special Concern. This species utilizes freshwater marsh habitat and is easy to identify by the male song. They prefer coastal and freshwater marshes for nesting (Roberson and Tenney 1993). Saltmarsh common yellowthroat are known to winter in Hanson Slough (Suddjian unpubl. field notes) and may breed in the marshes of Struve Slough, Hanson Slough, and Harkins Slough.

Yellow warblers are a California Species of Special Concern. They are common during spring and fall migration in central California, and uncommon to locally fairly common during the breeding season (Suddjian 1990, Roberson and Tenney 1993). Yellow warblers are obligate riparian breeding birds; they are most numerous where substantial areas of riparian habitat remain along major creeks and rivers. A variety of riparian trees are used during foraging, but habitats with willows and cottonwoods or willows and sycamores, with dense undergrowth, seem to be favored (Roberson and Tenney 1993). Outside the breeding season, this species may occur in a variety of habitats, but is still most numerous in riparian habitats. The yellow warbler's diet consists of spiders and insects, which it gleans from understory vegetation and the canopies of deciduous trees. Nests are constructed low in trees, typically from 2-12 feet above the ground (Harrison 1978). Numbers of yellow warblers are greatly reduced over much of their California breeding range, largely due to loss of riparian habitat and nest parasitism by the brown-headed cowbird (Remsen 1978). Yellow warblers may nest in the denser riparian areas along the Sloughs.

The yellow-breasted chat is a state Species of Special Concern. It was once a fairly common summer resident in riparian woodland throughout California. In central California, yellow-breasted chats appear to prefer dense riparian habitats dominated by willows, sycamores, and cottonwoods, with a well-developed understory, and are considered a riparian obligate species (Roberson and Tenney 1993). They inhabit the area from April to early August

(Roberson and Tenney 1993). Yellow-breasted chats forage at various heights in dense riparian foliage, gleaning insects from leaves and bark, and feeding on small fruits. They build their nest in dense vegetation, typically from 1-8 feet above the ground (Harrison 1978, Ehrlich *et al.* 1988). This species' numbers have declined dramatically in many parts of California, primarily due to loss and alteration of riparian habitat and possibly due to nest parasitism by brown-headed cowbirds (Remsen 1978). Yellow-breasted chat may nest in the denser riparian areas along the Sloughs.

Tricolored blackbird is a Federal and State Species of Special Concern. They inhabit freshwater marshes, stock ponds, and willow thickets. They prefer dense cattails, tules and rushes where they build deep cup nests. They breed in large colonies of 50-100+ pairs, from April to mid-May. During fall and winter, tricolored blackbirds are nomadic and may be observed in pastures, grasslands, cattle pens and marshes throughout the county (Roberson and Tenney 1993). Extensive alteration of the Salinas river floodplain, and drainage of marshes for agriculture and urban development are the main threats to this species (Roberson and Tenney 1993). Historically, tricolored blackbirds have been known to nest at Harkins, Hanson and West Branch Struve Sloughs (Suddjian 1990).

Yuma myotis is a federal and state Species of Special Concern. It inhabits a wide variety of habitats at lower elevations and is a year-round resident in California. Day roosts include buildings, trees, mines, caves, bridges and rock crevices. This bat feeds on emergent aquatic insects and forages over the surface of calm waters of ponds, streams and rivers (Heady 2000). Snags, trees with hollows and abandoned structures may provide roosting habitat for Yuma myotis in the watershed lands.

Western red bat is considered a sensitive species in the Santa Cruz Mountains Bioregion. This bat is a solitary foliage roosting species, associated with cottonwood and willow trees (Heady 2000). They prey primarily on moths (Heady 2000) and breeding occurs from late May to early July. Western red bats may occur in suitable riparian trees in watershed lands.

The Townsend's western big-eared bat is a state and federal species of special concern. Big-eared bats occur in a variety of plant communities throughout California, including coastal

conifer and broad-leaf forests, oak and conifer woodlands, arid grasslands and high elevation forests (Williams 1986). In coastal California, the big-eared bat is primarily associated with riparian forests, where it gleans insects from leaf surfaces. Roosting sites for Townsend's big-eared bat include limestone caves, lava tubes, mine tunnels, buildings, and other human-made structures within 100m of riparian habitat (Williams 1986, Pierson 1988). Townsend's big-eared bats are extremely sensitive to human disturbances at roost sites. Townsend's big-eared bats may roost in cavities in oaks or other trees and abandoned buildings within the Watsonville Sloughs Watershed.

San Francisco dusky-footed woodrat is a State species of special concern. These small mammals build large stick nests at the bases of trees and shrubs. They prefer forested habitat with a moderate canopy and brushy understory, and are often found on the upper banks of riparian forests. This woodrat feeds on a variety of woody plants, fungi, flowers and seeds (Jameson and Peeters 1988). Dusky-footed woodrat nests are expected to occur throughout the woodland areas of Watsonville Sloughs Watershed.

## References

Biosearch Wildlife Surveys. 1996. Santa Cruz Kangaroo Rat Survey, Buena Vista Country Club Site, Santa Cruz County.

Bulger, J. B. 1999. Terrestrial activity and conservation of California red-legged frogs (*Rana aurora draytonii*) in forested habitats of Santa Cruz County, California. Report prepared for Land Trust of Santa Cruz, dated March 2, 1999.

Busch, J. 1985. Waterfowl Habitat Use in Three Coastal Freshwater Sloughs. Senior Thesis, Bachelor of Arts, Biology, University of California Santa Cruz.

Busch, J. 1986. Draft Watsonville Slough Planning Study. Report prepared for Pajaro Valley Slough Restoration and Management Advisory Committee, Santa Cruz, CA.

Busch, J. 2000. Watching the Watsonville Wetlands. Watsonville Wetlands Watch, Freedom, CA.

California Department of Fish and Game. 1995-2000. California Natural Diversity Database. http://www.dfg.ca.gov/whdab/html/cnddb.html

Clark, W. S. and B. K. Wheeler. 1987. A field guide to hawks of North America. Houghton Mifflin Co. New York.

Ehrlich, P. R., D. S. Dobkin, and D. Wheye. 1988. The birder's handbook. Simon & Schuster, Inc. New York.

Envicom Corporation. 1998. Revised Draft Environmental Impact Report, Proposed Third High School Site at Harkins Slough Road, Watsonville, California.

Gilchrist, J. and Associates. 2001. Final Report, Conceptual Wetland Restoration Plan for MF Farming Property.

Gilchrist, J. & Associates, Habitat Restoration Group, Philip Williams and Associates, Wetlands Research Associates, and MCWRA Staff. 1997. Salinas River Lagoon Management and Enhancement Plan. Volume 1: Plan Text, Volume 2: Technical Appendices. Prepared for The Salinas River Lagoon Task Force and Monterey County Water Resources Agency.

Harrison, C. 1978. A field guide to the nests, eggs, and nestlings of North American birds. W. Collins Sons and Co., Cleveland, OH.

Hayes, M. P. and M. R. Jennings. 1988. Habitat correlates of distribution of the California red-legged frog (*Rana aurora draytoni*) and the foothill yellow-legged frog (*Rana boylii*): Implications for management. *In* Management of amphibians, reptiles, and small mammals in North America (R. C. Szaro, K. E. Severson, and D. R. Patton, tech. coord.). USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report. RM-166.

Heady, P. III. 2000. Bats of the Santa Cruz Mountain Bioregion. Unpublished report prepared for The Santa Cruz Mountain Bioregional Council, January 26, 2000.

Jameson, E. W. and H. J. Peeters. 1988. California mammals. Univ. of California Press, Berkeley.

Jennings, M. R. and M. P. Hayes. 1994. Amphibian and Reptile Species of Special Concern in California. Report to California Dept. of Fish and Game, Rancho Cordova, CA.

Moyle, P. B. 1973. Effects of introduced bullfrogs, *Rana catesbiana*, on native frogs of the San Joaquin Valley, California. Copeia 1973:18-22.

Nussbaum, R. A., E. D. Brodie, Jr., and R. M. Storm. 1983. Amphibians and reptiles of the Pacific Northwest. Univ. Press of Idaho, Boise.

Orten-palmer, Amelia. Supervisor for Santa Cruz County, U. S. Fish and Wildlife Service, Ventura Field Office. Personal communication, 2001.

Pierson, E. D. 1988. The status of Townsend's big-eared bat (*Plecotus townsendii*) in California, preliminary results: *P. t. townsendii* in coastal California 1987-1988. Wildlife Mgmt. Div., Nongame Bird and Mammal Section, Calif. Dept. Fish and Game.

Questa Engineering Corporation (1995). Draft Water Resources Management Plan for Watsonville Slough System, Santa Cruz County, prepared for Association of Monterey Bay Area Governments**:** Section 6, Appendix D.

Remsen, J. V., Jr. 1978. Bird species of special concern in California. Calif. Dept. Fish and Game Report No. 78-1.

Roberson, D. and C. Tenney (Eds). 1993. Atlas of the breeding birds of Monterey County California. Monterey Peninsula Audubon Society, Monterey, CA.

Ruth, S. B. 1989. Seascape uplands Santa Cruz long-toed salamander study. Unpublished report, Sept. 1989.

Ruth Ph.D., Steve. Biology Professor, Monterey Peninsula College, and local expert on

Santa Cruz long-toed salamander. Personal communication, 2001.

Santa Cruz Mountains Bioregional Council. 1999. Draft List of Sensitive Fauna in the Bioregion (#6b). November, 1999.

Shaffer, H. B., R. N. Fisher, and S. E. Stanley. 1993. Status report: The California tiger salamander (*Ambystoma californiense*). Final report to the California Dept. of Fish and Game, Inland Fisheries Div., Rancho Cordova, Calif., under contract FG 9422 and FG 1383.

Small, A. 1994. California birds: Their status and distribution. Ibis Publishing Company, Vista, CA.

Stebbins, R. C. 1985. Western reptiles and amphibians. Houghton Mifflin Co., New York.

Suddjian, D. L. 1990. Santa Cruz County breeding bird atlas project: Atlasser's assistant. Santa Cruz Bird Club, Santa Cruz, CA.

U.S. Fish and Wildlife Service. 1995. Federal Register Vol. 60, No. 148: August 2, 1995.

U.S. Fish and Wildlife Service. 1998. Federal Register Vol. 63, No. 155: August 12, 1998.

U.S. Fish and Wildlife Service. 2001. Federal Register Vol. 66, No. 49: March 13, 2001.

Williams, D. F. 1986. Mammalian species of special concern in California. Calif. Dept. of Fish and Game.

Zeiner, D. G., W. F. Laudenslayer, Jr., K. E. Mayer, and M. White. 1990. California's Wildlife, Volume II, Birds. Calif. Dept. Fish and Game, Sacramento, CA.

**Technical Appendix D: Fisheries and Aquatic Resources**

The upper watershed areas are drained by streams that tend to be intermittent or storm influenced in their upper reaches (Larkins Valley Creek, Gallighan Slough, Upper West Branch Slough, and Upper Struve Slough). These streams are hydrologically part of the Pajaro River system is affiliated with the fish communities of other tributaries of Monterey Bay including the San Lorenzo River system, Elkhorn Slough, and the Salinas River (Snyder 1912; Murphy 1948; Shepard and Emery 1941, cited in Murphy 1948). Freshwater fishes in streams tributary to Monterey Bay include many of the same species found in the Sacramento and San Joaquin River systems and are likely derived from Central Valley populations through geologic and climatic events that connected San Francisco Bay drainages with Monterey Bay drainages (Snyder 1912, Murphy 1948). It is likely that Central Valley species moved freely through the area now covered by San Francisco Bay, either when sea levels were lower in the geologic past or during periods of flood when the surface waters of the Bay become fresh. The Coyote Creek drainage has transitioned over geologic time from draining to San Francisco Bay and to currently draining to the Pajaro River system, thus providing a potential route for fish transfer between the two basins (Branner 1907 cited in Snyder 1912, Murphy 1948).

In smaller tributary streams that may be intermittent and are warmer than trout can tolerate, California roach may be the main permanent resident although other species may use these streams in the spring for spawning. Roach can use very small streams including intermittent reaches where only isolated pools remain during the dry season.

Lower gradient, warmer water stream sections with large pools that remain over the dry season support Sacramento sucker, Sacramento pikeminnow (squawfish), and hardhead (hardhead are not present in Monterey Bay tributaries). Pikeminnow are more common in Central Valley streams than in coastal streams and are absent from many coastal streams. Young of all these species tend to occur higher in the watershed and gradually move to downstream reaches as they mature and grow larger. Although sucker and pikeminnow are usually dominant, other species such as tule perch, roach, prickly sculpin, speckled dace, and

trout may also occur. Summer water temperatures in these streams usually exceed 20°C and may fluctuate during the day; however, under conditions of augmented flow, such as releases from a dam, trout may be able use warmwater habitats where high summer flows provide fast-water feeding habitat (Smith and Li 1983). Higher flows can result in an increase in drift of aquatic invertebrates used by trout for food. At high rates of food consumption, trout can sustain the higher metabolic rate required in warmer water. Therefore, under augmented flow conditions trout can occupy warmer habitats than may otherwise be possible (Smith and Li 1983).

In the lowest gradient reaches where streams form deep channels with sluggish currents, native fishes may include a mixture of freshwater fish, anadromous fish, and estuarine or marine species. This could include blackfish, hitch, splittail (not present in Monterey Bay tributaries), squawfish, and suckers as well as a number of introduced species. In larger rivers, anadromous species such as salmon, steelhead, lamprey, and sturgeon pass through these reaches on migrations and may spend variable amounts of time there.

### Tributary Streams

The Watsonville Sloughs support aquatic habitat conditions that depart substantially from an idealized conception of a typical watershed. Stream type aquatic habitat in the Watsonville Sloughs Watershed is limited by the watersheds small size, low elevation, and relatively low gradient. Most tributary streams are dry by early summer. Although possibly present historically in the Larkin Valley, the coldwater trout/steelhead habitat does not presently exist in sufficient abundance to support this species. The headwaters of the sloughs provide habitat more typical of the warm, small tributary type that would be expected to support California roach with prickly sculpin and stickleback also potentially present. Introduced exotic species such as mosquitofish (Gambusia) and green sunfish may be present also, particularly in lower gradient, less swiftly flowing sections.

### Seasonal Lake/Marsh Habitats

The watershed is dominated by lower gradient, warmer water habitat, with seasonally or permanently ponded water. These areas are generally shallow (2-3 feet deep) and support abundant growths of algae and floating and emergent aquatic vegetation. They are generally nutrient enriched and highly productive and as a result, experience oxygen depletion on seasonal and diurnal cycles (see Technical Appendix A). This habitat is likely to support species such as stickleback, hitch, blackfish, and possibly Sacramento sucker, although sucker would need access to stream habitats to complete spawning. All of these species can tolerate warm temperatures, low dissolved oxygen levels, and tend to prefer habitats with less current. They can also (with the exception of the sucker) complete their reproductive cycle in lotic habitats. In addition, the warmer, ponded water habitats of the sloughs would provide suitable habitat for introduced exotic species such as carp, mosquitofish, catfish, and members of the sunfish family, such as green sunfish.

The most extensive open water habitat is found in Harkins Slough. Some parts of Harkins slough reach depths of nine feet or more and exposure to coastal breezes can result in increased dissolved oxygen levels mixing all the way to the bottom waters. In contrast, much of the other slough habitat, such as in Struve Slough, consists of predominantly 1-3 foot water depths that is dominated by abundant growths of algae and aquatic plants with very little open water habitat. Fish life in these shallower more vegetated habitats is likely limited to species such as stickleback and Gambusia.

### Estuarine Habitats

Estuarine habitat is limited to the reach of Watsonville Slough downstream of the Shell Road Pump Station. This reach is a tributary arm of the Pajaro River lagoon and supports water quality conditions and fish populations typical of the larger lagoon environment. Smith (1993) found twenty-five species of fish in the Pajaro River lagoon of which nine were found in Watsonville Slough between Shell Road and the confluence with the lagoon. None of the species encountered by Smith are freshwater species. Threespine stickleback, arrow goby,

and tidewater goby are resident estuarine species. All others are marine species that use the lagoon and lower Watsonville Slough for spawning, juvenile rearing, or feeding. The reach is influenced by tidal circulation as well as freshwater inflows from upper watershed areas. Tide gates at Shell Road prevent upstream circulation of estuarine waters or upstream movement of estuarine fish. All aquatic habitats upstream of the Shell Road tide gate and pump are freshwater.

### Special Status Species

*Tidewater Goby*

Tidewater gobies (*Eucyclogobius newberryi*) have been reported most recently in Smith (1993) from both the Pajaro River Lagoon and the lower reach of Watsonville Slough. The tidewater goby is listed under the Federal Endangered Species Act as an endangered species but has recently been proposed for de-listing. The USFWS has determined that, north of Orange County, there are more populations than were known at the time of the listing, that the threats to those populations are less severe than previously believed, and that the tidewater goby has a greater ability than was known in 1994 to re-colonize habitats from which it is temporarily absent. The proposal would remove the northern populations of the tidewater goby from protection under the Act (Federal Register: June 24, 1999; Volume 64, Number 121). Tidewater goby is also listed as a California Special Concern species.

The tidewater goby is restricted to coastal, brackish-water habitats in California, originally from the mouth of the Smith River in Del Norte County, south to Agua Hedionda Lagoon, San Diego County (Swift et al., 1989). Although gobies are restricted to lagoons, there may be some exchange between populations and re-colonization of lost habitat has been reported. Larvae are one possible form of dispersal (Swift et al. 1989). In a study of five coastal lagoons on Vandenberg Air Force Base during 1994 and 1995, gobies were absent at one lagoon during most of the study but it was apparently recolonized during the spring of 1995, apparently from the Santa Ynez River during high winter flows (Swift et al. 1996). Available information indicates that recolonization can occur from populations as far as 10-20 kilometers distant. The nearby Elkhorn Slough also supports tidewater goby (Kukowski 1972, Swift et al. 1989).

Swift et al. (1989) list several criteria for lagoon conditions that favor tidewater gobies. These include: little or no channelization; allowing closure to the ocean for much of the year so that tidal fluctuation is absent or minimal; fresh unconsolidated sand is optimal for reproduction; high quality of inflowing water to increase habitable area of the lagoon in summer (nutrient enrichment can stimulate algal blooms, deplete oxygen, and lead to hydrogen sulfide formation-most fish species are intolerant of low dissolved oxygen and high hydrogen sulfide concentrations). Non-native predatory fish should be excluded. Centrarchid fish (sunfish and bass) and tidewater gobies are not usually found together and may not be able to coexist (Swift et al. 1989).

Gobies may move upstream during winter rains and high flows of inlet streams (Swift et al. 1989) as well as during the summer when algal blooms and hydrogen sulfide forms in the substrate and enters the water column. During this period most fish are at the upper end of lagoons where freshwater inflow occurs or at the seaward end where occasional waves wash into the Lagoon (Swift et al. 1989).

Swift et al. (1989) report that available data indicate that *Eucyclobius* complete their lifecycle in one year. Wang (1984) gives a life span of 1-3 years. Their short life span and restricted habitat make individual populations vulnerable to unique catastrophic events (floods, toxic events, introduction of predator species, drought, or habitat alteration). Nevertheless, available information indicates that *Eucyclobius* is tolerant of a very wide range of salinity, temperature, and other water quality conditions.

Tidewater goby have not been intensively studied locally but biology and life history information are available from other locations. Peak population abundance in Aliso Creek Lagoon (Orange County) is in late summer to early-fall (Swift et al. 1989, Swift et al. 1996). In late winter and early spring, before spawning occurs, population size is reduced by about 90% (Swift et al. 1989). In three years of study in Rodeo Lagoon (Marin County), Wang (1984) found spawning in all seasons and in different seasons each year but adult fish were seldom seen in winter months. *E. newberryi* were typically abundant in shallow water (1 meter deep or less) but deep water was not usually sampled. Swift et al. found that all sizes of *E. newberryi* usually occur at the upper end of lagoons at salinities of 10 parts per thousand (ppt)

or less. Of 60 collections, 65% were at 0-10 ppt, 20% were at 10-20 ppt, 17% at 20-30 ppt, and 2% at 42 ppt. The collection at 42 ppt was made at Bennett Slough, a tributary of Elkhorn Slough in Monterey County (Swift et al. 1989). In lab tests conducted by the California Department of Fish & Game (CDFG), tidewater gobies were maintained in freshwater, 10-15 ppt, 20 ppt, and normal seawater (33 ppt) with reproduction taking place under all four conditions (Worcester and Lea 1996). Differences in reproductive success, if any, were not reported. Worcester and Lea also held tidewater gobies in hypersaline water (45-54 ppt) for 6 months with no mortality. Holding temperatures during these tests ranged from 4.0 to 21.5°C. In salinity tolerance tests reported by Swift et al. (1989), tidewater gobies in salinities above 41 ppt experienced high mortality. In an experiment where salinity increased slowly due to evaporation, over half the gobies survived hypersaline conditions up to 1.75 times that of seawater.

*Steelhead*

Steelhead (Oncorhynchus mykiss) are not expected in upper reaches of the Watsonville Sloughs Watershed but smolts from the Pajaro River may spend brief periods of time in the estuary feeding before entering the ocean (The Habitat Restoration Group 1997). Adults may also enter the lower estuarine reach of Watsonville Slough from the Pajaro River to feed. Steelhead populations in the Pajaro River basin use Salsipuedes Creek, Corralitos Creek, Uvas Creek, and Llagas Creek for spawning and rearing. Smith (1993) found a few steelhead in the Pajaro Lagoon in August 1991 that he identified as holdover hatchery smolts. Steelhead inhabiting the Pajaro River Basin are a part of the South-Central California Coast Evolutionary Significant Unit (ESU) as defined by the National Marine Fisheries Service (NMFS). An ESU, as defined by the NMFS, is a distinct population segment of the biological species that is substantially reproductively isolated from other population segments and that represents an important component in the evolutionary legacy of the species. The South Central California Coast ESU is considered by NMFS to be distinct from the Southern California ESU to its south and the Central California Coast ESU to its north. The NMFS listed steelhead trout in the South-Central California Coast ESU as a Federally threatened species effective October 17, 1997. The South Central California Coast ESU includes steelhead populations in streams from the Pajaro River (inclusive) to

(but not including) the Santa Maria River. The Pajaro River and Watsonville Slough are also within the critical habitat designation for steelhead under the Federal Endangered Species Act (FESA). Southern steelhead (south of San Francisco Bay) are a California Special Concern species.

*Coho Salmon*

South of San Francisco Bay, coho salmon (Oncorhynchus kisutch) are currently known to have spawning populations in only Waddell Creek and Scott Creek. Smith found a single adult coho salmon in the Pajaro Lagoon in August 1991 that he believed entered the estuary to feed on abundant herring and topsmelt (Smith 1993). Such fish could presumably also enter the lower reach of Watsonville Slough. The Central California ESU coho salmon were listed as a threatened species as of October 31, 1996 (Federal Register, vol. 61, No. 212, October 31, 1996). The Central California ESU extends from Punta Gorda (Humboldt County, California) south to the San Lorenzo River. While not within the geographic boundaries of the ESU, coho salmon occurring in the Pajaro River or Watsonville Slough are presumably Central California ESU fish and protected under the take provisions of the FESA. The Pajaro River and Watsonville Slough are not within critical habitat designated for the Central California coho ESU (Federal Register, vol. 64, No 86, May 5, 1999) and therefore are not subject to habitat modification provisions of the ESA. Coho salmon south of San Francisco Bay are listed under the California Endangered Species Act (CESA) as an endangered species. The Pajaro River supported spawning populations of coho salmon, principally in Corralitos and Pescadero Creeks, until the late 1960s (Anderson 1995).

**2001 Fish Surveys**

Since no previous surveys have been performed in the freshwater reaches of Watsonville Slough, upstream of the estuary, limited sampling was conducted in June 2001. Further sampling is planned for late summer 2001.

*Methods*

Preliminary, reconnaissance level assessment of presence and distribution of fish species was initiated in June 2001 by visual observation and sampling by dip-net, minnow trap, and hoop trap. Two types of hoop trap were used, one of 4 foot diameter hoops hung with 1 inch mesh and one of 3 foot diameter hoops hung with 1/4 inch mesh. Both traps had two fykes and a single leader (20 feet on the small hoops, and 30 feet on the larger trap). The larger trap was fished for approximately 7 hours and the smaller trap for 6 hours, both during mid-day. During late summer additional traps will be fished and traps will be fished at night when they are generally more effective. The larger trap was set just upstream from the Harkins Slough Road bridge in 2-3 feet of water in the center of the channel. The smaller trap was set in Harkins Slough a short distance upstream from the railroad line (about 1/2 mile upstream from the confluence with Watsonville Slough.

*Results*

Based on the limited sampling completed to date, fish species occurrence in the sloughs is consistent with expectations. Sacramento blackfish, stickleback, carp, Gambusia, and black crappie were captured in Harkins Slough. Gambusia, stickleback, and prickly sculpin were observed in visual surveys of Larkin Creek from Harkins Slough upstream to about Windsong Way. Upper Harkins Slough was dry from Senda Ladera Drive upstream. Only stickleback were captured in Struve Slough though sampling was limited to dip-netting. Further sampling is required to develop a complete data set of existing fisheries resources.

## References

Anderson, K. R. 1995. A status review of the coho salmon (*Oncorhynchus kisutch*) in California south of San Francisco Bay. Report to the Fish and Game Commission, California Department of Fish and Game, Region 3, Monterey, California.

The Habitat Restoration Group. 1997. Appendix B: Fisheries Resources of the Lower Pajaro River and its Tributaries. In: Pajaro Valley Water Management Agency Local Water Supply and Distribution Environmental Impact Report.

Hunt, J.W., B. S. Anderson, B. M. Phillips, R. S. Tjeerdema, H. M. Puckett, V. deVlaming (1999). "Patterns of aquatic toxicity in an agriculturally dominated coastal watershed in California." Agriculture, Ecosystems, and Environment 75: 75-91.

Kukowski, G.E. 1972. A Checklist of the Fishes of the Monterey Bay Area Including Elkhorn Slough, the San Lorenzo, Pajaro, and Salinas Rivers. Contributions to the Moss Landing Marine Laboratories No. 26. Technical Publication 72-2. CASUS-MLML-TP-72-02. Moss Landing Marine Laboratories of the California State University.

Murphy, G. 1948. Distribution and Variation of the Roach (Hesperoleucus) in the Coastal Region of California. M.S. Thesis, University of California.

Smith, J.J. and The Habitat Restoration Group. 1993. Technical Appendix A: Aquatic Habitat and Fisheries. In: Pajaro River Lagoon Management Plan, Mitchell Swanson & Associates. 1993.

Smith, J. J. and Li, H. W. 1983. Energetic factors influencing foraging tactics of juvenile steelhead trout, Salmo gairdneri. In Predators and Prey in Fishes (D. L. G. Noakes et al. (eds.)), Ed., 173-180. W. Junk Publishers, Netherlands.

Snyder, J.O. 1912. The fishes of the streams tributary to Monterey Bay, California. Bulletin of the Bureau of Fisheries. United States Bureau of Fisheries. 32:49-72.

Swift, C.C., J.L. Nelson, C. Maslow, and T. Stein. 1989. Biology and distribution of the tidewater goby, *Eucyclogobius newberryi*, (Pisces: Gobiidae) of California. Contributions in Science, Number 404, pp. 1-19 Natural History Museum of Los Angeles County.

Swift, C.C., P. Duangsitti, C. Clemente, K. Hasserd, and L. Valle. 1996. Biology and distribution of the tidewater goby on Vandenberg Air Force Base, Santa Barbara County, California. Symposium on tidewater goby, Southern California Academy of Sciences Annual Meeting at Loyola Marymount University May 3-4, 1996.

Wang, J.C.S. 1984. Technical Report No. 15 On The Ecological Status of the Tidewater Goby, *Eucyclogobius newberryi* (Girard), in a Lagoon and Lake of the Golden Gate National Recreation Area, CA. Final Report to National Park Service. Contribution Number CPSU/UCD 337/1.

Worcester, K.R., and R.N. Lea. 1996. Observations on tidewater goby habitat utilization and laboratory maintenance during the California drought. Symposium on tidewater goby, Southern California Academy of Sciences Annual Meeting at Loyola Marymount University May 3-4, 1996.

U.S. Fish and Wildlife Service. 1996. Federal Register Vol. 61, No. 212: October 31, 1996.

U.S. Fish and Wildlife Service. 1999. Federal Register Vol. 64, No. 86: May 5, 1999.

U.S. Fish and Wildlife Service. 1999. Federal Register Vol. 64, No. 121: June 24, 1999.

# Technical Appendix E: Opportunities and Constraints

There are significant opportunities to undertake multiple objective resource enhancement projects that benefit water quality and drainage for agriculture and rural residential landowners. These improvements go hand in hand with the enhancement of native vegetation resources and improved aquatic and terrestrial wildlife habitats. The potential for improvements in public access, public awareness and education are abundant and the development of public trail systems could simultaneously help improve public transportation.

## Land Use Opportunities and Constraints

### Rural Land Use Areas

#### Upper Harkins Slough

This area is made up of rural residential parcels between 2 and 15 acres in size. Many of these properties have horses either in pasture or barn situations, where the animals are free to tread in and out of the stream channels. A common problem throughout this area has been erosion from un-maintained drainage structures. This lack of control of water as it comes off properties at higher elevations has caused gully formation, topsoil erosion and clogging of the slough areas. In addition, the lack of livestock waste control loads excess nutrients to the waterways, creates fly problems, and produces undesirable smells for surrounding neighbors.

*Opportunities*

- The opportunity exists within many of these parcels to create drainage control to direct the water safely as it flows off one property onto another and minimize surface erosion.
  - Ditch maintenance may include cleaning the ditches annually to keep water flowing.
  - Concrete, rock or vegetation stabilization of the ditch banks.
  - Properly sized culverts below roadways.
  - Restricting animals from entering the channels.

- The opportunity exists to create a management plan for the Larkin Valley to limit the downstream damage of drainage water and protect native species habitat. Many landowners want to alleviate erosion problems due to the loss of valuable soil and the deterioration of roads. Many landowners, but not all, are asking for help to stabilize their properties

- Manure management by properly composting animal waste can decrease nutrient runoff, flies and noxious odors. Composting also converts waste into an excellent planting medium in a relatively short time period.

*Constraints*

- The need for landowners to coordinate their efforts may present a challenge to the implementation of any plan because one non-participating landowner may limit the plan's overall success. However, the assumption is that landowners living in the rural areas of Larkin Valley do have a desire to preserve the natural landscape on their properties and what is needed is a collaborative organized effort to improve the natural resources.

- Another concern is the system for obtaining grading permits. Currently landowners are finding it can take 6 months to obtain permits to fix problems caused by storm runoff.

- The economic resources of the County of Santa Cruz Public Works and Planning Departments may limit the available funding for these projects.

**Hill and Terrace Agricultural Land Use**

Harkins Slough, Hanson Slough, Gallighan Slough and Struve Slough

Farming on hillslopes within Harkins Slough, Hanson Slough, Gallighan Slough and Struve Slough does occur on slopes of more than 5%. This creates many erosion problems during heavy runoff events over exposed loose soils. Transport of soil allows a large amount of fine sediment and/or farming chemicals to enter waterways and sensitive habitat areas. The current separation of agricultural drainage systems and natural sloughs is not great enough to reduce impacts of sediment erosion and transport. Antiquated drainage systems along County roads are in disrepair in certain areas, causing erosion of land and roads.

*Opportunities*

- Growers are concerned about erosion on their land because of chronic soil loss and the cost associated with inoperable roads. Out of economic concerns, many growers are now seeking assistance from the Santa Cruz County Resource Conservation District (SCCRCD) and private consultants to minimize the erosion and detain stormwater. Growers appear to be interested in more definitive boundaries between farmland drainage systems and protected waterways where habitat management and drainage improvements are the focus. These programs could be coordinated with the SCCRCD.

*Constraints*

- Urban encroachment and associated hardscape and drainage systems increase the volume of stormwater runoff. This further taxes an overburdened and aged drainage system downstream. This may not be avoided as housing and other developments are likely to continue, but proper planning for water runoff should be considered when land use changes occur.

**Bottomland Agricultural Land Use**

Upper and Middle Watsonville Sloughs and Beach Road Ditch

These planning areas are predominantly flat bottomlands adjacent to Watsonville Slough in production for vegetables and strawberries. There is little or no demarcation between protected waterway and farmland drainage areas and neither function satisfactorily. Water quality degradation and the accumulation of salts in the upper soil profile are issues caused by the lack of adequate drainage. Without an effective drainage system, water has spread over farmland and formed late winter/early spring ponds, postponing spring cultivation. The saturated soils on lands adjacent to flooded areas become inaccessible for plowing and have reduced their overall productivity. In addition, the invasion of non-farm plant seeds has spread onto farmland from wind and water transport during times of land inactivity.

*Opportunities*

- Growers in Beach Road/San Andreas Road are all very concerned about the near and long term consequences of the lack of drainage maintenance during the past 20 years. The

growers are willing to donate time and equipment to do maintenance work, but lack the ability to obtain permits in a timely manner. It is likely that a coordinated plan addressing the logistics of future maintenance will be needed.

- Growers appear receptive to creating a permanent line between farm operations and protected waterways of the Sloughs. Upgrading or constructing new drainage ditch/pump/berm facilities to separate farm ditches from the slough waterway could accomplish this goal (see WSCEP Figure 4-1). The growers understand that farmland may be lost in order to accomplish the separation. The tradeoff is an improvement in system-wide drainage reliability and a certainty of future crop production that would outweigh the poor drainage of the land in its current condition.

- Acquisition of farmland or dedication of waterway/drainage easements is possible in areas that are not farmable for more than 6 months out of a year. Opportunities to acquire and convert poorly drained or fallow land should be explored to develop ecologically viable seasonal wetland habitats.

*Constraints*

- There will be a future need for maintenance of the improved ditch/pump drainage systems.

- Continued urban expansion increases impervious land cover and ultimately results in greater annual runoff volumes entering the Sloughs.

**Hydrology/Water Quality Opportunities**

*Opportunities*

Many of the opportunities mentioned in the Land Use section above will have a direct benefit to hydrologic and water quality conditions in many of the improved areas. There is considerable opportunity to merge resource enhancement with drainage facility improvements in a manner that is economically favorable to agriculture. There are opportunities to improve

the runoff from urban lands into the Sloughs and to increase public awareness of slough resources. There are opportunities to develop meaningful economic opportunities for the Watsonville Community that will satisfy both the natural resource and agricultural objectives.

Middle and Upper Watsonville Slough and Beach Road Ditch Planning Areas

- The installation of a berm and agricultural drainage ditch/pump systems (see WSCEP Figure 4-1) mentioned in the Land Use section above would separate an expanded natural waterway from the agricultural drainage. The separation of agricultural drainage and wetland habitat would improve water quality and ecosystem function within the wetland. A pumping system could improve circulation and drainage on neighboring farmlands and have a positive effect on annual crop yields.

- The potential opportunity to use wetlands to treat wastewater generated from the City of Watsonville Wastewater Treatment Plant was explored as part of the joint City/PVWMA recycling feasibility study regarding the use of wetlands to polish effluent prior to discharge to the slough. The treated wastewater should not be intermixed or discharged into natural waterways unless BOD and nitrate concentrations are reduced to 30 mg/l. However, most freshwater bodies are phosphorus limited, so phosphorus removal is the critical need and wetland treatment alone probably could not reduce phosphorus to levels required to mitigate possible environmental degradation. It is estimated that 123 acres of new wetlands are needed to treat the volume of wastewater available; this area would have to be acquired.

Upper Watsonville Slough, Upper and Lower Struve Slough, and Lower Harkins Slough

- In areas where expansive inland marshes are forming in the winter months it is feasible to conduct ecological restoration though wetland enhancement, creation of urban runoff treatment wetlands, and wetland and upland vegetation management projects (i.e. replace exotic/invasive species with natives). The opportunities for wetland restoration exist where lands are either publicly owned (i.e. portions of Lower Struve Slough and Lower Harkins Slough), or publicly controlled by the California Department of Fish and Game (Lower Struve Slough/West Branch Struve Slough) or the City of Watsonville (Upper

Struve Slough and Upper Watsonville Slough). These projects could involve removal of mineral sediments from peat soil bottomlands, strategic grazing of grasslands to promote the emergence of native species, modification of waterways and wetlands through grading to improve hydrologic function, and the removal of reclamation berms or structures to improve hydrologic function.

- Areas of wetland upland habitat could be protected and restored through acquisitions (either fee title transfer or conservation easements). The 40-acre former Cardoza property (now known as High Ground Organics) is an excellent example of preserving both the agricultural and natural resources through use of conservation easements.

Upper, Middle and Lower Watsonville Slough, Gallighan Slough, Hanson Slough, and Beach Road Ditch

- There are opportunities to reduce sediment runoff from public and private roads and cropland by installing stable drainage ways (pipes, lined channels, etc.) and sediment retention basins and other soil conservation practices. These efforts could be beneficial in any of the planning areas containing expansive agricultural fields. The SCCRCD, in partnership with private landowners, has been developing demonstration projects throughout the watershed including a project along San Andreas Road near Watsonville Slough. Installation of road drainage and erosion repair projects could reduce long-term maintenance costs, especially in the Gallighan Slough Watershed along Buena Vista Road west of Highway 1.

Upper Harkins Slough

- In the Upper Harkins Slough Planning Area upstream of Highway 1 (Larkin Valley), there is an opportunity to reduce soil erosion from hill slope runoff within developments and along the riparian zone along the creek. Efforts to protect the channel from grazing pressures will help restore the riparian vegetation and overall aquatic habitat value in this area. This effort would need to be coordinated between private landowners and the Santa Cruz County Public Works. The desires and capabilities of all parties need to be identified and considered in an overall plan with a specific aim to reduce soil erosion (which would be a goal consistent with native vegetation resource management), provide greater reliability for road access, and to specifically address regulatory issues associated with land

use and channel maintenance for drainage. A pilot project has been identified in Upper Harkins Slough to reduce erosion, stabilize the eroding channel, and control runoff from the pasture to the waterway.

Watershed Wide: Opportunities Applicable to all Planning Areas

- Nutrient loading into the waterways is a vast non-point source pollution problem emanating from all planning areas. It may take years for source reduction to have an effect, but other examples of reductions in nutrient loads have resulted in a rapid and very positive response of the affected waterway. Management efforts should focus on sustainable fertilizer applications for farmlands, upgrades and maintenance of septic systems and public education on manure management. Water quality improvement projects could include urban runoff treatment by nearby wetlands.

*Constraints*

Restoration of natural or original hydrologic conditions may not be feasible in certain areas due to irreversible changes (i.e. drainage infrastructure, water supply projects, and land subsidence), the costs of modifying transportation infrastructure, and/or the ability to gain access for projects on private lands. This constraint applies to all planning areas.

Beach Road Ditch, Middle Watsonville Slough, and Lower Harkins Slough

- Agricultural uses require that saltwater inflows be limited to the area below Shell Road Pump Station unless new facilities are constructed. Moving the Shell Road Pump Station closer to the Harkins Slough PVWMA project may present risks to water supply, winter drainage, and saltwater intrusion of the neighboring agricultural fields.

- Improving the water quality in Beach Road Ditch may be limited by a lack of easement or lands to create isolated wetland treatment areas.

Watershed Wide: Constraints Applicable to all Planning Areas

- It may be difficult to stabilize erosion sites without private landowner cooperation, or public funding to stabilize roads.

- Land Acquisition may be required to initiate habitat enhancement.

- Previous sediment analyses suggest that soils in the Sloughs may contain elevated concentrations of trace metals and organic pesticides. Any restoration efforts involving earth moving project must address the impacts of exposing historically buried contaminants, such as DDT.

**Vegetation Resource Opportunities and Constraints**

There are significant opportunities to improve and manage the native vegetation resources within the watershed. An increase in native vegetative cover will benefit the overall botanical diversity of the region, enhance associated native communities, contribute to improved water quality in the Sloughs and waterways, and reduce the potential for catastrophic wildfire. These opportunities are present throughout the watershed and recommended actions will vary depending upon the vegetation type and the location within the watershed.

- Landowners in all planning areas could be encouraged to preserve and manage the native habitats on their properties if there were incentives in the form of simplified permitting on all government levels, funding and technical assistance. Discussions with resource agencies and regulators from all levels (City, County, State and Federal) indicated that implementation of a coordinated WSCEP could be a vehicle to streamline permitting.

- USFWS has a "Safe Harbors" program wherein conservation, restoration and management actions for endangered animal species can be done under an agreement that provides for a net expansion of habitat, but allows incidental take in designated areas. The level of protection for plants under an ESA is less, however, the concept of a "Safe Harbors "agreement could be an effective method to reduce regulatory conflicts and disincentives. By engaging in a "Safe Harbors" program the native plant communities would gain a net expansion in cover and quality in an agreeable manner for landowners.

**Opportunities and Constraints by Habitat Type**

Upper Watsonville Slough, Upper and Lower Struve Slough, Gallighan Slough, Hanson Slough, Upper and Lower Harkins Slough

***Wetlands and Riparian Areas***

The primary opportunities to resolve vegetation resource problems within the watershed wetland and riparian areas are:

- Widen confined channels to allow for the rehabilitation of a riparian corridor.
- Widen confined slough areas to allow for a more natural transition from wetland to upland habitats.
- Modify drainage features in the lower watershed wetlands to achieve water features that will increase plant species diversity.
- Efforts should be made to control/remove occurrences of invasive, non-native plant species.

Upper and Lower Harkins Slough, Gallighan Slough

***Coast Live Oak Woodland***

The watershed offers excellent opportunities to maintain and enhance the existing oak woodlands. Due to the increasing importance of preserving oak woodlands, their decline from development pressures and their importance for wildlife utilization, many agencies have policies to preserve and protect oak woodland resources, including California Department of Fish and Game. If resource management activities were envisioned within this habitat type, the actions should be done to enhance resource values. The following focused management actions would significantly benefit the biological resources of the habitat:

- Control the growth of invasive, non-native plant species that occur.
- Increase the native understory plant cover.
- Repair and stabilize existing erosion sites.

Upper Harkins Slough, Gallighan Slough

***Central Maritime Chaparral***

The watershed offers excellent opportunities to maintain or enhance the existing central maritime chaparral. As these habitats are known, or have the potential, to support special status species and have a high diversity of regionally significant native plant species, the continued maintenance of

this habitat would be a significant contribution of regional biodiversity goals and endangered species preservation.

Upper and Lower Struve Slough, Hanson Slough, Gallighan Slough, Upper and Lower Harkins Slough

***Grasslands***

The grasslands within the lower watershed offer significant opportunities for the management of grassland plant species, including known and potential habitat areas for the recovery of the Santa Cruz tarplant, an endangered species. Grassland management activities, such as rotational grazing, seasonal mowing and/or prescribed fire, would reduce the cover of non-native grasses and forbs and underlying thatch. A reduction in the thatch and non-native grass growth will facilitate the germination and growth of the tarplant (as well as other native grassland plant species that may still be present on the site). These grassland management actions will also reduce the infestations of invasive, non-native plant species within the watershed (e.g., poison hemlock, wild mustard, wild radish, Harding grass and Italian thistle). These actions, including the dedication of conservation easements on all the known occurrences of rare plants within the watershed will significantly aid in the recovery of these special status species.

Watershed Wide: Applies to all Planning Areas

***Decreasing the Loss of Native Vegetation***

One of the most-straightforward and rewarding restoration efforts would be the improvement of the native vegetation of the area through the conversion and removal of invasive exotic plant species (ruderal areas (weeds) and groves of non-native trees (i.e., eucalyptus and Monterey pine)), and the conversion of these areas to a native habitat type. With adoption of the WSCEP, the County could offer incentives to encourage landowners to convert these areas to native scrub, oak woodland, grassland or chaparral or to develop in non-sensitive areas. The existing County Code restricts the amount of development within sensitive habitat and offering incentives could encourage landowners to develop in non-sensitive areas. Possible incentives include reducing applicable permit fees and working with the County assessors office to provide property tax credits to property owners implementing habitat restoration and/or dedicating permanent conservation easements on their lands.

Adoption of the WSCEP may facilitate the development of grassland management plans with landowners, local fire districts, California Division of Forestry and regulatory agencies. The plan should include incentives for landowner participation such as waiving of permit fees, property tax credits or other measures.

The watershed area also offers opportunities to develop and implement a fire management program that would benefit native plant habitat and minimize the risk of catastrophic wildfires that threatens native habitats (including loss of rare plant species and habitat), and residential and commercial developments. The large groves of non-native trees (i.e., eucalyptus and Monterey pine) increase the fire hazard in these areas. The County Code currently identifies the development of a prescribed fire program within the San Andreas live oak woodland and central maritime chaparral as a means to manage these habitats, however, the consultants are unaware of the implementation of such a program. A fire program would enable the creation of a mosaic of different stage chaparral that would facilitate recruitment of Hooker's manzanita and other special status fire-dependent plant species. Adoption of the WSCEP may facilitate the development of such a fire management plan with landowners, local fire districts, California Division of Forestry and regulatory agencies. The plan should address protection/management of native habitats, conversion of non-native tree groves to less fire-hazardous native habitats and incentives for landowner participation.

**Wildlife Resource Opportunities and Constraints**

There are numerous opportunities for enhancement of wildlife resources within the Watsonville Sloughs System. Because of the ecological structure of natural environments, any of the opportunities and constraints described above for wetland enhancement, hydrology and vegetation directly transfer into wildlife benefits.

- The opportunities described above under the Hydrology section for improvement of water circulation in the sloughs, drainage improvements, and reduction in sediment will directly enhance the aquatic habitat.

- There are opportunities for improving wildlife corridors by land acquisition and/or

preservation by the adoption of conservation easements on key parcels. Owner cooperation will be critical in developing these types of improvements.

- Restoration efforts should focus on restoring native vegetation in currently preserved lands that have been historically impacted by previous land uses. Constraints exist where contiguous corridors for ideal wildlife movement are not possible. Barriers exist in the urban areas at the upper most section of Watsonville and Struve Sloughs.

- A strategic network of recreational trails on preserved lands provides opportunities for community involvement and education about wildlife resources. Constraints of recreational trails to wildlife resources include unauthorized access with motor vehicles and flushing of nesting wildlife by proximity of people or unleashed pets.

**Recreation Opportunities and Constraints**

*Opportunities*

- There are significant opportunities to develop a public trail system on public lands and easements in order to improve the public access to the Sloughs. These trail systems would not only improve access to the Sloughs, but would also connect to longer trail systems such as the proposed Davenport to Watsonville Trail along the UPRR, and the existing trail along the north and south levee maintenance road on the Pajaro River.

- The principal trail opportunities begin within the City of Watsonville along Upper Struve Slough from Main Street to Lee Road; Upper Watsonville Slough from above Main Street to Lee Road. Other trail opportunities include Struve Slough above Highway 1 to Green Valley Road, West Branch Struve Slough, West Branch Struve Slough to Harkins Slough by Harkins Slough Road, and Harkins Slough Road to UPRR trail and San Andreas Road. Reconstructing the levee along the east bank of Watsonville Slough between the Pajaro River mouth and Beach road could include a trail that would connect to the Pajaro River levee.

- A 9-acre site within the City of Watsonville has been proposed by the property owner for public acquisition and development by the Pajaro Valley Ohlone Council for an Ohlone

Village. COW utility easements and other constraints limit the available acreage.

- A specific trails master plan for the City of Watsonville is in preparation and will be incorporated into the final WSCEP. There will be public presentations and hearings and environmental review for the master plan within the City.

*Constraints*

- Private landowners may be reluctant to participate in linking public access due to concerns over liability, trespassing and potential vandalism.

## Technical Appendix F: Alternatives Analysis

Alternatives provide decision makers with an assessment of outcomes given different programs, projects and implementations. The alternatives seek to provide a view of habitat enhancement, water quality, and economic outcomes. The following alternatives were developed through the examination of restoration and enhancement opportunities and consultation with landowners and interest groups.

The changing land use conditions in the watershed present a significant challenge to describing *specific* enhancement projects and alternatives. Land availability is the key to the success of a *specific* plan. There is a desire to understand the full potential of present and future resource enhancement opportunities. Three alternative strategies are presented for each planning area:

1) **No Action** allows existing conditions to extend into the future;
2) **Current Enhancement Plan:** A plan that appears feasible under present conditions, based upon existing information and assuming estimates of unknown planning factors such as land use; and
3) **Full Resource Enhancement Plan:** A plan that enables restoration of natural resource conditions at or near historic conditions, but accounts for significant constraints (such as established infrastructure and agricultural and urban land use).

In the discussion below, each planning area is described and analyzed with regard to the application of three alternatives.

### Alternative Analysis for Specific Areas

#### UPPER WATSONVILLE SLOUGH

The Upper Watsonville Slough Planning Area is mostly contained within the City of Watsonville's jurisdiction and extends from its headwaters above Main Street to the low gradient drainage ditch/channel at Highway 1 near Beach Road. The lower portion of the Slough below Ford Street is under consideration by the City of Watsonville for expansion of wetlands and development of adjacent land.

The main stressors for the Upper Watsonville Slough Planning Area are:

- Land use is extensively urban and industrial, posing limitations on habitat enhancement.
- Water circulation is constricted by hydraulic structures at Main Street, Harkins Slough Road and Ford Street and the flat channel gradient downstream of Main Street.
- Water quality conditions are degraded by poor circulation, nutrient input, urban and agricultural pollution, and the lack of riparian or wetland vegetation within the Slough downstream of Ford Street.
- Vegetation resources are degraded due to loss of areas to urban cover and agricultural uses, invasion of exotic species, and clearing of vegetation associated with maintenance of former wetland areas and waterways.
- Wildlife resources are limited by urban land use cover, clear agricultural land, poor water quality, invasive exotic species (e.g. bullfrog) and lack of native vegetation cover for forage and habitat.

### *Alternatives Descriptions*

The No Action Plan retains existing conditions.

The Current Enhancement Plan includes the following elements:

- Degraded historic wetland areas upstream of Ford Street would be enhanced by removal of fill, most notably in the old City of Watsonville Dump, and removal of hydraulic constrictions at Ford Street. It is assumed that the Harkins Slough Road Crossing would be replaced with a less constricted structure under separate plans by the City of Watsonville, and that wetlands downstream of Ford Street would be restored under development and annexation plans now under consideration by the City of Watsonville.
- Freshwater marsh areas and the Slough channel would be selectively enhanced to improve water circulation, remove remnants of reclamation, stabilize channel banks and improve hydrologic conditions for native vegetation communities.
- The areas between the freshwater wetlands and riparian areas would be revegetated with native plant communities in transitional and upland settings. This would create fully native plant communities from the edges of wetlands up hillslopes to the hilltops

of urban cover. Areas on hillslopes covered in fill or trash would be rehabilitated to support native vegetation.

- Storm water treatment facilities would be installed at the major outfalls draining urban areas in order to remove pollutants.

The Full Resource Enhancement Plan includes the above actions with the following addition:

- The Main Street crossing would be reconstructed with a span to allow for improved water circulation.

### *Benefits and Impacts of Alternatives*

*Land Use*

- The No Action Plan does not change present land use. Future land use in the lower portion of the project reach would be dictated by the outcome of the present City of Watsonville plan to annex and develop the area surrounding the reach below Ford Street.
- The Current Enhancement Plan would involve minor changes in land use by converting private areas on hillslopes from dumping areas or extended backyards to native vegetation communities.
- The Full Resource Enhancement Plan would have the same effect as the Current Enhancement Plan.

*Water Quality and Geomorphology*

- The No Action Plan retains existing stressors without change. The exceptions would be improvements realized through separate wetlands restoration efforts by the City of Watsonville and replacement of the Harkins Slough Road Bridge.
- The Current Enhancement Plan would significantly improve water circulation by removing fill and hydraulic constrictions and by selectively dredging marsh areas. Sediment, nutrient and urban runoff pollution would be reduced through operation of storm water treatment systems.
- The Full Resource Enhancement Plan would improve water circulation through the improvement of the Main Street crossing.

*Native Vegetation Resources*

- A No-Action Plan retains the existing conditions for native vegetation except in the lower reach below Ford Street where separate plans by the City of Watsonville would enhance wetlands.
- The Current Enhancement Plan significantly improves native vegetation resources by converting degraded areas in wetlands and on hillslopes to native vegetation cover. This would improve vegetation diversity in wetlands, transitional and upland areas.
- The Full Resource Enhancement Plan has the same benefits as the Current Enhancement Plan.

*Wildlife and Fisheries Resources*

- The No Action Plan retains existing conditions with the exception of separate City of Watsonville projects. The enhancement of the Slough and wetlands below Ford Street expands aquatic habitat and primary productivity by expansion of native vegetation cover. Replacement of the Harkins Slough Road Bridge would improve water circulation and water quality and remove a barrier to wildlife migration.
- The Current Enhancement Plan significantly improves wildlife habitat by expanding native vegetation cover and diversifying wetlands. Improved water quality would reduce impediments to aquatic productivity and improve food sources for fish and waterfowl. Improved water circulation and reduction of nutrient loading will reduce eutrophic conditions and lessen the risk of fish kills. Native vegetation enhancement would improve waterfowl and songbird cover, food sources and breeding habitat.

The Full Resource Enhancement Plan would improve wildlife migration above Main Street.

**MIDDLE WATSONVILLE SLOUGH**

Middle Watsonville Slough extends from the Shell Road Pump to Highway 1. It is surrounded by predominantly agricultural lands, with a small industrial development on Lee Road. The Slough is generally a straight ditch in the flat, northern edge of the Pajaro River floodplain.

The main stressors in Middle Watsonville Slough are:

- Land use encroachment constricts the Slough to a drainage ditch in most areas, limiting habitat and introducing pollutants (sediment, nutrients and urban runoff).
- Water circulation is low due to flat channel gradient and hydraulic constrictions such as the Shell Road Pump and reaches choked with sediment.
- Extreme nutrient and other contaminant loading from both surrounding and upstream land uses significantly degrade water quality and limit aquatic habitat quality.
- Native vegetation is limited to small pockets mixed with exotic species and adjacent to barren lands.
- The aquatic habitats for invertebrates and fish are compromised as a result of the poor water quality and vegetative conditions.
- The productivity of agricultural land adjoining this reach is degraded by saturated soils and the overall failing of the drainage system.

***Alternatives Descriptions***

The No Action Plan retains existing conditions.

The Current Enhancement Plan includes the following elements:

- The Slough and agricultural drainage system would be reconstructed into two separate channels: a dedicated agricultural drainage ditch and a protected waterway (see WSCEP Figure 4-1). This treatment would be used from Lee Road to the existing levee along the south side of the Slough between Shell Road and San Andreas Road. The agricultural drainage system would include runoff detention basins to remove nutrients and sediments prior to discharge to the protected waterway of the Slough. The new system could include an expanded marsh plain with the protected waterway. The specific design would depend upon the hydraulic criteria for the ditch and land availability (which would be subject to negotiation with multiple landowners).
- Areas of degraded native vegetation would be enhanced by the removal of exotic species and perhaps by regrading land to remove fill and remnants of reclamation. New marsh areas, interior levee slopes and the hillslope rising to the north would be revegetated with native wetland, transitional and upland species.

- The Slough channel would be restructured to obtain natural variability in pattern (i.e. meanders) and depth (pools and shallows). The marsh plain would be excavated to create backwater channels and variable topography to support a range of vegetation from freshwater marsh and riparian forest to transitional and upland species.
- The Shell Road Pump would be modified at its present location and operated as suggested in the Lower Watsonville Slough project description.

In addition to the actions mentioned above, the Full Resource Enhancement Plan would include the following elements:

- The existing levee along the south side of the Slough between Shell Road and San Andreas Road would be set back to the historic limit of marsh soils. The marsh plain would be expanded to the limits of historic marsh soils and reverted to wetlands.
- The slough channel would be reconstructed into a natural meandering channel with small tributary channels draining the adjoining marshes.
- The Shell Road Pump would be moved from it present location to the upstream end of historic marsh soils (about San Andreas Road) as described in the Lower Watsonville Slough alternatives section. The agricultural drainage system would be reconstructed at the edge of the new protected waterway and marsh.
- Native vegetation and associated habitats would be restored along the northern side of the Slough to the uplands on the hillslopes, providing areas of transitional and upland native plant communities. The restored areas would include restored upland habitat from the extending northward towards Buena Vista Road into the Gallighan Slough drainage and would include the upland areas between Lower Harkins, Hanson, Lower West Branch Struve and Lower Struve Slough; this would create an area dedicated to habitat from Watsonville Slough to the western edge of Gallighan Slough near San Andreas Road.

***Benefits and Impacts of Alternatives***

*Land Use*

- The No Action Plan would retain existing uses along the Slough. The reversion of agricultural land to seasonal wetlands would continue and perhaps accelerate due to land subsidence and the deteriorating drainage system.
- The Current Enhancement Plan would convert fallow and actively farmed land into wetlands and protected waterway by agreement with landowners. The landowners would receive a reliable and dedicated drainage system and regulatory relief for maintenance activities. Some lands may be acquired by purchase or acquisition of conservation easements.
- The Full Resource Enhancement Plan would convert significant areas of agricultural and fallow land to conservation and enhancement and have a major impact to existing land uses.

*Water Quality and Geomorphology*

- The No Action Plan would allow degraded water quality conditions to persist. The habitat value for aquatic species would continue to be limited by poor circulation and pollutant inputs.
- The Current Enhancement Plan would significantly improve water quality and circulation and ease stressors affecting aquatic health. Increased native vegetation cover would enhance nutrient uptake. A separate protected waterway and agricultural drainage system would greatly reduce nutrient and sediment inputs from agricultural practices.
- The Full Resource Enhancement Plan would significantly improve water circulation and nutrient uptake in expanded restored wetlands. Restoration of upland areas along the north side of the Slough would reduce sediment input to the Slough by stabilizing eroding land.

*Native Vegetation Resources*

- The No-Action plan would allow existing conditions to persist leaving degraded patches of native vegetation surrounded by barren land and exotic vegetation.

- The Current Enhancement Plan would significantly improve native vegetation resources by converting and expanding native communities. Improvements in all vegetation communities from freshwater marsh to riparian forest, transitional and upland would be realized.
- Full Resource Enhancement would create broadly expanded areas of continuous native vegetation communities spanning from wetland to uplands areas, markedly improving species diversity.

*Wildlife and Fisheries Resources*

- The No Action Plan would allow existing conditions to persist leaving potential habitat areas in a degraded condition. Aquatic habitat and primary biological productivity would be stymied by poor water quality and a lack of native vegetation cover. Terrestrial wildlife habitat would remain in a degraded condition.
- The Current Enhancement Plan would dramatically improve wildlife habitat by creating a protected waterway with significantly improved water quality and expanded areas of native vegetation. Migration corridors would be improved along the Slough through reconfiguration and operation of Shell Road Pumps and the expansion of habitat areas in restored wetlands and adjacent transitional and upland habitats. Waterfowl habitat would be expanded and food source quality and quantity would be improved by the re-establishment of healthy trophic levels.
- The Full Resource Enhancement Plan would restore the ecosystem functions from the base of the food chain in wetlands to higher mammals roaming a large area dedicated to wildlife habitat.

**LOWER WATSONVILLE SLOUGH**

The lower Watsonville Slough is the reach below the Shell Road Pump and includes the Pajaro Dunes development below Beach Road, the levee/drainage pump system on the east side of Watsonville Slough from Beach Road to the mouth, and the publicly owned land between Shell Road and Beach Road.

The key resource stressors identified in this area are:

- Degraded salt-marsh habitat due to reclamation. The extent of the salt marsh is confined by Pajaro Dunes development to the west, the flood control levee to the east, and the Shell Road Pump Station inland.
- The Shell Road Pump Station has abruptly eliminated the natural brackish transition. This barrier also prevents and limits the inland migration of aquatic flora and fauna.
- Concentrated agricultural runoff is discharged directly into the Slough from Beach Road Ditch and at the Shell Road Pump Station. This increases nutrient delivery, increases algal production and reduces dissolved oxygen concentrations, especially during periods when the lagoon mouth is closed.
- The polluted estuarine waters of Watsonville Slough exposes Federal and State listed anadromous fish to potentially toxic waters.
- The quality of native plant communities and wildlife habitat is degraded by exotic, invasive vegetation and the fill and structural remains of past dredging and reclamation attempts.

***Alternatives Descriptions***

The No-Action plan would retain present conditions into the future without any change in management or physical or biological condition.

The Current Enhancement Plan would involve implementing enhancement projects within present land uses. The actions would include:

- Pre-treat agricultural runoff from the Beach Road Ditch through a treatment wetland There are two possible configurations: a) public land north of Beach Road to Shell Road or b) agricultural ditch along backside of levee then discharged to a pretreatment wetland inside levee. A preferred plan would be determined in the design process.
- Renovate the Shell Pump Station to improve its reliability from leaking saltwater allow for a higher pump capacity and instantaneous, variable operation of gates and pumps to allow exchange during freshwater periods, but close and provide flood protection when saltwater and/or high tidal stages are present.

- Remove exotic vegetation cover and plant native vegetation in existing marsh, adjacent transition and upland areas, as well as on the levee along the eastern side of the Slough.
- Work with Pajaro Dunes development to manage marsh areas between the access road and Slough to enhance resources.
- Remove fill berms and antiquated drainage structures throughout the wetlands to improve marsh hydrology for native vegetation. Create islands for waterfowl refugia.
- Re-contour and construct the levee along the east side of the Slough from Beach Road to the mouth to develop more favorable terrain for native vegetation. Revegetate levee with native species and re-route agricultural drainage to pre-treatment wetland. Construct trail on top of levee to connect Pajaro River levee trail to Beach Road.

In addition to the above actions, the Full Resource Enhancement Plan would include the following features:

- Set back the levee/ditch system along the east side of the Slough from the mouth to the location Shell Road pump (existing or new upstream location) to the edge of the historic marsh soils and/or the location of historic slough channels. Restore wetlands (salt and brackish marsh) in the setback area with native plants. Plant native transitional and upland species on the new levee.
- Move the Shell Road Pump from its present location to the eastern end of the historic slough/marsh system (inland to approximately San Andreas Road). Reconstruct adjoining levee system from Shell Road to new pump location. Install pump facilities that reliably protects water quality upstream from seawater intrusion (i.e. improved pump capacity and less leakiness than the present structure) but allow but allow for instantaneous variable pump operation for exchange during freshwater conditions but closed during presence of saltwater.
- Conduct native plant enhancement over remaining areas of potential marsh habitat, including manicured areas of Pajaro Dunes. Conduct revegetation projects to convert degraded areas and areas of exotic invasive plants to native vegetation communities.
- Remove fill berms and dredge tributary channels to improve the hydrology of marsh plain to create more favorable conditions for native vegetation.

***Benefits and Impacts of Alternatives***

*Land Use*

- The No Action Plan would retain existing uses and therefore have no effect.
- The Current Enhancement Plan would not change existing land use significantly and only to the extent that the Pajaro Dunes Homeowners Association allows conversion of manicured marsh areas to natural habitat. Landowners would be involved in design planning process in order to ensure that no unwanted change to present land uses occurs.
- The Full Resource Enhancement Plan would have a significant impact and unavoidable impact on land use and is not feasible under present conditions. The levee setback would involve a loss of over 50 acres of prime farmland under private ownership, an outcome not supported by the landowners or growers.

*Water Quality and Geomorphology*

- The No Action Plan would allow existing stressors to remain leaving the Slough and marsh in a degraded condition.
- The Current Enhancement Plan would improve water quality significantly by pre-treating polluted runoff from agricultural lands thereby addressing a key stressor. However, pollution sources upstream would remain unless addressed simultaneously. The use of wetlands for pre-treatment may degrade the water quality of wetlands used and maintenance must consider the potential for contaminants.
- The Full Resource Enhancement Plan would improve water quality beyond the Current Enhancement Plan by maximizing vegetated area for nutrient uptake, and creating a large buffer area between Beach Road Ditch and the aquatic habitat of the Slough. As a result, the Full Resource Enhancement Plan more effectively relieves the water quality stressors

*Native Vegetation Resources*

- The No Action Plan would allow the existing degraded condition to persist, allowing the area to remain below its potential for native vegetation resources.

- The Current Enhancement Plan would have significant benefits to native vegetation resources by converting degraded areas to native plant communities. Recontouring the levee and creating more areas for transition and upland habitats expands benefits to native vegetation.
- The Full Resource Enhancement Plan would vastly improve native vegetation resources by expanding salt marsh and brackish marsh communities, and diversify the native vegetation cover.

*Native Wildlife and Fisheries Resources*

- The No-Action Plan does not effectively address stressors and continues to expose aquatic wildlife to high nitrate levels, persistent pollutants, and eutrophic conditions. If these adverse conditions continue, the aquatic species composition and diversity will be extremely simplified, ultimately reducing the food source for waterfowl and higher trophic levels. Allowing degraded native vegetation conditions to persist would continue to suppress aquatic habitat quality.
- The Current Enhancement Plan would significantly improve conditions for aquatic wildlife by improving water quality. Vegetation enhancement and conversion of degraded areas to native plant communities would improve habitat, cover and food sources for waterfowl, songbirds and aquatic species. Modifying the operations of the Shell Road Pump would vastly improve water circulation and the movement of aquatic species to reaches upstream of Shell Road. The creation of transitional habitats on an improved levee would create important ecosystem transition zones valuable to a variety of species.
- The Full Resource Enhancement Plan would significantly improve wildlife habitat conditions beyond the Current Enhancement Plan. Expanded areas of salt and brackish marsh would greatly improve waterfowl breeding habitats and food sources. The expansion of native vegetation would directly diversify the wildlife habitat. The additional improvements in water quality and circulation would further improve food sources for aquatic species and waterfowl. Upgrading and moving the Shell Road Pump upstream to the historic boundary of marsh would effectively restore original conditions for salt marsh and brackish marsh habitats, which would maximize

waterfowl and marsh productivity while buffering habitats from active land use areas. However, moving the pump upstream could expose the PVWMA Harkins Slough Project Intake and surrounding agricultural land to high TDS water (already a problem) unless it is proven that an upgraded facility could feasibly protect land and water supply.

**UPPER STRUVE SLOUGH AND UPPER WEST BRANCH ABOVE HIGHWAY 1**

The headwaters of Struve Slough and West Branch Struve Slough originate just south of the Watsonville Municipal Airport and extend to Highway 1. The drainage area of is predominantly dense urban residential and commercial development on hilltops and hillslopes, with open space and wetland areas increasing in width and area towards the Highway 1.

The main stressors on Upper Struve Slough are:

- Extensive urban development encroaching into wetlands and hillslopes removes areas for native plant communities and wildlife habitat, and brings pollution sources close to sensitive areas.
- Poor drainage in the Sloughs between Pennsylvania Drive and Main Street results in poor water circulation.
- Water quality in the Sloughs is influenced by urban runoff and non-point source pollution.
- The removal of native vegetation and wildlife habitat is compounded by expansion of urban tolerant wildlife species such as raccoons, opossum, and starlings.

***Alternatives Descriptions***

The No Action Plan retains existing conditions. This includes projects independent of the WSCEP, including the City of Watsonville Plan to replace the Harkins Slough Road fill and culvert crossing with a spanned bridge.

The Current Enhancement Plan includes the following elements:

- Remove or modify hydraulic structures to improve water circulation including the Main Street crossing. As assumed under the No Action Plan, the City of Watsonville is planning the replacement of the Harkins Slough Road crossing with a span structure.

- Native vegetation communities would be restored by the removal of exotic vegetation and planting degraded wetlands and hillslope areas with native plants. Existing urban runoff pre-treatment basins could be modified to enhance hydrology and soil conditions for native plant communities.
- Selective dredging would be conducted to improve water circulation, to remove remnants of reclamation and to diversify aquatic habitats.
- Urban storm water runoff pre-treatment systems would be added at drainage outfalls where they do not exist. These could be created wetlands or a combination of catch basins, detention structures and filters. The precise design would depend upon many engineering factors, but this alternative assumes the need to improve urban runoff quality will be realized.

The Full Resource Enhancement Plan would be the same as the Current Resource Enhancement Plan due to the constraints of urban cover on the landscape.

***Benefits and Impacts of Alternatives***

*Land Use*

- The No Action plan does not affect present land use coverage.
- The Current Enhancement potentially changes land use coverage in minor ways for some areas as a result of constructing pre-treatment systems for urban runoff, and by converting degraded land on hillslopes to native vegetation communities.
- There is no Full Resource Enhancement Plan proposed.

*Water Quality and Geomorphology*

- The No Action Plan allows existing conditions and stressors to persist leaving water quality in a degraded condition. An exception would be the improvement in water circulation realized by replacement of the Harkins Slough Road crossing by the City of Watsonville under a separate project.
- The Current Enhancement Plan significantly improves water circulation and the quality of urban runoff thereby addressing stressors related to pollutant loading and

water circulation. Improvement in water quality in the area above Highway 1 will improve water quality in waterways within the lower watershed.

*Native Vegetation Resources*

- The No-Action Plan would retain the present degraded vegetation cover, which would maintain native vegetation resources well below their potential.
- Under the Current Enhancement Plan, native vegetation resources would be significantly improved by revegetation projects in wetlands and in open space areas on hillslopes. Once completed, the abundance and diversity of plant communities would be improved.

*Wildlife and Fisheries Resources*

- The No Action Plan maintains wildlife habitat in a degraded condition with the exception of the replacement of Harkins Slough Road crossing, which would improve migratory barrier for wildlife.
- The Current Enhancement significantly improves conditions for wildlife. Restoration of native plant communities in upland, transitional and wetland habitats would provide new habitats and food sources for birds and terrestrial wildlife. Improved water circulation through replacement of constrictions and selective dredging would enhance water quality for aquatic species and would improve primary biological productivity. Improved water quality resulting from treatment of urban runoff would improve conditions for aquatic species affecting by pollution.

**LOWER STRUVE SLOUGH/WEST BRANCH STRUVE SLOUGH**

This Planning area includes all of Struve Slough and West Branch Struve Slough downstream of Highway 1 to its confluence with Watsonville Slough just upstream of the UPRR crossing.

The main stressors in the Lower Struve Slough/ West Branch Struve Slough planning area are:

- Extensive urban and commercial development from upstream areas transports pollutants to aquatic habitats in Lower Struve and West Branch Struve Sloughs.
- Water quality is affected by runoff and intermixing with agricultural drainage, especially by

recently cultivated agricultural fields of the lower reaches of the planning area.

- Harkins Slough and Lee Roads are hydraulic barriers that reduce water circulation and affect water quality.
- Land subsidence within the lower reaches present challenges to providing future drainage for agriculture.
- Native vegetation cover in wetlands, transitional areas and uplands is degraded by invasive exotic species and the remnants of past agricultural and reclamation activities.
- Wildlife habitat is compromised by exotic vegetation cover and poor water quality from low circulation and pollutant loading.

### *Alternatives Descriptions*

The No Action Plan retains existing conditions.

The Current and Full Resource Enhancement Plans are considered the same and include the following elements:

- Native vegetation cover would be restored in all areas by removing exotics and improving hydrology and soil conditions in degraded areas and planting appropriate native species. This would occur over the entire planning area, nearly all of which is publicly owned.
- Lee Road crossing would be removed completely or replaced with a span structure to improve water circulation. Selective dredging would be conducted to remove remnants of reclamation activities and to improve water circulation and water quality.
- The lower reach of Struve Slough and its confluence with Watsonville Slough between Lee Road and the UPRR crossing would be reconfigured to reconstruct the decaying drainage system. The precise plan would be developed in consultation with private landowners and growers.

### *Benefits and Impacts of Alternatives*

*Land Use*

- The No Action Plan does not change land uses.

- The Current Enhancement Plan does not significantly change land use in the upper planning area above Lee Road as most of the land is publicly owned and dedicated to resource conservation. Agricultural land use below Lee Road could be converted to protected waterway as a result of re-configuring the drainage system. However, the area reverting to wetlands is rapidly expanding due to land subsidence and decaying drainage conditions and implementing the Current Enhancement Plan would conserve farmland.

*Water Quality and Geomorphology*

- The No Action Plan would retain existing conditions and degraded water quality conditions would persist. These conditions could worsen is the drainage system in the lower reach continues to decay and revert areas to low circulation wetlands.
- The Current Enhancement Plan would significantly improve water circulation by removing water flow constrictions. Separating agricultural runoff from the lower reach of the Slough would significantly improve water quality conditions. Increasing vegetation cover in the lower reach will increase biouptake of excessive nutrients and improve water quality locally and in downstream reaches.

*Native Vegetation Resources*

- The No Action Plan would leave native vegetation resources in a degraded condition with the planning area remaining far below its potential value.
- The Current Enhancement Plan would significantly improve native vegetation resources by replacing degraded and cleared areas and exotic vegetation with native plant communities in wetland, transitional and upland areas. The diversity and abundance of native plants would be significantly improved.

*Wildlife and Fisheries Resources*

- The No Action Plan would retain degraded conditions for wildlife and the wildlife resources would remain far below their potential.
- Conditions for wildlife would be significantly improved with the Current Enhancement Plan by restoration of native plant communities for terrestrial wildlife,

and improved water circulation for aquatic wildlife. Expanded wetlands and improved water quality in the lower reach will significantly improve aquatic wildlife conditions.

**GALLIGHAN SLOUGH**

Gallighan Slough (see WSCEP Figure 3-10) extends from its headwaters at Highway 1 on the north and east, to San Andreas Road on the west. The Slough flows through the middle of the watershed past the County landfill and then enters Lower Harkins Slough below the Harkins Slough Road crossing.

The main stressors in Gallighan Slough are:

- High sediment loads eroding from agricultural fields, roads and some surrounding areas.
- High sediment loads from poorly designed and maintained road and drainage ditches along Buena Vista Road from San Andreas Road to the County landfill.
- Native vegetation impacted by cleared land and roads and degraded lands.
- Wildlife habitat fragmented by roads and cleared areas. Aquatic habitat affected by excessive sediment input and by migratory barriers.

***Alternatives Descriptions***

The No Action Plan retains existing conditions.

The Current Enhancement Plan includes the following elements:

- Upgrade the storm water drainage system along Buena Vista Road from San Andreas Road to Highway 1 to reduce erosion and sediment supply to Gallighan Slough. Install adequate culverts to pass large floods and stabilize roadside ditches, road cuts and road fill areas with riprap and/or native vegetation if feasible. Use pre-treatment facilities to remove sediment before discharge to waterways.
- Restore native vegetation habitat in areas of public ownership and negotiate to expand into areas of private ownership. Ensure that the final disposition of the landfills is to restore native vegetation appropriate to its location in the landscape.
- Expand programs to encourage landowners to reduce erosion and sediment discharge from private lands through education and by providing technical assistance.

The Full Resource Enhancement Plan would include:

- Remove Buena Vista Road from the Gallighan Slough riparian corridor between Harkins Slough Road and San Andreas Road and restore the stream and flood plain. Revegetate with native plant communities.
- Restore all wetland areas in tributary streams and swales with native wetland and transitional plant species.
- Expand native vegetation cover over entire watershed area to create a conservation corridor extending from the northwest corner of the watershed to the eastern watershed boundary with Lower Harkins Slough.

***Benefits and Impacts of Alternatives***

*Land Use*

- The No Action alternative would retain existing conditions and not change present land use. The landfills will eventually be reclaimed to publicly owned open space and perhaps expanded into an adjacent area.
- The Current Enhancement Plan may involve conversion of some limited areas of agricultural use and degraded areas to native vegetation and habitat. Conversion would occur as a result of negotiation with landowners.
- The Full Resource Enhancement Plan would have a significant impact on land use by converting agricultural land and private open space to native vegetation and habitat (it is assumed that rural residential uses would not be affected). This Plan is not presently feasible due to a lack of an agreement with landowners.

*Water Quality and Geomorphology*

- The No Action Plan would allow present conditions to persist resulting in degraded water quality due to oversupply of sediment.
- The Current Plan would result in measurable benefits for water quality by sediment reduction and improved storm water discharge to Lower Harkins Slough.
- The Full Resource Enhancement Plan would maximize water quality improvement for Gallighan Slough and Lower Harkins Slough.

*Native Vegetation Resources*

- The No Action Plan would allow degraded conditions to persist.
- The Current Plan would allow for improvement and possible expansion of native plant communities.
- The Full Resource Enhancement Plan would maximize native vegetation communities and would allow connection of large areas of restored native vegetation in other planning areas.

*Wildlife and Fisheries Resources*

- The No Action Plan would retain degraded conditions for wildlife and fisheries.
- The Current Enhancement Plan would significantly improve wildlife and fisheries conditions by improving water quality and removing migratory barriers along Buena Vista Road. Areas restored to native vegetation would improve habitat for birds and terrestrial species.
- The Full Resource Plan would maximize wildlife habitat and create a habitat corridor extending across the watershed.

**HANSON SLOUGH**

Hanson Slough drains a relatively small basin situated between Lower Harkins and Lower Struve Sloughs. Harkins Slough Road transverses the upper watershed area and land use is predominately agriculture and grazing. The headwaters originate above Harkins Slough Road in a hilly area highly impacted by cattle grazing operations.

The main stressors of Hanson Slough are:

- Water quality is degraded by land uses including the intensive grazing operations in the upper watershed exposing soils to surface erosion, removing of native vegetation cover, and compacting of soils within the waterway
- Animal waste deposited directly into the waterway contributes to the nutrient contamination of the Slough.

- Despite some patches of riparian forest along the waterway, native vegetation cover is sparse in the upper watershed and areas below Harkins Slough Road, decreasing overall diversity and abundance.
- Wildlife habitat is limited and degraded by present land uses, a lack of native vegetation cover and apparent degraded water quality.

### *Alternatives Descriptions*

The No Action Plan retains existing conditions.

The Current Enhancement Plan includes the following elements:

- Native vegetation cover would be improved and expanded to increase abundance and diversity of plant communities, and also as a means to create sediment-filtering buffers along waterways (an expansion of the Watershed Institute's riparian restoration and water quality project). The area converted to native plant communities would be determined through consultations with landowners.
- A grazing management plan would be developed to implement a waterway and water quality protection plan above Harkins Slough Road. The plan would include a manure management plan and grazing methods to eliminate sediment and nutrient pollution delivered to the waterway.
- The channel of Hanson Slough and its tributaries would be improved to reduce erosion, improve aquatic habitat and the water quality of runoff leaving the basin.

The Full Resource Enhancement Plan would include the following elements:

- Native vegetation communities would be restored over the entire Hanson Slough watershed to create a wetland to hilltop mosaic of wildlife habitat.
- Hanson Slough waterway would be restored to pre-disturbance condition.

### *Benefits and Impacts of Alternatives*

*Land Use*

- Under the No Action Plan land use would remain the same.

- The Current Enhancement Plan would enlarge the area of native vegetation and habitat and replace agricultural and grazing lands to the extent that can be negotiated with the current landowners.
- The Full Resource Enhancement Plan would significantly change land use by converting grazing and agricultural lands to areas dedicated to wildlife habitat and native vegetation communities. This would eliminate agricultural and grazing land use on these lands, a scenario that is not feasible unless the lands are acquired or otherwise dedicated to resource conservation.

*Water Quality and Geomorphology*

- The No Action Plan would allow present conditions to continue leaving degraded water quality conditions within the Hanson Slough Planning Area. Downstream areas (e.g. Watsonville Slough and Struve Slough) would continue to receive sediment and nutrient runoff from Hanson Slough.
- The Current Enhancement Plan would significantly improve water quality by reducing sediment and nutrient sources delivered to the watercourse. This would improve conditions for aquatic habitat within the watershed and in downstream areas.
- The Full Resource Enhancement Plan would stabilize soils and reduce pollution to the maximum extent possible by removing disturbances and restoration of native plant communities.

*Native Vegetation Resources*

- The No Action Plan would allow degraded conditions for native vegetation resources to continue.
- The Current Enhancement Plan would significantly improve native plant abundance and diversity.
- The Full Enhancement Plan would maximize native vegetation resources to the extent possible.

*Wildlife and Fisheries Resources*

- The No Action Plan would allow degraded conditions for wildlife and fisheries to continue. Impacts would continue within the watershed and offsite in downstream areas where water quality impairment limits aquatic resources.
- The Current Enhancement Plan would significantly improve wildlife and fisheries resources by expanding habitat area and improving water quality.
- The Full Resource Enhancement Plan would maximize wildlife habitat from wetland to upland areas in the watershed.

**UPPER HARKINS SLOUGH**

Upper Harkins Slough is the longest waterway in the Watsonville Sloughs system extending 7 miles inland through Larkin Valley. In the upper watershed area above Highway 1 (see WSCEP Figure 3-12) Harkins Slough flows as a stream within Larkin Valley, a narrow, linear valley surrounded by moderately steep hillslopes and tributary valleys. A significant amount of this watershed consists of large parcels zoned rural residential, providing groundwater recharge and portions of wildlife habitat, relatively absent in much of the remaining areas of Watsonville Sloughs Watershed.

The main stressors for Upper Harkins Slough are:

- The riparian habitat and wetlands along the Slough has many reaches that have been exposed by land clearing and/or erosion leaving a roadside ditch or an unprotected channel within grazing lands. These degraded reaches fragment valuable areas of riparian vegetation and aquatic habitat. In addition, channel erosion produces sediment during high flows.
- Septic systems and livestock manure are chronic sources of nutrients to the groundwater and waterways.
- Erosion occurring in cleared areas or disturbed by grazing or development contribute an excessive sediment supply to local and downstream reaches. This reduces aquatic habitat quality and clogs waterways causing flooding.

***Alternatives Descriptions***

The No Action Plan would allow present conditions to continue.

The Current Enhancement Plan recognizes a need to coordinate the activities and desires of the multiple landowners in the Larkin Valley Area. The specific information needed is not available. The overall aim of the recommendations is to decrease erosion and entrainment of nutrients from unmanaged manure and septic systems and includes the following elements as next steps:

- Establish a Management Plan to coordinate land use practices in Harkins Slough for drainage maintenance and management of riparian, wetlands and sensitive species habitats. The Plan would coordinate land use activities on the multiple properties such that impacts to vegetation and wildlife resources can be minimized by the timing and methods of maintenance.
- Conduct a pilot drainage improvement project to demonstrate planning, engineering, resource enhancement and maintenance techniques that could be applied to waterways.
- Develop a native vegetation enhancement and education program for local landowners to improve native vegetation stands. Provide ways for grant money to use on private land to improve native vegetation.
- Develop manure management plans for livestock operations to minimize entrainment of nutrients into waterways.
- Develop a plan to upgrade deficient septic systems.

The Full Resource Enhancement Plan was not developed because it would involve converting a large area of multiple land ownership to resource conservation, which is considered infeasible because of economic reasons.

***Benefits and Impacts of Alternatives***

*Land Use*

- The No Action Plan would retain existing conditions and have not effect on land use.
- The Current Management Plan may affect land use by converting disturbed areas used for grazing or other activities to resource conservation.

- No Full Resource Management Plan was developed due to the infeasibility of acquiring large tracts of land from small parcels of privately owned land and converting it to resource management.

*Water Quality and Geomorphology*

- The No Action would allow degraded habitat conditions to exist making Larkin Valley a significant source of sediment and nutrients.
- The Current Enhancement Plan would begin a process by which significant improvements in water quality and reductions in sediment and nutrient input could be realized. This would benefit water quality in Larkin Valley and in downstream areas.

*Native Vegetation Resources*

- The No Action Plan would allow native vegetation resources to remain in a degraded condition.
- The Current Enhancement Plan could significantly improve native vegetation cover, but the final result would depend upon the outcome of the ultimate drainage management plans and public outreach.

*Wildlife and Fisheries Resources*

- The No Action Plan would allow present degraded wildlife conditions to continue.
- The Current Enhancement Plan could significantly improve wildlife habitat by expanding and improving native vegetation cover. Water quality improvements realized through nutrient and sediment inflow reductions would improve aquatic habitat conditions within Larkin Valley and in downstream areas.

**LOWER HARKINS SLOUGH**

Lower Harkins Slough extends from Highway 1 to the northern edge of the Pajaro Valley where it meets Watsonville Slough. The area is mostly fallow agricultural and grazing land with sparse buildings associated with present or past agricultural uses (cattle grazing and dairy operations) and concentrated public and private residences. The main access points are Harkins Slough Road, Ranport Road and the UPRR crossing.

The area of Lower Harkins Slough and extending to Struve Slough west of Highway 1 represents the best area for large wetland and ecosystem restoration. Much of the land on the valley floor is in wetlands and/or under public ownership. A significant area of the adjoining hillslopes is publicly owned, in conservation easement or are not actively cultivated or grazed.

The main stressors in Lower Harkins Slough are:

- Lower Harkins Slough receives contaminants generated in the upper watersheds of Larkin Valley and Gallighan Slough. The main pollutant types are sediment from roads and agriculture, nutrients from septic systems, livestock manure and fertilizer, and a variety of pollutants from landfill runoff.
- Poor water circulation and the progressive expansion of seasonal lakes are due to the combined effects of hydraulic constrictions (UPRR, Harkins Slough Road and Highway 1) and land subsidence. Winter inundation of recently cultivated agricultural fields will decrease the water quality of overlying waters.
- Vegetation resources in the wetlands, transitional areas and uplands are degraded by land use leaving clear and degraded conditions and areas dominated by exotic invasive species.
- Wildlife and fisheries are limited by poor water circulation, lack of native vegetation cover and migration barriers at road crossings (UPRR, Harkins Slough Road, Ranport Road and Highway 1 culverts).

### *Alternatives Descriptions*

The No Action Plan retains existing conditions.

The Current Enhancement Plan includes the following elements:

- Removal of the hydraulic constriction at Harkins Slough Road to improve water circulation.
- Selective dredging in wetland areas to remove reclamation era fill and structures and to improve aquatic habitat diversity and water circulation.
- Enhance native vegetation in available areas (public lands and those subject to consultation with private landowners). Restore native plant communities in the wetlands, transitional areas and uplands.

- The Full Resource Enhancement Plan would include the following elements:
- Restore native vegetation communities throughout the planning area and convert all land use to resource conservation. This would cover the areas from the wetlands to the hilltops throughout the entire planning area.
- Replace constricted waterway crossings at Ranport Road and Highway 1 in order to improve wildlife migratory corridors.

***Benefits and Impacts of Alternatives***

*Land Use*

- The No Action Plan would not significantly change existing land use.
- The Current Enhancement Plan would convert agricultural land and undeveloped or fallow land to resource conservation to the extent allowed by public land ownership and negotiation with landowners.
- The Full Resource Enhancement Plan would significantly change land use by converting all available land to resource conservation. This is not feasible unless privately held land and easements (e.g. UPRR crossing) are converted to resource conservation by acquisition or conservation easement.

*Water Quality and Geomorphology*

- The No-Action Plan would retain existing conditions and the degradation of water quality would continue.
- The Current Restoration Plan would significantly improve water quality by improving water circulation, thereby offsetting some of the effects of nutrient loading. Restoration of native vegetation cover in wetland and transitional areas would allow for filtering sediments eroded from disturbed areas.
- The Full Resource Enhancement Plan would maximize water circulation improvements and stabilize soils from erosion with native vegetation cover.

*Native Vegetation Resources*

- The No Action Plan leaves vegetation in its present degraded condition.

- The Current Enhancement Plan significantly improves and expands native vegetation cover thereby improving native plant diversity.
- The Full Resource Enhancement Plan maximizes native vegetation cover in the planning area from wetlands to hilltops, thereby creating large areas with diversity.

*Wildlife and Fisheries Resources*

- The No Action Plan retains the existing condition and leaves the area well below its resource potential for aquatic habitat and terrestrial wildlife.
- The Current Enhancement Plan significantly improves wildlife and fisheries resources by restoring native vegetation communities and improving water circulation.
- Full Resource Enhancement Plan maximizes wildlife habitat restoration and creates the basis for broad ecosystem restoration and broadening of wildlife food webs.

**BEACH ROAD DITCH**

The land use surrounding Beach Road Ditch is exclusively active agricultural field cultivation. On south side of the road, Beach Road Ditch extends the length of Beach Road from Lee Road to its discharge into Lower Watsonville Slough estuary. On the north side of the road, waters from Lee Road head north at San Andreas Road and discharge directly to Watsonville Slough at San Andreas Road during high flows. During the drier months the drainage on the north side appears to evaporate or infiltrate rather than reaching the Slough waters directly.

The main stressors present in the Beach Road Ditch are:

- Concentrated, untreated, and potentially toxic agricultural drainage is eventually released into Watsonville Slough at two specific locations.
- Saltwater intrusion continues due to groundwater overdraft to meet irrigation needs.
- Wildlife and aquatic habitat is relatively non-existent.

***Alternatives Descriptions***

The No Action Plan retains existing conditions.

The Current Enhancement Plan includes the following elements:

- Widen existing agricultural drainage ditches.

- Plant and encourage vegetative growth within the wetlands beginning in the spring months, especially wetland vegetation capable of uptaking large amount of nutrients, such as bulrush and cattails. Prior to winter storms, selectively harvest a portion of the vegetation to ensure proper flood capacity during high flows and minimal vegetation growing periods (winter).

The Full Resource Enhancement Plan would be the same as the Current Resource Enhancement Plan due to the constraints of agricultural land acquisition.

***Benefits and Impacts of Alternatives***

*Land Use*

- The No Action plan does not change present land use coverage.
- The Current Enhancement changes land use coverage due to a small encroachment on the neighboring agricultural land to increase the width of the Beach Road Ditch.
- There is no Full Resource Enhancement Plan proposed.

*Water Quality and Geomorphology*

- The No Action Plan allows existing conditions and stressors to persist leaving water quality in a degraded and potentially toxic condition.
- The Current Enhancement Plan significantly decreases nutrient and pollutant loading to Lower Watsonville Slough. Vegetated banks of Beach Road Ditch will eliminate bank erosion and decrease maintenance efforts.
- There is no Full Resource Enhancement Plan proposed.

*Native Vegetation Resources*

- The No-Action Plan would retain the lack of vegetation cover.
- Under the Current Enhancement Plan, vegetative cover will exist along the Beach Road Ditch corridor during the warmer months of the year.
- There is no Full Resource Enhancement Plan proposed.

*Wildlife and Fisheries Resources*

- The No Action Plan maintains wildlife habitat in a degraded condition.
- The Current Enhancement could provide a small corridor of habitat for birds.
- There is no Full Resource Enhancement Plan proposed.

# Technical Appendix G: A Review of the Bird Resources of Watsonville Sloughs Watershed, Santa Cruz County California

David L. Suddjian Biological Consulting Services prepared the bird resources review presented below.

## Introduction

The Watsonville Slough system includes some of the most important bird habitat areas in the Monterey Bay area and the most extensive wetland habitat areas in Santa Cruz County. The overall value of the slough system is highlighted by the great variety of bird species known to occur there (279) and the significantly large numbers of several species that visit the Sloughs compared to other areas in the local region. The diversity and abundance of birds have attracted bird watchers through the seasons, helping to provide a substantial amount of information about the area's avifauna.

Within the context of Santa Cruz County, the varied wetlands and open water habitats of the Sloughs support significant numbers of migratory and wintering waterbirds. Numbers of winter waterfowl in the Sloughs are usually second in the county only to those using College Lake, and in some years the Sloughs rank first in numbers of ducks. The wetlands host large portions of the county's breeding populations of several nesting waterbirds. The grassland habitats and other open areas on the uplands between the Sloughs are highly important for migratory and wintering raptors. Several breeding species associated with grasslands were principally found in the Pajaro Valley only in the lands around the Sloughs. Unfortunately, there has been a significant decline in populations of many grassland birds in the slough system over the last few decades due to habitat loss and degradation. A third habitat of high importance for birds is deciduous riparian forest and woodland associated with the Sloughs. Riparian habitat is widely recognized for its high abundance and species richness of birds, and especially its value for breeding landbirds and as "stop over" for migratory landbirds.

## Study Area and Information Base

This assessment of bird resources includes the entire watershed of the Watsonville Slough system, along with the Pajaro River mouth, but it focuses on the Sloughs themselves and the surrounding upland habitats upstream to Freedom Boulevard and Buena Vista Road. The principal areas of interest for this assessment include the seasonally- and permanently-flooded portions of the Sloughs and the various upland habitats in close proximity to those parts of the Sloughs.

This assessment has been based on existing information, including: (1) species files and other archived data maintained by the Santa Cruz Bird Club since 1974; (2) data from the Santa Cruz County Breeding Bird Atlas Project (1987-1993); (3) various published and unpublished summaries in a library of Santa Cruz avifauna which have been developed by the bird club; (4) data from portions of the Moss Landing Christmas Bird Count covering the Sloughs; and (5) results of my own bird studies conducted in the study area from 1986 to the present.

**Patterns of Bird Occurrence and Habitat Use**

At least 279 bird species have been recorded in the study area as defined above (Technical Sub-Appendix G-1). Thirty-seven species (13%) occur within the study area only or principally at the Pajaro River mouth area and make little to no use of the Sloughs themselves. These are all waterbirds associated with the ocean and littoral habitats, including such species as loons, Brown Pelican, Snowy Plover, Marbled Godwit, Sanderling, Heermann's Gull, and Elegant Tern. Ninety-four species (34%) have occurred only rarely in recent years, being found fewer than five times per year (many not found annually and represented by only 1-3 total records of occurrence). These include species such as Tundra Swan, Garganey, Eurasian Wigeon, Swainson's Hawk, Stilt Sandpiper, Ruff, Purple Martin, Red-eyed Vireo, Prairie Warbler Summer Tanager and Clay-colored Sparrow.

Aside from the rarities and species principally associated with the Pajaro River mouth, 171 species (61%) have been found to occur regularly in the slough watersheds in recent years. As expected, waterbirds (herons, waterfowl, shorebirds, gulls etc.) are well represented, and nearly all the waterbird species that use freshwater habitats in Santa Cruz County are found in the slough watersheds. Also well represented, through declining in recent years, are species associated with grassland and other open upland habitats.

General patterns of occurrence and habitat use are described below. Technical Sub-Appendix G-2 gives specific information for selected species of potential management concern.

*Freshwater Wetlands*

A broad range of microhabitats are found within the freshwater wetlands of the Sloughs, including open water areas ranging in size from many acres to small fractions of an acre, seasonally exposed mudflat along the margins of open water areas, and areas dominated by various types of emergent wetland vegetation. The seasonal pattern of winter flooding and dry-season draw down is a critical feature for the birds, providing different habitat conditions in different seasons and increasing the productivity of aquatic habitats for foraging birds.

Some representative species using the freshwater wetlands and open water habitats of the Sloughs are: Pied-billed Grebe, American White Pelican, American Bittern, Great Blue Heron, Great Egret, Snowy Egret, Green Heron, Black-crowned Night-Heron, Canada Goose, Gadwall, American Wigeon, Cinnamon Teal, Northern Pintail, Green-winged Teal, Canvasback, Ring-necked Duck, Hooded Merganser, Ruddy Duck, Osprey, Peregrine Falcon, Virginia Rail, Sora, American Coot, Killdeer, Black-necked Stilt, Greater Yellowlegs, Western Sandpiper, Least Sandpiper, Red-necked Phalarope, California Gull, Caspian Tern, Belted Kingfisher, Black Phoebe, Marsh Wren, Common Yellowthroat, Lincoln's Sparrow, Song Sparrow, Red-winged Blackbird and Great-tailed Grackle.

In the context of Santa Cruz County, the freshwater wetlands of the Sloughs support significant breeding populations for Pied-billed Grebe, American Bittern, Black-crowned

Night-Heron (but nests there only irregularly), Green Heron, Gadwall, Mallard, Cinnamon Teal, Ruddy Duck, Virginia Rail, Common Moorhen, American Coot, Killdeer, Black-necked Stilt, Marsh Wren, Common Yellowthroat, Red-winged Blackbird and Great-tailed Grackle (Santa Cruz County Breeding Bird Atlas unpubl. data; Suddjian 1990). In particular, the Sloughs presently host a majority of the county's nesting populations of Pied-billed Grebe, American Bittern, Gadwall, Cinnamon Teal, Ruddy Duck, Black-necked Stilt, Marsh Wren, and Great-tailed Grackle.

Grebes, pelicans, cormorants, the large herons and egrets, terns and other fish-eating species reach their greatest numbers in areas of large to moderate-sized open water. Numbers are generally greatest from late spring to early fall, when many of those present are non-breeders, breeding birds that commute to the Sloughs to forage, and post-breeding visitors. Relatively large numbers of herons and egrets are sometimes also found during winter. No significant roost of herons and egrets has been reported recently, although the wetlands and willows of Hanson Slough supported one in the1970s and 1980s (Santa Cruz Bird Club data), and Black-crowned Night-Herons roost as scattered individuals in willow areas near the wetlands.

Waterfowl are generally dependant on open water areas of various sizes. Portions of the Sloughs with large to moderate-sized areas of open water are of the greatest importance for migrating and wintering waterfowl. Nesting waterfowl use such areas, too, but also occur where small areas of open water form a mosaic with emergent vegetation. Large areas of open upland habitats on slopes adjacent to the Sloughs are also critical for nesting ducks, and many nests are actually placed in such areas.

Shorebirds favor shallow flooded marsh, flooded fields, margins of open water areas, and mud that is exposed as flooded areas dry out. Numbers of wintering shorebirds have been variable and generally low in recent years, principally because suitable habitat is then often limited. More shorebirds wintered in the drought years of the late 1980s, when exposed mud or shallow water habitat was available much of the winter (Santa Cruz Bird Club data). Spring migrant shorebirds make special use of the exposed mud at flooded agricultural fields, especially as water levels recede from March to early May. Numbers of shorebirds in spring are highly variable, depending on flooding conditions, but during migratory pulses aggregate numbers from the low hundreds to well over one thousand birds may use the Sloughs. Fall migrant shorebirds have mostly been found at Harkins Slough in recent years, where numbers range widely depending on the amount of exposed mud habitat. Exposed mudflat is rare in Santa Cruz County, so when conditions are good during August to October this area may have more shorebirds than any other freshwater area in the county. Nesting shorebirds include small numbers of Killdeer and Black-necked Stilt.

Gulls use the Sloughs principally for day roosting, preening and drinking. The main area used for such activity is Harkins Slough adjacent to the county landfill, and the Anderson Peat Ponds at the south end of the Slough. Gulls also forage in some areas, especially Mew Gulls at the margins of flooded agricultural fields in winter, and Bonaparte's Gulls at the peat ponds.

Dense wetland vegetation is used year-round by Marsh Wren, Common Yellowthroat, Song Sparrow and Red-winged Blackbird. Large roosts of various blackbirds and starlings occur in some years in areas with tule or cattail marsh. The Sloughs presently have the county's only nesting Great-tailed Grackles, a recent colonist in the region, which has been found nesting at Watsonville and Struve Sloughs.

Freshwater wetland areas currently of the greatest importance for birds are: (1) Harkins Slough from downstream of Ranport Road to a short ways downstream of Harkins Slough Road; (2) Anderson Peat Ponds; (3) Watsonville Slough near the mouth of Struve Slough; (4) Watsonville Slough near Ford Road; (5) West Struve Slough; (6) and East Struve Slough from its mouth to Harkins Slough Road.

*Brackish Wetlands of Lower Watsonville Slough and the Pajaro River Mouth*

This important area is treated only briefly here as it is outside much of the direct management scope of this project.

The lower reach of Watsonville Slough (downstream of Shell Road) and the adjacent Pajaro River mouth are a distinctive part of the slough system with regard to birds. These areas are linked to the more inland parts of the slough system by the waters of Watsonville Slough, and there is some degree of bird movement between the coastal and inland parts of the system. However, the segment of Watsonville Slough between Shell Road and Harkins Slough is of low value for birds with little wetland habitat, and the intervening distance of over 2 kilometers leaves the coastal and inland parts of the slough system physically separated from each other for most bird species.

The coastal location of lower Watsonville Slough and the Pajaro River mouth and their brackish water habitats attract a unique set of waterbirds. The brackish wetlands along Watsonville Slough are the most extensive area of this habitat available for birds in Santa Cruz County. The Slough and wetlands sometimes provide important exposed mudflat that may be used by many shorebirds, but amounts of exposed mudflats are highly variable, depending on tides, levels of flow in the Pajaro River, and varying degrees of exchange of water flowing across the beach. The sand flats along the margins of the river lagoon are similarly important for shorebirds. The margins of lower Watsonville Slough and the Pajaro River lagoon are important for nesting Black-necked Stilt and American Avocet.

The Pajaro River lagoon and its margins attract large numbers of many coastal and ocean species that gather there to drink, bathe, roost and forage. During much of the year it is common to find composite flocks of 1000 to 10,000 birds at the river mouth area. In appropriate seasons there are large flocks of Brown Pelican, California, Western, Glaucous-winged and other gulls, Elegant, Caspian and Forster's terns, and Double-crested Cormorants. Relatively large flocks of shorebirds are often present, with Sanderling, Willet, Marbled Godwit, Whimbrel and Dunlin being common in season. Snowy Plovers nest on the beach in the vicinity of the lagoon. They formerly also nested on mudflat areas along lower Watsonville Slough, but have not done so for many years. The waters of the lagoon and Slough also attract diving ducks, such as Lesser Scaup, Bufflehead and Common

Goldeneye, and Grebes, such as Western, Clark's and Eared. Moderate numbers of various herons and egrets are present year round.

*Grassland*

Areas considered here include typical grassland habitats, as well as open upland areas dominated by non-native herbaceous species and some fallow agricultural land that is not regularly tilled or cultivated. Areas supporting scrub vegetation (coyote brush, blackberry brambles) set within grassland-dominated areas are included here, as well.

The grasslands and other open areas without active agricultural activity are of critical importance for the birds of the slough system. Few such areas remain available for birds in the lowlands of the Pajaro Valley, where most grassland has been replaced by row-crops or orchard. Grasslands near wetlands are especially rare. The grasslands and other open upland habitats attract birds that add greatly to the diversity of species using the slough system. Indeed, the resources of both the inter-slough upland habitats and adjacent slough wetlands come together in a synergistic relationship that greatly enhances the habitat value and utilization of both areas by birds. The importance of this integral relationship cannot be overstated, as it is key to sustaining the avian richness and full ecological functions of the slough system.

Many species that are generally attracted by the grasslands and open upland areas (e.g., various raptors, shrikes, swallows, sparrows) also make substantial use of the wetlands in the Sloughs. The riparian and other vegetation of the Sloughs is used heavily for roosting by some raptors that feed in the grasslands (e.g., White-tailed Kite). Some species associated principally with the Sloughs visit the uplands to forage (e.g., blackbirds, herons and egrets, some shorebirds) or nest (e.g., ducks). The utilization of the Sloughs by many species of waterbirds is bolstered to a large degree by the buffering effect of adjacent, large open upland areas. At least one species, the Tricolored Blackbird, requires both wetland and grassland habitat types in the study area during the breeding season. Unfortunately, it is presently extirpated as a nesting species. Underlying the easily observed life history functions of foraging and nesting are the complex roles that uplands play in overall slough system's nutrient cycling, runoff, water quality, and support of prey populations.

Grassland areas presently of the greatest importance for birds include areas along the east side Harkins Slough, areas around West Struve Slough, and areas near East Struve and Watsonville Sloughs inland of Highway 1. The area inland of Highway 1 recently supported the most extensive grassland communities, but much land there has been (and continues to be) converted to development.

The grasslands and other open habitats attract a wide array of raptor species, including White-tailed Kite, Northern Harrier, Red-shouldered Hawk, Red-tailed Hawk, Ferruginous Hawk, Golden Eagle, American Kestrel, Merlin, Peregrine Falcon, Barn Owl, Great Horned Owl and (formerly regular) Burrowing Owl and Short-eared Owl. Several of these species nest in the slough system, but the variety and abundance of raptors is greater during the non-breeding season. Raptor surveys conducted late fall and winter in the main slough areas have sometimes found as many as 14-18 species, with composite numbers of 45-85

individuals (Suddjian 1988, D. Suddjian pers. obs.). Among these, the Red-tailed Hawk and White-tailed Kite tend to be much more numerous than other species, often accounting for about 75% of all the raptors.

These habitats are important for other landbirds as well, such as Say's Phoebe, Loggerhead Shrike, various swallows, American Pipit, many sparrows (especially Savannah, Grasshopper, Lincoln's, Golden-crowned and White-crowned), Red-winged, Tricolored and Brewer's Blackbirds, Western Meadowlark, and various finches and goldfinches. The Loggerhead Shrike is a locally rare and declining species in Santa Cruz County. The uplands of the slough system still support one to two nesting pairs (among the very small number of pairs still nesting in the county), with somewhat elevated numbers present during the non-breeding season. Grasshopper Sparrow nested recently at several areas in the slough system, but has become extirpated at most, and may only remain nesting at grasslands near Larkin Valley Road between Highway 1 and Buena Vista Road. Savannah Sparrow, Western Meadowlark and Tricolored Blackbird also nested in the slough system in recent decades, but appear to be presently extirpated.

Among the waterbirds using these habitats, the most frequent uses are for foraging by Great Blue Heron, Great Egret, Cattle Egret (presently rare), Killdeer, Whimbrel and Long-billed Curlew, and nesting by ducks, (especially Mallard, Cinnamon Teal and Gadwall).

*Active Agricultural Land*

Actively farmed agricultural land co-occurs with grassland and other open habitats in the slough system and has recently replaced some areas that were occupied by grassland. In general, agricultural fields (including planted fields, plowed fields, and short-term fallow fields) are little used by birds. Foraging resources are poor, especially in fields planted with truck crops. Low vegetative diversity, lack of cover and regular ground disturbance are probably other important factors that lead to the low habitat value for birds. The limited bird use of active agricultural fields that does occur is mostly occasional foraging by raptors (especially along weedy field margins), and use by foraging phoebes, American Crows, shrikes, sparrows, House Finch and Killdeer. Various swallows are at times numerous as the feed on insects over the fields.

*Deciduous Riparian Forest*

Deciduous riparian forest provides valuable habitat for riparian-associated birds and also is used by many wetland birds for roosting and nesting. The deciduous foliage supports large prey populations of insects and other invertebrates. The dense growth of the vegetation provides excellent cover and many nesting opportunities. Snag features provided by dead trees or large dead limbs are important perches for raptors, herons and egrets and nest sites for cavity nesting birds. In general, the larger, more extensive stands of willows are more important for birds than small or isolated patches, although even the small patches provide valuable structural diversity and cover in the Sloughs.

Of the large willow stands, those at Harkins Slough (both downstream of Harkins Slough Road and downstream of Ranport Road), Hanson Slough, and at upper Watsonville Slough

(between Freedom Boulevard and Ford Road) are of the greatest value within the study area. To some degree, potential bird use of the riparian forest in the area is somewhat limited by its fairly simple structure (dominated mostly by willows, lacking a tall overstory), and the seasonal flooding that persists in many areas well into the nesting season.

Representative species using the riparian forest include: Green Heron, White-tailed Kite, Sharp-shinned Hawk, Cooper's Hawk, Red-shouldered Hawk, Anna's Hummingbird, Allen's Hummingbird, Nuttall's Woodpecker, Downy Woodpecker, Pacific-slope Flycatcher, Warbling Vireo, Western Scrub-Jay, Violet-green Swallow, Tree Swallow, Chestnut-backed Chickadee, Bewick's Wren, Ruby-crowned Kinglet, Swainson's Thrush, Wrentit, Cedar Waxwing, Orange-crowned Warbler, Yellow-rumped Warbler, Yellow Warbler, Wilson's Warbler, Spotted Towhee, Fox Sparrow, Song Sparrow, Black-headed Grosbeak, Red-winged Blackbird, Brown-headed Cowbird, House Finch and American Goldfinch.

The riparian forest is of special concern for its role in providing a preferred nesting habitat for most of the Neotropical migrant landbirds that breed in the study area (e.g., Pacific-slope Flycatcher, Tree Swallow, Warbling Vireo, Swainson's Thrush, Yellow Warbler, Wilson's Warbler, Black-headed Grosbeak.) Many of these species have exhibited regional or more local population declines over recent decades.

*Coast Live Oak Woodland*

Coast live oak woodland is fairly limited in extent near the Sloughs themselves, but occurs extensively in parts of the upper watershed. Its overall habitat values are similar to those described for the riparian forest. Large live oaks are especially favored as nest and perch sites for raptors, and snag features that commonly occur are critical resources for cavity nesting species. Acorns are an important food for some birds, especially jays, Acorn Woodpecker, Varied Thrush and Band-tailed Pigeon. Oaks often host large populations of insects and other invertebrates, and so are important for migratory landbirds in the spring and fall.

It achieves its highest value in parts of the upper watershed where it occurs in fairly extensive stands with variably dense undergrowth of blackberry, poison oak and coffeeberry. The smaller stands adjacent to the Sloughs are used especially by raptors for roost, perch and nest sites.

Representative species in the coast live oak woodland include: Sharp-shinned Hawk, Cooper's Hawk, Red-tailed Hawk, Nuttall's Woodpecker, Downy Woodpecker, Hairy Woodpecker, Northern Flicker, Western Scrub-Jay, Hutton's Vireo, Oak Titmouse, Chestnut-backed Chickadee, Ruby-crowned Kinglet, Hermit Thrush, Varied Thrush, Orange-crowned Warbler, Yellow-rumped Warbler, Spotted Towhee, California Towhee, Golden-crowned Sparrow, and Purple Finch.

*Plantings of Eucalyptus, Monterey Pine*

Mature plantings of exotic evergreen trees such as blue gum and other eucalyptus species, Monterey pine, and cypress provide resources for some birds that approximate those of our native conifer forests, and the avifauna in a large woodlot or planted grove bears a

correspondingly similarity to that of a native forest area. This is fostered where live oaks grow amid or adjacent to the exotic trees and where there is at least moderate development of understory vegetation.

Large eucalyptus trees with large limb structure are highly favored as nest sites for Red-tailed Hawk, Red-shouldered Hawk and Great Horned Owl. In other parts of the county they support nesting colonies of Great Blue Herons, but none are yet known from the study area. Interestingly, some tall eucalyptus stands support nesting Neotropical migrants that are otherwise absent in the study area, such as Olive-sided Flycatcher and Western Wood-Pewee. Large flowering eucalyptus are visited heavily by hummingbirds and various insectivorous land birds. Stands of Monterey pines and cypresses are used seasonally by Pine Siskin, Red Crossbill, Brown Creeper, Pygmy Nuthatch, Red-breasted Nuthatch, and Golden-crowned Kinglet, all species that are sparse in other habitats in the study area.

*Developed Areas*

Developed lands within the study area provide little to no resources for the wide suite of species of concern within the study area. They are mostly frequented by a small group of species common about homes and other development, many of which also occur widely in other habitats within the study area.

The landfills of Santa Cruz County and the City of Watsonville are important foraging areas for many species of gulls, blackbirds (including the declining Tricolored Blackbird), European Starling, American Crow and Common Raven. Portions of the landfills that are out of active use are also visited by foraging raptors.

## Population Trends and Changing Patterns of Bird Use

It is beyond the scope of this review to provide a highly detailed assessment of changing bird population trends. The available information is too fragmented for many species or for parts of the study area to permit a detailed approach. Most existing specific information (e.g., censuses or counts for individual species with associated date and location) was only archived beginning in 1974 and that remained fairly limited until the later 1980s and onward. Information on birds in specific areas (e.g., Hanson Slough) has been spotty over time due to changing access and due to the changing habitats of bird watchers, whose general observations have been a principal source of data. Given this source, reported data have often been biased toward the unusual or rare species that are the focus of much birding.

Another factor complicating evaluation of changes in bird populations is a mix of proximal and regional trends, such that is not always clear that a local cause has led to an observed local change. For example, declines in numbers of wintering Lesser Scaup using the study area may reflect local habitat conditions or may be related to large-scale population changes or regional distributional shifts. Increasing numbers of Great Egrets no doubt reflect long term state wide population recoveries from exploitation in the 19$^{th}$ and early 20$^{th}$ centuries, but might also be a result of the growing regional breeding population. Grasshopper Sparrows are decreasing in many parts of California, but their decline in the study area can also be clearly linked to habitat changes within the area itself.

Even with all these complicating factors, I think sufficient formal and informal observations have occurred in recent decades to permit some general comments on real changes in bird populations and patterns of use in the study area.

*General Changes Related To Habitat and Land Use*

Undoubtedly the most dramatic changes in bird numbers occurred in the 19th century and through the 1950s, as the study area and surrounding lands were being initially settled and developed. Profound regional decreases in many bird populations are generally known to have occurred in that period, such as great decreases in regional numbers of waterfowl (Grinnell and Miller 1944; Gordon 1974). However, there is very little specific information known from the Watsonville Slough system, and regional habitats and bird populations have changed so substantially since the pre-European/American period, that there is little value in looking so far back when considering present management issues in the study area. More to the point are bird population trends and changing human land uses in the recent decades, from 1970s to the present.

Significant regional and local decreases in wetland, riparian and grassland habitats have resulted in the greatest degree of change in bird use of the slough system. Reductions in habitat area simply reduce the number of individuals that may use the remaining habitat, and eventually some habitat areas become too small to support the needs of certain species (Saunders et al. 1991, Wilcove 1987). Tied to the actual losses of habitat have been the effects of increasing fragmentation, isolation, habitat degradation and disturbance of the remaining natural habitats (Saunders et al. 1991, Rolstad 1991, Hanski and Gilpin 1991). All these have dramatic impacts on the ability of the remaining habitat to support its natural functions as bird habitat for the wide array of species that occupy the area. As development and agricultural land uses have increased within and around the study area, these effects have no doubt been important for specific habitat areas within the study area, and in their relationship to natural habitat outside the study area.

Grasslands

Grasslands and other inter-slough upland habitats have seen the most dramatic change in recent decades. Increases in cultivated land, especially land used for row crops, have eliminated grassland and other upland habitat. At the same time, extensive recent housing and commercial development of uplands adjacent to the Sloughs has eliminated large areas of habitat, particularly inland of Highway 1. This has led to a loss of certain grassland species within the whole slough system, or in particular areas within the system, and reduced abundance of virtually all grassland species.

Natural upland habitat was retained on portions of the land sloping down to the Sloughs adjacent to most of the recent housing or commercial developments. However, the retained areas are not sufficient to support most grassland-associated species, especially with regard to nesting. Cessation of most grazing in the study area has led to a spread of noxious invasive species in some areas, reducing habitat values for grassland species. Other areas that were formerly grazed have been converted to row crops.

The steady and continued reduction of lowland grassland habitat is highly significant in the context of Santa Cruz County. Loss of grasslands and other open lowland habitats has been one of the most substantial type changes in the history of the county's settlement and development. Little grassland remains in the mid-county coastal region, and it has been greatly reduced in the Pajaro Valley, especially in proximity to seasonal wetlands.

Wetlands

Direct losses of wetland habitat have been somewhat less in recent decades compared to loss of grassland. This has been due to increased wetland protection, increased appreciation of wetland values, and the problems inherent in farming or developing the seasonally flooded sloughs. Peat extraction at the south end of Harkins Slough removed some seasonal wetlands, but created permanent open water ponds that are attractive to some waterbirds. Some seasonally flooded areas have suffered degradation of habitat values from the spread of invasive weeds, such as cocklebur at Hanson Slough. Other detrimental changes have resulted from changing land uses on the uplands adjacent to the Sloughs. These have severed or hampered the integral synergistic relationship between wetlands and uplands described above, reducing bird use of both the Sloughs and remaining uplands. For example, waterfowl use in the Struve Slough upstream of Main Street is very low compared to less impacted portions of the Slough near Highway 1. The current development project between Struve and Watsonville Sloughs will further reduce the habitat values of Struve Slough.

Nesting waterfowl have no doubt been affected by predation from the non-native red fox, a species that has increased greatly in the study area over the last 20 years and has been documented to affect nesting populations of many birds. Changing land uses have probably also led to population increases of rats and feral domestic cats, species that also prey on bird nests.

A recent, though perhaps temporary, beneficial change has resulted from the closure of Harkins Slough Road and Lee Road when they are seasonally flooded. This has fostered development of wetland and riparian vegetation near the roads. The reduced disturbance from automobile traffic has led to increased bird use of the wetlands near the roadways. These closed road segments also provide some of the better bird viewing opportunities currently available at the Sloughs.

Riparian Forest

Populations of some bird species associated with the riparian forest are exhibiting pronounced changes (mostly declines) in the study area, although the reasons are not fully evident. Most of the suite of Neotropical migrants that nest in the study area use riparian habitat, and most of them are experiencing declining numbers in the study area and elsewhere in the local region over the last decade (Santa Cruz Bird Club data; Suddjian 2000). There do not seem to have been substantial losses in riparian habitat in the slough system during the most recent decades, although losses have occurred in the upper watershed of Struve Slough and development has approached close to riparian in some areas. Habitat

degradation has also been evident in some areas, especially from dumping of waste and debris, such as at Harkins Slough.

Two factors may be contributing to recent declines in some riparian species. First, nest parasitism by the brood parasite Brown-headed Cowbird is known to have adverse impacts on a number of its host species (Lowther 1993, Mayfield 1977, Robinson et al. 1995, Rothstein 1994). Most host species produce fewer of their own young when nests are parasitized by cowbirds, and some parasitized nests produce no host young at all. Cowbirds are fairly recent immigrants to the study area, and their local breeding population has shown a general increase in recent decades (Santa Cruz Bird Club data). Cowbird host species documented in the study area and vicinity include many of the riparian-associated species, most notably Pacific-slope Flycatcher, Warbling Vireo, Swainson's Thrush, Yellow Warbler and Wilson's Warbler, all species showing local declines (Santa Cruz County Breeding Bird Atlas unpubl. data; Suddjian 1990, Suddjian 2002).

A second factor may be an indirect impact from the clearing of over 200 acres of riparian forest at the nearby Pajaro River corridor in March 1995 (Suddjian 2002). I postulated that the former very large amount of habitat of the river corridor, known to support large numbers of nesting pairs of many Neotropical migrant birds, served as a population "source" for smaller riparian areas in the local region (cf. Pullium 1988). This function was no doubt greatly reduced following the 1995 clearing, and this may have affected bird population in the smaller nearby riparian areas, where effects of habitat fragmentation, cowbird parasitism and other factors may be relatively high.

Another factor that may affect breeding birds in riparian habitat is possible increased predation of nests by American Crows and Common Ravens. Populations of both species have grown in recent decades, and both are widely known to prey on the nests of songbirds. However, such predation has not been studied or documented in the study area to date.

*Specific Changes Documented for Selected Species*

As a whole, more species have exhibited recent population decreases in the slough system than those that have increased. Many of the decreases and increases have been directly or indirectly related to human land use patterns and their effects on natural habitats, although the causal relationships are not always clear. Many increasing species have rebounded since historic declines (usually human caused), while others have recently colonized the area for the first time.

Species obviously increasing in recent decades in the study area are: Brown Pelican (following historic decline; occurrence limited to Pajaro River mouth area), American White Pelican, Double-crested Cormorant, Great Egret (following historic decline), Canada Goose (following historic decline), Gadwall (breeding population), Peregrine Falcon (following historic decline), Black-necked Stilt, Caspian Tern, Elegant Tern (limited to Pajaro River mouth), American Crow, Common Raven, European Starling, Great-tailed Grackle, Brown-headed Cowbird, and Hooded Oriole.

Species obviously decreasing in recent decades in the study area are: Green-winged Teal, Cinnamon Teal, Redhead, Lesser Scaup, Ruddy Duck, Northern Harrier, Red-tailed Hawk, Ferruginous Hawk, Golden Eagle, Burrowing Owl, Short-eared Owl, Warbling Vireo, Horned Lark, Tree Swallow, Bank Swallow, Western Bluebird, Swainson's Thrush, Loggerhead Shrike, Yellow Warbler, Wilson's Warbler, Savannah Sparrow, Grasshopper Sparrow, Tricolored Blackbird, Western Meadowlark. A number of other species show indications of local declines, but there is insufficient information to clearly document a change.

Some of these declining species nested in the study area until fairly recently, but are now extirpated there as breeding species, or nearly so. These include: Warbling Vireo, Horned Lark, Bank Swallow, Loggerhead Shrike, Yellow Warbler, Savannah Sparrow, Grasshopper Sparrow, Tricolored Blackbird and Western Meadowlark. Other species were regular in the non-breeding season until fairly recently, but are now extremely rare: Redhead, Burrowing Owl, Short-eared Owl, Western Bluebird and Tricolored Blackbird (except at the county and city landfills).

The local histories of selected species are presented below as examples of increasing and decreasing species. The reader is also referred to the species accounts in Technical Sub-Appendix G-2.

Examples of Increasing Species

American White Pelicans were generally absent in Santa Cruz County until recent decades, with very few records before the mid-1980s, when small winter flocks began to appear at some lakes and wetlands in the Pajaro Valley. Its winter presence in the valley by the late 1980s, but it remained only occasional at the Sloughs until the late 1990s. In 2001 the first late summer and fall flocks appeared in the Sloughs, in numbers greater than anytime previously, and in 2002 large flocks were present through the summer. This increase appears to be related to a broad regional population increase, and perhaps a distributional shift related to changing resource availability.

Great Egrets have shown a long-term increase in Santa Cruz County and the Sloughs, especially since the 1970s. This has presumably been a result of a long recovery following cessation of exploitation for the hat trade. Since the late 1980s numbers have increased greatly in the Sloughs, especially in the spring and summer months. This may be due to an increasing regional breeding population, with colonies recently established at Elkhorn Slough and Pinto Lake and burgeoning in the San Francisco Bay Area.

Black-necked Stilt was only discovered nesting in the county at the Pajaro River mouth area in the 1970s, but it has since increased somewhat and, since the mid-1990s, it now nests at several of the Sloughs when conditions are suitable. Nesting has been confirmed at all of the Sloughs.

Common Raven was absent in the slough system until the late 1980s, when individuals began to appear in the non-breeding season as part of a general region wide increase. Numbers grew steadily through the 1990s, when they were often concentrated at the county

and city landfill. Flocks of 25-200+ birds became regular and it is now present in the study area year round.

Great-tailed Grackle has undergone a dramatic range extension in California, first appearing in the state in 1964 and nesting in 1969 (Small 1994). The first Santa Cruz County record was in 1994, and it was first reported from the Sloughs at Harkins Slough in 1998. In 2001 multiple pairs were found nesting at the confluence of Watsonville Slough and Struve Slough, with more nesting and increasing numbers in 2002. The species is probably now resident in the slough area, still the only breeding station known for the county.

Brown-headed Cowbird was probably absent in the region prior to the 1920s, or was perhaps a very rare non-breeding visitor (Grinnell and Miller 1944). Since then, in a dramatic population increase it has colonized much of California (Laymon 1987). Breeding was first detected in the county in the 1930s and it became increasingly common especially from the 1970s onward. It is now a year round resident in the slough system with a substantial breeding population.

Examples of Decreasing Species

Northern Harrier probably nested historically in the slough system, although there are no specific nesting confirmations known. Nonetheless, until recently it was regular year round, most numerous in the fall and winter. Nesting populations have recently faired well in other parts of the local region (e.g., grasslands along the north Santa Cruz County coast), but harriers have become increasingly scarce in the slough system in the breeding season over the last 20 years. Non-breeding season numbers have also declined. This decline is related to loss grassland habitat.

Red-tailed Hawks have decreased as in the slough system as both a breeding bird and especially a wintering bird. This decline is related to lost grassland habitat and increased agricultural and urban development.

Burrowing Owl has experienced a long-term decline in Santa Cruz County. It occurred regularly as a non-breeder (and perhaps once a breeder) in the slough system until the mid-1980s, after which time it became increasing erratic and rare in occurrence. Presently only one site in Santa Cruz County (U.C. Santa Cruz Campus) is regularly occupied by non-breeders. This decline in the Sloughs apparently reflects both regional population changes and loss of grassland habitat and increased agricultural and urban development.

Short-eared Owl occurrences have followed a pattern very similar to the Burrowing Owl. There are hardly any records from the Sloughs since the early 1990s, although it was regular non-breeding visitor there through the late 1980s. This decline is related to loss grassland habitat and increased agricultural and urban development.

Warbling Vireo was a moderately common breeding species in the larger riparian patches at Watsonville, Hanson and Harkins Slough through the early1990s, but it has since declined to become fairly rare and locally extirpated within the slough system. This decline in the study

area is apparently related to large-scale population changes, exacerbated by regional habitat loss and cowbird parasitism.

Swainson's Thrush was fairly common in the riparian thickets of all the Sloughs through the 1980s, but had shown a steady decline through the 1990s to the present. This decline in the study area is apparently related to large-scale population changes, exacerbated by regional habitat loss and cowbird parasitism.

Yellow Warbler nested in the slough system through the late 1980s in riparian forest at Watsonville Slough, Hanson Slough and Harkins Slough. It presently appears to be extirpated as a breeding bird, and since the early 1990s has declined widely or disappeared as a breeder at a number of riparian corridors throughout the county. Reasons for the local extirpations are unclear, although regional habitat loss and cowbird parasitism are probably involved.

Grasshopper Sparrow nested on the slopes between Harkins and Hanson Slough until in the late 1980s and near Struve Slough until the early 1990s. It is presently extirpated from both these areas, with nesting in the study area now limited to grasslands along upper Harkins Slough inland of Highway 1. This decline is related to loss grassland habitat and increased agricultural and urban development.

Tricolored Blackbird was a common winter visitor, flocking in the 100s and low 1000s in the grasslands and wetlands of the Sloughs in the 1970s and 1980s. It nested at Hanson Slough in the late 1980s and probably elsewhere at other times. It is presently extirpated as a breeder in the study area and is rarely seen in the non-breeding season away from the county and city landfills. The loss of local grassland foraging habitat probably led to its extirpation as a breeding species. Reasons for the decline of flocks in the non-breeding season probably reflect loss of foraging habitat and regional declines in the species population.

Western Meadowlark was an uncommon breeder at various areas of upland grassland between the Sloughs until the late 1980s, but has apparently been extirpated as a breeding species subsequently. Numbers visiting the area during the non-breeding season have also declined. This decline is related to loss grassland habitat and increased agricultural and urban development.

**References Cited**

Grinnell, J. and A. H. Miller. 1944. The distribution of the birds of California. Pacific Coast Avifauna No. 27. Cooper Ornithological Club. Reprinted 1986, Artemesia Press.

Gordon, B.L. 1974. Monterey Bay area: natural history and cultural imprints. The Boxwood Press. Pacific Grove, CA.

Hanski, I. and M. Gilpin. 1991. Metapopulation dynamics: brief history and conceptual domain. Biological Journal of the Linnean Society 42:3-16.

Laymon, S. A. 1987. Brown-headed Cowbirds in California: historical perspectives and management opportunities in riparian habitats. Western Birds 18:63-70.

Lowther, P. E. 1993. Brown-headed Cowbird (*Molothrus ater*). *In* The Birds of North America, No. 47 (A. Poole and F. Gill Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Mayfield, H. 1977. Brown-headed Cowbird: agent of extermination? American Birds 31:107-113

Pullium, H. R. 1988. Sources and sinks, and population regulation. American Naturalist 132: 652-661.

Roberson, D. and C. Tenney (Eds.). 1993. Atlas of the breeding birds of Monterey County, California. Monterey Peninsula Audubon Society.

Robinson, S. K., S. I. Rothstein, M. C. Brittingham, L. J. Petit and J. A. Grzybowski. 1995. Ecology and behavior of cowbirds and their impact on host populations. Pp. 428-460 *in* T. E. Martin and D. M. Finch (eds.), Ecology and management of Neotropical migratory birds. Oxford Univ. Press.

Rolstad, J. 1991. Consequences of forest fragmentation for dynamics of bird populations: conceptual issues and the evidence. Biological Journal of the Linnean Society 42:149-163.

Rothstein, S. I. 1994. The cowbird's invasion of the Far West: history, causes and consequences experienced by host species. Pp. 301-315 *in* J. R. Jehl Jr., and N. K. Johnson (eds.), A century of avifaunal change in western North America. Studies in Avian Biology No. 15. Cooper Ornithological Society.

Saunders, D. A., R. J. Hobbs and C. R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology 5:18-32.

Small, A. 1994. California birds – their status and distribution. Ibis Publishing Co.

Suddjian, D. L. 1988. Numbers of diurnal raptors and shrikes as the South County Sloughs, 12 August - 27 November 1988. Unpubl. report.

Suddjian, D. L. 1990. Atlaser's assistant: a preliminary analysis of the status and distribution of breeding birds in Santa Cruz County. 2nd Edition. Santa Cruz Bird Club.

Suddjian, D. L. 2000. Disappearing birds. Albatross 46 (1): 1,11. http://santacruzbirdclub.org/disappear.html

Suddjian, D. L. 2002. Riparian bird populations at the Pajaro River: A look at the impacts of the 1995 vegetation clearing and subsequent bird use of the intact and cutover riparian forest.

Wilcove, D. S. 1987. From fragmentation to extinction. Natural Areas Journal 7:23-29.

**Technical Sub-Appendix G-1: Birds of the Watsonville Slough System, Santa Cruz County, CA**

This list includes bird species known to have occurred in the area of the Watsonville Sloughs, Santa Cruz County, California through August 2002. The area considered for this list includes the watersheds of Watsonville, Gallighan, Harkins, Hanson and Struve Sloughs, and the Pajaro River mouth (lagoon and beach, exclusive of the ocean).

Bird records from approximately the last 50 years are included, although most information is from the mid-1980s to the present. Information was taken principally from the county bird records maintained by the Santa Cruz Bird Club (including information from the Moss Landing Christmas Bird County and Santa Cruz County Breeding Bird Atlas) and from my personal studies.

***Annotations***

"*" Species confirmed to nest in the area defined during 1978-2002.
"*?" Species suspected to nest in the area defined during 1978-2002, but nesting not yet confirmed.
"x" Species recorded only rarely (e.g., fewer than 5 times per year; some not even annually) in recent decade (1993 – 2002)
"p" Species occurs principally at the Pajaro River mouth and Watsonville Slough downstream of Shell Road, but rarely or not at all elsewhere in the area defined.
"i" Species introduced.

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|---|---|
| **FAMILY: GAVIIDAE (Loons)** | |
| Red-throated Loon (*Gavia stellata*) | x, p |
| Pacific Loon (*Gavia arctica*) | x, p |
| Common Loon (*Gavia immer*) | x, p |
| **FAMILY: PODICIPEDIDAE (Grebes)** | |
| Pied-billed Grebe (*Podilymbus podiceps*) | * |
| Horned Grebe (*Podiceps auritus*) | p |
| Red-necked Grebe (*Podiceps grisegena*) | x, p |
| Eared Grebe (*Podiceps nigricollis*) | |
| Western Grebe (*Aechmophorus occidentalis*) | |
| Clark's Grebe (*Aechmophorus clarkii*) | |
| **FAMILY: PROCELLARIDAE (Shearwaters, Fulmars, Petrels)** | |
| Northern Fulmar (*Fulmarus glacialis*) | x, p |
| **FAMILY: PELECANIDAE (Pelicans)** | |
| American White Pelican (*Pelecanus erythrorhynchos*) | |
| Brown Pelican (*Pelecanus occidentalis*) | p |
| **FAMILY: PHALACROCORACIDAE (Cormorants)** | |
| Brandt's Cormorant (*Phalacrocorax penicillatus*) | x, p |
| Double-crested Cormorant (*Phalacrocorax auritus*) | |
| Pelagic Cormorant (*Phalacrocorax pelagicus*) | x, p |

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|---|---|
| **FAMILY: ARDEIDAE (Herons and Bitterns)** | |
| American Bittern (*Botaurus lentiginosus*) | * |
| Great Blue Heron (*Ardea herodias*) | |
| Great Egret (*Ardea alba*) | |
| Snowy Egret (*Egretta thula*) | |
| Cattle Egret (*Bubulcus ibis*) | |
| Green Heron (*Butorides virescens*) | * |
| Black-crowned Night-Heron (*Nycticorax nycticorax*) | * |
| **FAMILY: THRESKIORNITHIDAE (Ibises and Spoonbills)** | |
| White-faced Ibis (*Plegadis chihi*) | x |
| **FAMILY: CATHARTIDAE (American Vultures)** | |
| Turkey Vulture (*Cathartes aura*) | |
| **FAMILY: ANATIDAE (Swans, Geese, and Ducks)** | |
| Greater White-fronted Goose (*Anser albifrons*) | x |
| Snow Goose (*Chen caerulescens*) | x |
| Ross' Goose (*Chen rossii*) | x |
| Canada Goose (*Branta canadensis*) | |
| Brant (*Branta bernicla*) | x, p |
| Tundra Swan (*Cygnus columbianus*) | x |
| Wood Duck (*Aix sponsa*) | x |
| Gadwall (*Anas strepera*) | * |
| Eurasian Wigeon (*Anas penelope*) | x |
| American Wigeon (*Anas americana*) | |
| Mallard (*Anas platyrhynchos*) | * |
| Garganey *(Anas querquedula)* | x |
| Blue-winged Teal (*Anas discors*) | |
| Cinnamon Teal (*Anas cyanoptera*) | * |
| Northern Shoveler (*Anas clypeata*) | * |
| Northern Pintail (*Anas acuta*) | |
| Green-winged Teal (*Anas crecca*) | |
| Canvasback (*Aythya valisineria*) | |
| Redhead (*Aythya americana*) | x |
| Ring-necked Duck (*Aythya collaris*) | |
| Greater Scaup *(Aythya marila*) | p |
| Lesser Scaup (*Aythya affinis*) | |
| Surf Scoter (*Melanitta perspicillata*) | p |
| White-winged Scoter (*Melanitta fusca*) | x, p |
| Oldsquaw (*Clangula hyemalis*) | x, p |
| Bufflehead (*Bucephala albeola*) | |
| Common Goldeneye (*Bucephala clangula*) | |
| Barrow's Goldeneye (*Bucephala islandica*) | x, p |
| Hooded Merganser (*Lophodytes cucullatus*) | |
| Common Merganser (*Mergus merganser*) | x |
| Red-breasted Merganser (*Mergus serrator*) | p |
| Ruddy Duck (*Oxyura jamaicensis*) | * |
| **FAMILY: ACCIPITRIDAE (Hawks, Harriers and allies)** | |

| | |
|---|---|
| Osprey (*Pandion haliaetus*) | |
| White-tailed Kite (*Elanus leucurus*) | * |
| Bald Eagle (*Halieaeetus leucocephalus*) | x |
| Northern Harrier (*Circus cyaneus*) | *? |
| Sharp-shinned Hawk (*Accipiter striatus*) | |
| Cooper's Hawk (*Accipiter cooperii*) | |
| Red-shouldered Hawk (*Buteo lineatus*) | * |
| Swainson's Hawk (*Buteo swainsoni*) | x |
| Red-tailed Hawk (*Buteo jamaicensis*) | * |
| Ferruginous Hawk (*Buteo regalis*) | x |
| Rough-legged Hawk (*Buteo lagopus*) | x |
| Golden Eagle (*Aquila chrysaetos*) | |
| **FAMILY: FALCONIDAE (Caracaras and Falcons)** | |
| American Kestrel (*Falco sparverius*) | * |
| Merlin (*Falco columbarius*) | |
| Peregrine Falcon (*Falco peregrinus*) | |
| Prairie Falcon (*Falco mexicanus*) | x |
| **FAMILY: PHASIANIDAE (Quails, Pheasants, and Relatives)** | |
| Ring-necked Pheasant (*Phasianus colchicus*) | *, i (extirpated) |
| California Quail (*Callipepla californica*) | * |
| **FAMILY: RALLIDAE (Rails, Gallinules, and Coots)** | |
| Virginia Rail (*Rallus limicola*) | * |
| Sora (*Porzana carolina*) | * |
| Common Moorhen (*Gallinula chloropus*) | * |
| American Coot (*Fulica americana*) | * |
| **FAMILY: CHARADRIIDAE (Plovers and Relatives)** | |
| Black-bellied Plover (*Pluvialis squatarola*) | p |
| Pacific Golden-Plover (*Pluvialis fulva*) | x |
| Snowy Plover (*Charadrius alexandrinus*) | *, p |
| Semipalmated Plover (*Charadrius semipalmatus*) | |
| Killdeer (*Charadrius vociferus*) | * |
| Mountain Plover (*Charadrius montanus*) | x, p |
| **FAMILY: RECURVIROSTRIDAE (Avocets and Stilts)** | |
| Black-necked Stilt (*Himantopus mexicanus*) | * |
| American Avocet (*Recurvirostra americana*) | * |
| **FAMILY: SCOLOPACIDAE (Sandpipers and Relatives)** | |
| Greater Yellowlegs (*Tringa melanoleuca*) | |
| Lesser Yellowlegs (*Tringa flavipes*) | |
| Solitary Sandpiper (*Tringa solitaria*) | x |
| Willet (*Catoptrophorus semipalmatus*) | x, p |
| Wandering Tattler (*Heteroscelus incanus*) | x, p |
| Spotted Sandpiper (*Actitis macularia*) | |
| Whimbrel (*Numenius phaeopus*) | |
| Long-billed Curlew (*Numenius americanus*) | |
| Marbled Godwit (*Limosa fedoa*) | p |
| Ruddy Turnstone (*Arenaria interpres*) | p |
| Black Turnstone (*Arenaria melanocephala*) | x, p |

| | |
|---|---|
| Surfbird (*Aphriza virgata*) | x, p |
| Red Knot (*Calidris canutus*) | x, p |
| Sanderling (*Calidris alba*) | p |
| Semipalmated Sandpiper (*Calidris pusilla*) | x |
| Western Sandpiper (*Calidris mauri*) | |
| Least Sandpiper (*Calidris minutilla*) | |
| Baird's Sandpiper (*Calidris bairdii*) | |
| Pectoral Sandpiper (*Calidris melanotos*) | |
| Dunlin (*Calidris alpina*) | |
| Stilt Sandpiper (*Calidris himantopus*) | x |
| Ruff (*Philomachus pugnax*) | x |
| Short-billed Dowitcher (*Limnodromus griseus*) | |
| Long-billed Dowitcher (*Limnodromus scolopaceus*) | |
| Common Snipe (*Gallinago gallinago*) | |
| Wilson's Phalarope (*Phalaropus tricolor*) | |
| Red-necked Phalarope (*Phalaropus lobatus*) | |
| Red Phalarope (*Phalaropus fulicaria*) | x, p |
| **FAMILY: LARIDAE (Gulls and Terns)** | |
| Pomerine Jaeger (*Stercorarius pomarinus*) | x, p |
| Parasitic Jaeger (*Stercorarius parasiticus*) | p |
| Laughing Gull (*Larus atricilla*) | x, p |
| Franklin's Gull (*Larus pipixcan*) | x, p |
| Bonaparte's Gull (*Larus philadelphia*) | |
| Heermann's Gull (*Larus heermanni*) | p |
| Mew Gull (*Larus canus*) | |
| Ring-billed Gull (*Larus delawarensis*) | |
| California Gull (*Larus californicus*) | |
| Herring Gull (*Larus argentatus*) | |
| Thayer's Gull (*Larus thayeri*) | |
| Western Gull (*Larus occidentalis*) | |
| Glaucous-winged Gull (*Larus glaucescens*) | |
| Glaucous Gull (*Larus hyperboreus*) | x |
| Sabine's Gull (*Xema sabini*) | x, p |
| Black-legged Kittiwake (*Rissa tridactyla*) | x, p |
| Caspian Tern (*Sterna caspia*) | |
| Royal Tern (*Sterna maxima*) | x, p |
| Elegant Tern (*Sterna elegans*) | p |
| Common Tern (*Sterna hirundo*) | p |
| Arctic Tern (*Sterna paradisaea*) | x, p |
| Forster's Tern (*Sterna forsteri*) | |
| Least Tern (*Sterna antillarum*) | x, p |
| Black Tern (*Chlidonias niger*) | x |
| Black Skimmer (*Rynchops niger*) | x, p |
| **FAMILY: ALCIDAE (Auks, Murres, and Puffins)** | |
| Common Murre (*Uria aalge*) | x, p |
| **FAMILY: COLUMBIDAE (Pigeons and Doves)** | |
| Rock Dove (*Columba livia*) | *, i |

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|---|---|
| Band-tailed Pigeon (*Columba fasciata*) | *? |
| Mourning Dove (*Zenaida macroura*) | * |
| **FAMILY: TYTONIDAE (Barn Owls)** | |
| Barn Owl (*Tyto alba*) | * |
| **FAMILY: STRIGIDAE (Typical Owls)** | |
| Western Screech-Owl (*Otus kennicotti*) | *? |
| Great Horned Owl (*Bubo virginianus*) | * |
| Northern Pygmy-Owl (*Glaucidium gnoma*) | *? |
| Burrowing Owl (*Athene cunicularia*) | x |
| Long-eared Owl (*Asio otus*) | x |
| Short-eared owl (*Asio flammeus*) | x |
| **FAMILY: APODIDAE (Swifts)** | |
| Vaux's Swift (*Chaetura vauxi*) | |
| White-throated Swift (*Aeronautes saxatalis*) | x |
| **FAMILY: TROCHILIDAE (Hummingbirds)** | |
| Anna's Hummingbird (*Calypte anna*) | * |
| Rufous Hummingbird (*Selasphorus rufus*) | |
| Allen's Hummingbird (*Selasphorus sasin*) | * |
| **FAMILY: ALCEDINIDAE (Kingfishers)** | |
| Belted Kingfisher (*Ceryle alcyon*) | |
| **FAMILY: PICIDAE (Woodpeckers and Wrynecks)** | |
| Acorn Woodpecker (*Melanerpes formicivorous*) | * |
| Red-naped Sapsucker (*Sphyrapicus nuchalis*) | x |
| Red-breasted Sapsucker (*Sphyrapicus ruber*) | |
| Nuttall's Woodpecker (*Picoides nuttallii*) | * |
| Downy Woodpecker (*Picoides pubescens*) | * |
| Hairy Woodpecker (*Picoides villosus*) | * |
| Northern Flicker (*Colaptes auratus*) | * |
| **FAMILY: TYRANNIDAE (Tyrant Flycatchers)** | |
| Olive-sided Flycatcher (*Contopus cooperi*) | * |
| Western Wood-Pewee (*Contopus sordidulus*) | * |
| Willow Flycatcher (*Empidonax traillii*) | x |
| Pacific-slope Flycatcher (*Empidonax difficilis*) | * |
| Black Phoebe (*Sayornis nigricans*) | * |
| Say's Phoebe (*Sayornis saya*) | |
| Ash-throated Flycatcher (*Myiarchus cinerascens*) | |
| Tropical Kingbird (*Tyrannus melancholicus*) | x |
| Cassin's Kingbird (*Tyrannus vociferans*) | x |
| Western Kingbird (*Tyrannus verticalis*) | |
| **FAMILY: LANIIDAE (*Shrikes*)** | |
| Loggerhead Shrike (*Lanius ludovicianus*) | * |
| **FAMILY: VIREONIDAE (Typical Vireos)** | |
| Cassin's Vireo (*Vireo cassinii*) | |
| Hutton's Vireo (*Vireo huttoni*) | * |
| Warbling Vireo (*Vireo gilvus*) | * |
| Red-eyed Vireo (*Vireo olivaceus*) | x |
| **FAMILY: CORVIDAE (Jays, Magpies, and Crows)** | |

| | | |
|---|---|---|
| Steller's Jay (*Cyanocitta stelleri*) | * | |
| Western Scrub-Jay (*Aphelocoma californica*) | * | |
| American Crow (*Corvus brachyrhynchos*) | * | |
| Common Raven (*Corvus corax*) | *? | |
| **FAMILY: ALAUDIDAE (Larks)** | | |
| Horned Lark (*Eremophila alpestris*) | x | |
| **FAMILY: HIRUNDINIDAE (Swallows)** | | |
| Purple Martin (*Progne subis*) | x | |
| Tree Swallow (*Tachycineta bicolor*) | * | |
| Violet-green Swallow (*Tachycineta thalassina*) | * | |
| Northern Rough-winged Swallow (*Stelgidopteryx serripennis*) | * | |
| Bank Swallow (*Riparia riparia*) | *, x (extirpated as breeder) | |
| Cliff Swallow (*Hirundo pyrrhonota*) | * | |
| Barn Swallow (*Hirundo rustica*) | * | |
| **FAMILY: PARIDAE (Titmice)** | | |
| Chestnut-backed Chickadee (*Poecile rufescens*) | * | |
| Oak Titmouse (*Baeolophus inornatus*) | * | |
| **FAMILY: AEGITHALIDAE (Bushtit)** | | |
| Bushtit (*Psaltriparus minimus*) | * | |
| **FAMILY: SITTIDAE (Nuthatches)** | | |
| Red-breasted Nuthatch (*Sitta canadensis*) | | |
| Pygmy Nuthatch (*Sitta pygmaea*) | * | |
| **FAMILY: CERTHIIDAE (Creepers)** | | |
| Brown Creeper (*Certhia americana*) | * | |
| **FAMILY: TROGLODYTIDAE (Wrens)** | | |
| Bewick's Wren (*Thryomanes bewickii*) | * | |
| House Wren (*Troglodytes aedon*) | | |
| Winter Wren (*Troglodytes troglodytes*) | | |
| Marsh Wren (*Cistothorus palustris*) | * | |
| **FAMILY: REGULIDAE (Kinglets)** | | |
| Golden-crowned Kinglet (*Regulus satrapa*) | | |
| Ruby-crowned Kinglet (*Regulus calendula*) | | |
| **FAMILY: SYLVIIDAE (Gnatcatchers and Old World Warblers)** | | |
| Blue-gray Gnatcatcher (*Polioptila caerulea*) | | |
| **FAMILY: TURDIDAE (Thrushes, Robins, Bluebirds and allies)** | | |
| Western Bluebird (*Sialia mexicana*) | x | |
| Swainson's Thrush (*Catharus ustulatus*) | * | |
| Hermit Thrush (*Catharus guttatus*) | | |
| American Robin (*Turdus migratorius*) | * | |
| Varied Thrush (*Ixoreus naevius*) | | |
| **FAMILY: TIMALIIDAE (Wrentit and allies)** | | |
| Wrentit (*Chamaea fasciata*) | * | |
| **FAMILY: MIMIDAE (Mockingbirds and Thrashers)** | | |
| Northern Mockingbird (*Mimus polyglottos*) | * | |
| California Thrasher (*Toxostoma redivivum*) | * | |
| **FAMILY: STURNIDAE (Starlings)** | | |

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|---|---|
| European Starling (*Sturnus vulgaris*) | *, i |
| **FAMILY: MOTACILLIDAE (Wagtails and Pipits)** | |
| American Pipit (*Anthus rubescens*) | |
| **FAMILY: BOMBYCILLIDAE (Waxwings)** | |
| Cedar Waxwing (*Bombycilla cedrorum*) | |
| **FAMILY: PARULIDAE (Wood Warblers)** | |
| Tennessee Warbler (*Vermivora peregrina*) | x |
| Orange-crowned Warbler (*Vermivora celata*) | * |
| Nashville Warbler (*Vermivora ruficapilla*) | x |
| Virginia's Warbler (*Vermivora virginiae*) | x |
| Yellow Warbler (*Dendroica petechia*) | * (extirpated as breeder?) |
| Chestnut-sided Warbler (*Dendroica pensylvanica*) | x |
| Magnolia Warbler (*Dendroica magnolia*) | x |
| Yellow-rumped Warbler (*Dendroica coronata*) | |
| Black-throated Gray Warbler (*Dendroica nigrescens*) | |
| Townsend's Warbler (*Dendroica townsendi*) | |
| Hermit Warbler (*Dendroica occidentalis*) | x |
| Prairie Warbler (*Dendroica discolor*) | x |
| Palm Warbler (*Dendroica palmarum*) | x |
| Blackpoll Warbler (*Dendroica striata*) | x |
| Black-and-white Warbler (*Mniotilta varia*) | x |
| American Redstart (*Setophaga ruticilla*) | x |
| Ovenbird (*Seiurus aurocapillus*) | x |
| Northern Waterthrush (*Seiurus noveboracensis*) | x |
| Mourning Warbler (*Oporornis philadelphia*) | x |
| MacGillivray's Warbler (*Oporornis tolmiei*) | x |
| Common Yellowthroat (*Geothlypis trichas*) | * |
| Wilson's Warbler (*Wilsonia pusilla*) | * |
| Yellow-breasted Chat (*Icteria virens*) | x |
| **FAMILY: THRAUPIDAE (Tanagers and allies)** | |
| Summer Tanager (*Piranga rubra*) | x |
| Western Tanager (*Piranga ludoviciana*) | |
| **FAMILY: EMBERIZIDAE (Towhees, Sparrows, Longspurs and allies)** | |
| Spotted Towhee (*Pipilo maculatus*) | * |
| California Towhee (*Pipilo crissalis*) | * |
| Chipping Sparrow (*Spizella passerina*) | x |
| Clay-colored Sparrow (*Spizella pallida*) | x |
| Vesper Sparrow (*Pooecetes gramineus*) | x |
| Lark Sparrow (*Chondestes grammacus*) | x |
| Savannah Sparrow (*Passerculus sandwichensis*) | * (extirpated as breeder?) |
| Grasshopper Sparrow (*Ammodramus savannarum*) | * |
| Fox Sparrow (*Passerella iliaca*) | |
| Song Sparrow (*Melospiza melodia*) | * |
| Lincoln's Sparrow (*Melospiza lincolnii*) | |
| Swamp Sparrow (*Melospiza georgiana*) | |

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|---|---|
| White-throated Sparrow (*Zonotrichia albicollis*) | |
| Harris' Sparrow (*Zonotrichia querula*) | x |
| Golden-crowned Sparrow (*Zonotrichia atricapilla*) | |
| White-crowned Sparrow (*Zonotrichia leucophrys*) | * |
| Dark-eyed Junco (*Junco hyemalis*) | |
| **FAMILY: CARDINALIDAE (Cardinals, Grosbeaks, Buntings and allies)** | |
| Rose-breasted Grosbeak (*Pheucticus ludovicianus*) | x |
| Black-headed Grosbeak (*Pheucticus melanocephalus*) | * |
| Blue Grosbeak (*Guiraca caerulea*) | x |
| Lazuli Bunting (*Passerina amoena*) | |
| Indigo Bunting (*Passerina cyanea*) | x |
| **FAMILY: ICTERIDAE (Blackbirds, Orioles and allies)** | |
| Bobolink (*Dolichonyx oryzivorus*) | x |
| Red-winged Blackbird (*Agelaius phoeniceus*) | * |
| Tricolored Blackbird (*Agelaius tricolor*) | * (extirpated as breeder) |
| Western Meadowlark (*Sturnella neglecta*) | * (extirpated as breeder?) |
| Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*) | x |
| Rusty Blackbird (*Euphagus carolinus*) | x |
| Brewer's Blackbird (*Euphagus cyanocephalus*) | * |
| Great-tailed Grackle (*Quiscalus mexicanus*) | * |
| Brown-headed Cowbird (*Molothrus ater*) | * |
| Hooded Oriole (*Icterus cucullatus*) | * |
| Bullock's Oriole (*Icterus bullockii*) | * |
| **FAMILY: FRINGILLIDAE (Finches)** | |
| Purple Finch (*Carpodacus purpureus*) | * |
| House Finch (*Carpodacus mexicanus*) | * |
| Red Crossbill (*Loxia curvirostra*) | x |
| Pine Siskin (*Carduelis pinus*) | |
| Lesser Goldfinch (*Carduelis psaltria*) | * |
| American Goldfinch (*Carduelis tristis*) | * |
| **FAMILY: PASSERIDAE (Weaver Finches)** | |
| House Sparrow (*Passer domesticus*) | *, i |

## Technical Sub-Appendix G-2: Patterns of Occurrence and Abundance of Selected Species

Accounts describing the patterns of occurrence and abundance of selected species are provided here to permit a more detailed assessment their individual status and habitat use in the study area. Species included are those of potential management concern for this management plan, including: (1) waterbirds that make significant use of the Sloughs themselves (exclusive of species principally found only at the Pajaro River mouth), (2) raptors which occur regularly in the study area (or did so until recently), and (3) selected other landbirds of management interest which make significant use of the slough habitats and upland habitats in close proximity to the Sloughs.

The general status of other species can be assessed from the species list given in Appendix 1, and from information provided on a checklist of the birds of Santa Cruz County at http://santacruzbirdclub.org/chlists.html.

The following terms used in the species accounts are here defined:

*Common To Abundant* - Moderate to large numbers in proper habitats in the indicated season(s). Nearly always present and easily located.

*Fairly Common* - Moderate to small numbers in proper habitats in the indicated season(s). Usually present and easily located. May occur locally in large numbers under optimal conditions.

*Uncommon* - Small numbers in proper habitats in the indicated season(s). Usually present but may require searching to locate.

*Rare* - Very small numbers annually (or virtually annually) in proper habitats in the indicated season(s). Often requires a specific search to locate. Occurrence predictable and regular.

*Casual* - Few records in the indicated season(s).

*Irregular* - Abundance varies substantially year to year (may be less numerous than indicated or even absent some years).

**Pied-billed Grebe** (*Podilymbus podiceps*). Fairly common year-round resident with local breeding numbers augmented by migrants during fall and winter. Occurs in all aquatic habitats with open water. Breeding occurs in freshwater marsh habitat where there is a mixture of emergent vegetation marsh and significant areas of open water. Floating nests are built in the water, anchored to (and hidden in) adjacent vegetation. Nesting documented in Watsonville, Struve, Hanson and Harkins Slough, with an aggregate breeding population in the range of 15-25 pairs. More widespread during the non-breeding season, when significant numbers also occur at lower Watsonville Slough and Pajaro River mouth.

**Eared Grebe** (*Podiceps nigricollis*). Uncommon to rare non-breeding season visitor to open water habitats at all the Sloughs and the Pajaro River mouth. Most frequent at Pajaro River mouth, lower Watsonville Slough and Shorebirds Pond. Most records are of 1-5 birds during November to February. Rare in spring.

**Western Grebe** (*Aechmophorus occidentalis*). Fairly common non-breeding season visitor to open water habitats at Pajaro River mouth, lower Watsonville Slough and Anderson Peat Ponds. Often found in small groups of 1-10 birds, but occasionally forms large flocks at Pajaro River mouth of 50-200 birds. Present from late September to March, but numbers highest from late November to February.

**Clark's Grebe**. (*Aechmophorus clarkii*). Uncommon non-breeding season visitor to the same areas as Western Grebe, and often found in association with that species. Present from November to March, and seen in groups of 1-5 birds.

**American White Pelican** (*Pelecanus erythrorhynchos*). Status in flux. Formerly generally absent. Then from the late 1980s through the late 1990s it occurred rarely and irregularly (but with increasing frequency) in small flocks during the winter season. Numbers during that period were typically 1-20 birds per flock. In 2001 flocks appeared from August onwards. A series of observations in summer 2002 were the first of over-summering birds. Numbers have increased in the last few years, with flocks of 75-275 birds now being reported.

Occurs in open water habitats and adjacent mudflats and sand flats at Pajaro River mouth, lower Watsonville Slough, Harkins Slough, Watsonville Slough and Struve Slough. Foraging has been observed in all areas. Flocks are most frequently found at Harkins Slough and the Pajaro River mouth. Observations suggest that flocks roosted over-night at Harkins on some dates in summer 2002. But it is also clear that there is regular movement between this study area and roost sites at Elkhorn Slough, Bennett Slough and McClusky Slough.

**Double-crested Cormorant** (*Phalacrocorax auritus*) . Fairly common to common from late July through March, and uncommon April to mid-July. Occurs in all areas with moderate to large areas of open water habitat, with the largest flocks (up to 75-200 birds) reported from Harkins Slough, lower Watsonville Slough and Pajaro River mouth. Does not nest in the study area, but breeding colonies recently established at Pinto Lake and Elkhorn Slough. Feeds in the open water habitats and rests on open shoreline of exposed mud or sand, sometimes using willows or other trees for perch sites.

**American Bittern** (*Botaurus lentiginosus*). Uncommon year-round resident in freshwater marsh habitat at Harkins, Hanson, Watsonville and Struve Sloughs. Breeding has been documented at Harkins and Struve Sloughs, and probably occurs at Hanson and Watsonville Sloughs, as well. Aggregate breeding population in the Sloughs estimated to be about 5-10 pairs in recent years, more than any other area in the Monterey Bay region. Requires seasonally flooded marsh with mix of open water and dense emergent vegetation for nesting. Nests are placed low in dense marsh vegetation.

**Great Blue Heron** (*Ardea herodias*). Fairly common year-round resident, being most numerous from September to February. Occurs in all areas of aquatic habitat, and (to a lesser degree) in adjacent upland areas with grasses and weeds. No nests have ever been reported in the study area (nearest known nesting is at Pinto and Kelly lakes), but local breeders and non-breeders frequent the Sloughs during the breeding season. Areas of partially flooded vegetation and the

margins of open water areas provide important foraging habitat. Large willows and other trees are used for perching and roosting, with snags being especially favored. Peak aggregate numbers from different parts of the Sloughs have been in the range of 20-35 birds.

**Great Egret** (*Ardea alba*). Fairly common year-round resident, being recently most numerous May to September. Occurs in all areas of aquatic habitat, and (to a lesser degree) in adjacent upland areas with grasses and weeds, but favors areas with partially flooded vegetation and open water. Great Egrets only recently began nesting in the Monterey Bay region, first at Elkhorn Slough in 1987 (Roberson and Tenney 1993). Nesting was first noted in Santa Cruz County at Pinto Lake in 1995, which remains the county's only breeding colony. Birds using the Sloughs during the main breeding season are probably mostly non-breeding birds, with post-breeding dispersers (probably from the San Francisco Bay area and Elkhorn Slough) present from July onwards. Large willows and other trees are used for perching and roosting, with snags being especially favored. Peak aggregate numbers from different parts of the Sloughs have been in the range of 50-125 birds.

**Snowy Egret** (*Egretta thula*). Year-round resident, being fairly common from August to February, and uncommon during the breeding season. Occurs in all areas of aquatic habitat, favoring areas with partially flooded vegetation and open water. Does not nest in the Monterey Bay region. Large willows and other trees are used for perching and roosting, with snags being especially favored. Peak aggregate numbers from different parts of the Sloughs have been in the range of 50-100 birds.

**Cattle Egret** (*Bubulcus ibis*). Presently rare with no reports from the study area for two years, and few reports since 1995. First recorded in the study area in 1974, as part of its range expansion throughout most of California, following initial colonization of the state in 1962. Variably uncommon to fairly common from the late 1970s to mid-1980s from October through March (rare in April), but then numbers declined substantially from the late 1980s onward. A summary of its changing status in Santa Cruz County is at: http://santacruzbirdclub.org/recce.html. The recent declines have been widely noted throughout coastal northern California. Uses terrestrial habitats to a much greater degree than other herons and egrets, favoring grassland, fallow fields, roadsides and areas with cattle. A night roost formerly occurred at Hanson Slough. During its years of highest abundance peak counts in the study area were in the range of 20-50 birds.

**Green Heron** (*Butorides virescens*). Uncommon year-round resident occurring in areas with freshwater marsh, flooded riparian vegetation, or riparian vegetation adjacent to open water. Small numbers (estimated 4-8 pairs) nest throughout the study area, with most breeding records from Harkins Slough. Nests are built in willows or other trees, both near water and well away from water. It is unusual to see more than 1-2 birds in any given area.

**Black-crowned Night Heron** (*Nycticorax nycticorax*). Uncommon to fairly common year-round resident, with numbers highest from October to February. Occurs in all aquatic habitats, favoring those with a mix of freshwater marsh and open water. Roosts in areas of dense willows. Has nested in colonies in the study area in some years (e.g., about 20 pairs used Hanson and Harkins Sloughs in 1990), but apparently does not nest in the area regularly.

However, some of the best nesting habitat has not been checked during recent breeding seasons due to limited access. Known nest colonies have been in dense stands of willows. Peak aggregate winter numbers from different parts of the Sloughs have been in the range of 50-75 birds.

**White-faced Ibis** (*Plegadis chihi*). Rare visitor during spring and fall migration, and casual winter visitor. Frequency of occurrence has increased in the region in the past 15 years. Occurs in freshwater and brackish marsh, although some records have been of flocks simply flying over. Most recent records from Harkins Slough, but also recorded at Struve and Hanson Sloughs, lower Watsonville Slough and the Pajaro River mouth. Most records are of 1-7 birds, but flocks of up to 37 have been reported.

**Turkey Vulture** (*Cathartes aura*). Uncommon visitor from late January to October, and rare visitor from November to mid-January. Principally seen flying over the study area, foraging especially over upland habitats between the Sloughs. Generally only 1-5 are seen at any given time. Does not nest in or adjacent to the study area.

**Greater White-fronted Goose** (*Anser albifrons*). Rare visitor from October to February. Most records from Harkins Slough, lower Watsonville Slough, Pajaro River mouth and Shorebirds Pond. Usually found in groups of 1-4 birds, occasionally in larger flocks. Individuals or small flocks have occasionally remained for several weeks or months during the winter. Uses open water habitats and its shoreline.

**Snow Goose** (*Chen caerulescens*). Rare visitor from November to February. Most records from Harkins Slough, lower Watsonville Slough, Pajaro River mouth and Shorebirds Pond. Usually found in groups of 1-3 birds, very occasionally in larger flocks. Individuals have occasionally remained for several weeks or months during the winter. Uses open water habitats and its shoreline.

**Ross' Goose** (*Chen rossii*). Rare visitor from October to February. Casual during spring migration in April. Individuals have occasionally remained for several weeks or months during the winter, and a few have even lingered on through summer at Shorebirds Pond. Most records from Harkins Slough, lower Watsonville Slough, Pajaro River mouth and Shorebirds Pond. Usually found in groups of 1-2 birds, occasionally in small flocks. Incidence of occurrence has increased since the mid-1980s. Uses open water habitats and its shoreline.

**Canada Goose** (*Branta canadensis*). Rare to uncommon year-round resident, most frequently noted from September to May, but more rarely during the summer months. It has occurred throughout the study area, but most reports have come from Harkins Slough. Canada Geese use a variety of aquatic habitats with open water, and also forage on grassy uplands and in agricultural fields near the Sloughs. Numbers typically range from 1-30 birds, but larger flocks have occasionally been seen. They rarely remain in any one area for very long, except for occasional over-wintering individuals at Harkins Slough and Shorebirds Pond.

Several subspecies have occurred, although the most frequent are *B. c. maxima*, *moffetti* and *minima*. The subspecies *moffetti* has greatly increased its regional population and range in the

central coast region since the early 1980s, and this has been reflected in increased occurrence of Canada Geese in the study area, especially from spring through early fall. Nesting has not occurred there yet, but may be anticipated in the future.

**Tundra Swan** (*Cygnus columbianus*). Casual to rare visitor from December to February. Records have been at Pajaro River mouth and Harkins Slough. Most have been of 1-4 birds, but flocks of 20 have been reported. Occurs at areas with large expanses of open water.

**Gadwall** (*Anas strepera*). Uncommon from April to August, and fairly common from September to March. The Sloughs are the most important nesting area for Gadwalls in Santa Cruz County. There have been no recent surveys of the breeding population, but it is estimated to be about 15-25 pairs. Breeding birds occur in freshwater marsh with open water at Struve, Hanson, Harkins and Watsonville Sloughs. Nests are located amid grasses and weedy vegetation somewhat upslope from marsh habitat, and sometimes in the marsh itself. Non-breeding season visitors use all types of open water habitat, and marsh areas with a mosaic of open water and emergent vegetation. The greatest counts during the winter have come from Harkins and Watsonville Sloughs.

**American Wigeon** (*Anas americana*). Fairly common to common visitor from September to March, with peak numbers during early winter. Occurs in all types of open water habitat, and in freshwater marsh with open channels. The highest counts have been reported from Harkins Slough and lower Watsonville Slough.

**Mallard** (*Anas platyrhynchos*). Common year-round resident, being locally abundant during the winter in some years. There have been no recent surveys of the breeding population, but it is estimated to be about 50-60 pairs. Breeding birds occur in all open water habitats, especially in areas with emergent freshwater marsh vegetation. They are most frequent at Harkins, Struve and Watsonville Sloughs. Nests are located amid grasses and weedy vegetation somewhat upslope from marsh habitat, and sometimes in the marsh itself. Non-breeding season visitors use all types of open water habitat, and marsh areas with a mosaic of open water and emergent vegetation. The greatest counts during the winter have come from Harkins and Watsonville Sloughs.

**Blue-winged Teal** (*Anas discors*). Rare visitor from September to April. It is most consistently encountered during periods of migration in mid-Fall and late winter, but some over-wintering birds (usually 1-4 individuals) occur in many years. Occurs in all areas with open water habitat in association with various types of marsh vegetation. Fall migrants have been most frequent at lower Watsonville Slough, while spring migrants have been found more widely. Most recent winter records have been from Struve and Harkins Sloughs.

**Cinnamon Teal** (*Anas cyanoptera*). Uncommon from May to early January, and fairly common to locally common from mid-January to April. The Sloughs are the most important nesting area for Cinnamon Teal in Santa Cruz County. There have been no recent surveys of the breeding population, but it is estimated to be about 10-20 pairs. Breeding birds occur in freshwater marsh with open water at Struve, Hanson, Harkins and Watsonville Sloughs. Nests are located amid grasses and weedy vegetation somewhat upslope from marsh habitat, and sometimes in the

marsh itself. Non-breeding season visitors favor areas where open water intermingles with freshwater marsh vegetation, areas with partially inundated vegetation, and flooded agricultural fields. A southward passage of migrants in the fall is subtle with fairly few appearing in the study area, but a northward passage from January to spring brings hundreds of teal into the study area. Up to 800 have been counted in the Sloughs on one day at that time. These birds are most abundant at Harkins, Watsonville and Struve Sloughs.

**Northern Shoveler** (*Anas clypeata*). Uncommon to fairly common visitor from September to March, with peak numbers during early winter. Occurs in all types of open water habitat, and in freshwater marsh with open channels. The highest counts have been reported from Harkins Slough and lower Watsonville Slough. Individuals occasionally linger into spring or (very rarely) over summer. One breeding record at Harkins Slough in 1998 remains the only confirmed breeding evidence for Santa Cruz County. Very small numbers may nest in Monterey County at Elkhorn Slough and Salinas River mouth.

**Northern Pintail** (*Anas acuta*). Fairly common to common visitor from September to March, with peak numbers during early winter. Small numbers occasionally linger to early May, and individuals have very rarely been found in late spring or summer. Occurs in all types of open water habitat, and in freshwater marsh with open channels. The highest winter counts have been reported from Harkins Slough. Not confirmed to nest in Santa Cruz County, but very small numbers nest in Monterey County at Salinas River mouth and (none recently?) at Elkhorn Slough.

**Green-winged Teal** (*Anas crecca*). Fairly common to common visitor from September to March, with peak numbers during winter. Small numbers occasionally linger to late May, and individuals have very rarely been found in summer. Occurs in all types of open water habitat and in freshwater marsh with open channels. The highest winter counts have been reported from Harkins Slough, where it is sometimes abundant, but winter counts vary widely from year to year.

**Canvasback** (*Aythya valisineria*). Variably uncommon to locally common visitor from late October to March, with individuals occasionally lingering to late April. Occurs in relatively large areas of open water, such as Harkins Slough, Anderson Peat Ponds, lower Watsonville Slough and the Pajaro River mouth. Winter numbers very greatly from year to year. Most recent high counts of many hundreds have been at Harkins Slough.

**Ring-necked Duck** (*Aythya collaris*). Variably uncommon to locally common visitor from late October to March, with individuals occasionally lingering to early May. Occurs in relatively large areas of open water, freshwater marsh with open channels and in areas of flooded riparian vegetation. Numbers vary greatly from year to year. Most recent high counts have been from Harkins, Hanson and Watsonville Sloughs.

**Lesser Scaup** (*Aythya affinis*). Variably uncommon to locally common visitor from late October to March. Individuals occasionally linger to over-summer. Occurs in relatively large areas of open water, especially at Pajaro River mouth and lower Watsonville Slough. Winter

numbers have recently varied greatly from year to year, and have generally decreased in the study area over the last 15 years.

**Bufflehead** (*Bucephala albeola*). Uncommon to fairly common late October to March, rare in April. Individuals occasionally linger to over-summer. Occurs in areas of open water. Largest numbers congregate at Pajaro River mouth and lower Watsonville Slough, but also regular at Shorebirds Pond, Anderson Peat Ponds, and Harkins Slough.

**Common Goldeneye** (*Bucephala clangula*). Uncommon late October to March. Occurs in areas of open water. Largest numbers congregate at Pajaro River mouth and lower Watsonville Slough, but also regular at Shorebirds Pond, Anderson Peat Ponds, and Harkins Slough.

**Hooded Merganser** (*Lophodytes cucullatus*). Uncommon (occasionally fairly common) visitor from late October to April. Peak numbers usually present November to January. Occurs mostly in freshwater habitats with a mix of open water and marsh vegetation. Numbers vary from year to year. Found most frequently at Harkins Slough, and at portions of East Struve and Watsonville Sloughs upstream of Highway 1. Found much more rarely near the ocean at lower Watsonville Slough and the Pajaro River mouth. The Sloughs comprise an important area for this species in Santa Cruz County.

**Ruddy Duck** (*Oxyura jamaicensis*). Fairly common to locally common from October to March, uncommon from April to September. The Sloughs are the most important nesting area for this species in the county. There have been no recent surveys of the breeding population, but it is estimated to be about 10-20 pairs. Nesting evidence has been reported from Harkins, Hanson, Struve and Watsonville Sloughs, occurring in freshwater marsh with areas of open water. Nests are located amid grasses and weedy vegetation somewhat upslope from marsh habitat, and sometimes in the marsh itself. Non-breeding season visitors favor areas with relatively large expanses of open water, such as lower Watsonville Slough, Pajaro River mouth, Anderson Peat Ponds, and Harkins Slough.

**Osprey** (*Pandion haliaetus*). Rare visitor, possibly year-round. Most are noted from September to April (especially during migration periods), but also occurs in late spring and summer. Found widely where there is open water habitat suitable for foraging, and also seen flying over the study area. Most frequently reported from the Pajaro River mouth, lower Watsonville Slough and Harkins Slough. Usually just single birds are seen. A series of breeding season records from the Pajaro Valley in recent years has hinted at possible nesting in the valley area, but breeding has not yet been confirmed there.

**White-tailed Kite** (*Elanus leucurus*). Uncommon to locally fairly common year-round resident, with resident breeding numbers apparently augmented by migrants during fall and winter. Occurs in upland habitats and adjacent woodlands, favoring grassland, scrub and ruderal areas, but generally makes little use of agricultural fields. Also uses riparian and extensive wetland vegetation within the Sloughs themselves. Nesting has been documented in association with all of the Sloughs. No recent survey of nesting kites has been undertaken, but the breeding population is estimated to be about 6-8 pairs. Nests are built in trees in riparian forest, oak woodland or other trees (e.g., Monterey pine is often used). Nests may be near the Sloughs, or

well-removed from them. Winter roosts sometimes gather in willows in the Sloughs, where they have been noted at Harkins and Hanson Sloughs. Aggregate peak non-breeding season counts from the study areas have been of 40-60 birds. Single fall and winter counts from Harkins Slough have reached 40 birds.

**Northern Harrier** (*Circus cyaneus*). Rare from April to August, increasing to uncommon from September to March. Occurs in various open habitats, including grassland, fallow fields, ruderal areas, and freshwater and brackish marsh. Generally makes little use of actively farmed fields. Small numbers (about 4 pairs) formerly nested in the study area at Watsonville, Harkins, Struve and Hanson Sloughs, but I am not aware of any recent breeding confirmations. Individuals are still seen on occasion during the breeding season, indicating that nesting may still occur or be re-established. Nests are placed on the ground in grassland or open scrub. Loss of upland foraging and nesting habitat to development and row crops has recently reduced the value of the study area for this species, and has likely compromised the area's ability to support nesting. Migrants are present during the non-breeding season, when the species is found throughout the area in suitable habitat.

**Sharp-shinned Hawk** (*Accipiter striatus*). Uncommon from September to April, and rare from late June to August. Occurs in a wide variety of habitats, including all terrestrial types, and both freshwater and brackish marsh. Most commonly noted in the vicinity of riparian or live oak woodland. Not known to nest in the study area or near vicinity, but individuals may be seen during summer, dispersing from breeding areas in the nearby Santa Cruz Mountains.

**Cooper's Hawk** (*Accipiter cooperii*). Uncommon from September to April, and rare from late June to August. Patterns of occurrence are essentially the same as for Sharp-shinned Hawk, described above. Nests nearer to the study area than Sharp-shinned, with confirmations as close as the Seascape area, but no breeding records reported from the study area itself.

**Red-shouldered Hawk** (*Buteo lineatus*). Uncommon year-round resident. Numbers increase slightly during winter. Occurs throughout the study area in all upland habitats, and in riparian woodland in the Sloughs. Favors areas with woodland or a mosaic of trees and open areas. Confirmed to nest near Harkins, Gallighan and Watsonville Sloughs, Rancho Road and Larkin Valley. Nests are built in the upper canopy of a large tree. Those known from the study area have been in eucalyptus and Monterey pine. Breeding population in the study area estimated to be about 6-9 pairs.

**Red-tailed Hawk** (*Buteo jamaicensis*). Uncommon from April to September, fairly common from October to March. Occurs throughout the study area in all upland habitats, and in riparian woodland in the Sloughs. Favors grassland or fallow fields, or a mosaic of trees and open areas. Confirmed to nest near Gallighan and Watsonville Sloughs, Rancho Road and Larkin Valley. Nests are built in the upper canopy of a large tree. Those known from the study area have been in eucalyptus. Breeding population in the study area estimated to be about 6 pairs. Highest concentrations in winter are found on open uplands around Harkins, Hanson, Struve and Watsonville Sloughs, but numbers have decreased in recent years, as habitat has been lost to development and row crop agriculture.

**Ferruginous Hawk** (*Buteo regalis*). Rare visitor from late October to February. Favors grassland and other open habitat between the Sloughs, but has become less frequent in recent years as such areas have been lost to development, especially inland of Highway 1.

**Golden Eagle** (*Aquila chrysaetos*). Rare visitor during all months, but occurrence is erratic. In recent years, most records are thought to pertain to a pair that has nested north of the study area near Corralitos, ranging to the Sloughs to forage. But there are periods of several months when no eagles are reported in the study area. Most frequently seen around Harkins Slough and the open areas inland of Highway 1 near Struve and Watsonville Sloughs. Foraging activity is focused on grasslands. Habitat conditions have deteriorated for this species in the study area, as grassland is lost to development and row crops.

**American Kestrel** (*Falco sparverius*). Uncommon resident. Numbers increase slightly in winter. Occurs throughout the study area in all upland habitats, and in riparian woodland in the Sloughs. Favors grassland or fallow fields, or a mosaic of trees and open areas. Confirmed to nest at Harkins, Hanson, Gallighan and Watsonville Sloughs, Larkin Valley and at Palm Beach. Nests are built cavities in large tree, or in "cavities" in buildings (e.g., inside of a roof). Breeding population in the study area estimated to be about 6-8 pairs. Numbers have decreased in recent years, as foraging habitat has been lost to development and row crop agriculture.

**Merlin** (*Falco columbarius*). Rare visitor from late September to April. Uses all habitats in the study area, but favors grasslands, riparian woodland and aquatic areas for hunting. Typically 1-3 present in the area during winter.

**Peregrine Falcon** (*Falco peregrinus*). Rare visitor from August to April, casual May to July. Occurs throughout the study area, but favors areas with aquatic habitats and adjacent grassland. Seen most frequently at the Pajaro River mouth, but also many reports from Harkins and lower Watsonville Sloughs.

**California Quail** (*Callipepla californica*). Uncommon to locally fairly common. Occurs in all upland habitat types except actively farmed fields, and is generally sparse in grasslands except near shrubby cover. Nests in areas with dense shrub or other understory vegetation. Available information suggests the local population may be in decline.

**Virginia Rail** (*Rallus limicola*). Rare to uncommon April to August, uncommon to locally fairly common September to March. Occurs in throughout in freshwater marsh and seasonally flooded riparian woodland, especially where there is dense cover provided by wetlands vegetation together with areas of open water. Also occurs in the brackish pickleweed marsh of lower Watsonville Slough during the fall and winter. Nests are built in the marsh. Nesting has been confirmed at Harkins and Hanson Sloughs, but presumably also occurs in suitable habitat in the other Sloughs. A rough estimate for recent breeding population is on the order of 5-8 pairs. A winter survey of much of the suitable habitat in the slough system in January 1994 used taped playback of calls to elicit responses and found 38 Virginia Rails (D. Suddjian unpubl. data). The greatest numbers were detected at Harkins, Hanson, West Struve and Struve Sloughs.

**Sora** (*Porzana carolina*). ). Rare from April to August, uncommon to locally fairly common September to March. Distributed in the same fashion as Virginia Rail, although typically less numerous than that species. Nests are built in the marsh. Sora is one of the rarest breeding species in Santa Cruz County, with only one nesting confirmation from the slough system – at Hanson Slough in 1988. It is unknown if breeding occurs annually. The January 1994 tape playback survey found 21 Sora, with the greatest number at Harkins Slough (D. Suddjian unpubl. data).

**Common Moorhen** (*Gallinula chloropus*). Rare from April to August, uncommon September to March. Occurs in freshwater marsh where there is a mix of open water and dense to moderately dense emergent wetland vegetation. Nests are placed in the marsh. Recent estimates of the breeding population are 2-5 pairs. Nesting has been confirmed at Harkins, Hanson, West Struve and Struve Sloughs. Numbers increase somewhat in the fall and winter.

**American Coot** (*Fulica americana*). Fairly common April to September, and common to locally abundant September to March. Occurs throughout in areas of open water habitat and freshwater and brackish marsh. Nests in marsh vegetation. Breeding numbers are greatest where there is a mix of moderate to large open water areas, and moderately dense marsh vegetation, such as at Harkins Slough near Harkins Slough Road. Nesting has been confirmed in all the Sloughs. Recent estimates of the breeding population have been on the order of 30-35 pairs. Number rise sharply in mid-fall, and from late fall through winter flocks of several 100 may be seen in the larger open water areas.

**Semipalmated Plover** (*Charadrius semipalmatus*). Uncommon to fairly common from late March to early May and from mid-July to October, and rare from November to February. Occurs along the margins of the Pajaro River mouth and elsewhere at the edges of open water habitat. Migrants are generally more common at the Pajaro River mouth than inland, although fall migrants have recently been found regularly in good numbers at Harkins Slough. Wintering birds are typically found only at the Pajaro River mouth, and casually inland to Harkins Slough and Watsonville Slough near Ford Road. Peak migration counts are typically of 20-50 birds, while winter counts are usually only 1-2 birds.

**Killdeer** (*Charadrius vociferus*). Fairly common August to February, uncommon March to July. Occurs in a wide variety of open settings, including margins of open water, mudflats and sandflats, grassland and agricultural fields. Nests on the ground often near open water, but sometimes well removed in low grassland or other very open settings (such as along farm roads). Recent estimates of the breeding population have been of 6-10 pairs. During migration and winter it is common to see groups of 2-6 birds, but loose flocks of 20-40 are not unusual. The greatest numbers have been found at the Pajaro River mouth, lower Watsonville Slough and Harkins Slough.

**Black-necked Stilt** (*Himantopus mexicanus*). Uncommon to locally fairly common year round. Has generally increased in recent years, especially as a breeder, although aggregate numbers are still relatively small. Recent estimates of the breeding population have been of 8-12 pairs, with nesting confirmed at all the Sloughs and the Pajaro River mouth. Nests are placed on the ground or amid low marsh vegetation in open settings. Non-breeding season numbers are

variable, but aggregate numbers have been about 30-50 birds in recent years, with most found at lower Watsonville Slough, Shorebirds Pond and the Pajaro River mouth.

**American Avocet** (*Recurvirostra americana*). Rare to locally uncommon year round, although at times absent from the study area. Numbers increased somewhat over recent decades, but since the late 1990s it has been fairly scarce. Breeding has been documented only at the Pajaro River mouth and lower Watsonville Sloughs. Estimates of the breeding population in recent years have ranged from 0-5 pairs. Generally more numerous in the non-breeding season, when it is also more widespread (but still most numerous in the Pajaro River mouth area). Aggregate counts in the fall and winter have ranged from 10-60 birds.

**Greater Yellowlegs** (*Tringa melanoleuca*). Uncommon to locally fairly common July to October and April to May, and rare to uncommon November to March. Occurs in shallow waters and the margins of open water areas throughout. Typically seen in loose groups of 1-4 birds, with flocks of up to 20 during migratory peaks. During winter usually only 1 or 2 are in any given area and aggregate numbers are usually only 2-6 birds.

**Lesser Yellowlegs** (*Tringa flavipes*). Rare April to May, rare to uncommon late July to October, and rare (but sometimes absent) November to March. Occurs in the same settings as Greater Yellowlegs. Few reports in spring migration, but more regular in fall migration. Usually only 1-2 are noted at a given spot, but groups of 10-15 have been seen during migratory peaks in August and September. Found most often at Harkins Slough, lower Watsonville Slough and the Pajaro River mouth.

**Spotted Sandpiper** (*Actitis macularia*). Rare to uncommon April to May and late July to October, rare from November to March. Found along margins of open water areas, most often at Harkins Slough, lower Watsonville Slough and the Pajaro River mouth. Generally only 1-2 are seen in a given area, with flocks of 3-5 being rarely noted. Nests nearby along the Pajaro River, upstream of Watsonville.

**Western Sandpiper** (*Calidris mauri*). Uncommon to locally fairly common late March to mid-May and from mid-July to early November, and casual late November to early March. Found at the margins of open water areas, on mudflats and sandflats, and in shallow water. Most regular and numerous at the Pajaro River mouth and lower Watsonville Slough. Suitable habitat in the inland portion of the slough system is often limited, especially in spring. Drying margins of flooded agricultural fields, as along Watsonville Slough near Struve Slough and near Ford Road are used in spring. Harkins Slough has provided good habitat in recent fall seasons. Numbers at the Pajaro River mouth area in migration are often in the range of 50-100 birds, with occasional peaks of up to 500 birds. Numbers inland during migration are generally more modest. Often absent during the winter season, or found in groups of just 1-5 when present.

**Least Sandpiper** (*Calidris minutilla*). Uncommon to locally fairly common late March to mid-May and from mid-July to early November, and rather uncommon late November to early March. Habitat use and pattern of occurrence as for Western Sandpiper, but this species is more regular and numerous during the winter season, when flocks of 10-50 birds may be found.

**Baird's Sandpiper** (*Calidris bairdii*). Rare from late July to late September, and causal to from October early November. Frequents mudflats and sandflats, and the margins of open water areas. Recent fall seasons have recorded 5-15 individuals in the study area, especially at Pajaro River mouth and Harkins Slough.

**Pectoral Sandpiper** (*Calidris melanotos*). Rare from late August to October, and causal in November. Occurs in the same habitats and areas as Baird's Sandpiper. Recent fall seasons have recorded 5-30 individuals in the study area

**Dunlin** (*Calidris alpina*). Uncommon to locally fairly common late March to mid-May and from September to early November, and rare to uncommon late November to early March. Habitat use and pattern of occurrence as for Western Sandpiper. Spring and fall migration peaks may have flocks of several hundred birds, with the greatest numbers usually at the Pajaro River mouth. Winter numbers are variable depending on slough flooding, and few have been present in that season in recent years.

**Short-billed Dowitcher** (*Limnodromus griseus*). Uncommon to fairly common April to early May, and late July to September. Occurs in shallow open water, along the margins of open water areas and at mudflats. Harkins Slough, lower Watsonville Slough and Pajaro River mouth are favored sites. Flocks of 20-40 are typical, but may be seen in the low 100s during migration peaks, especially at the Pajaro River mouth.

**Long-billed Dowitcher** (*Limnodromus scolopaceus*). Uncommon to fairly common April to early May, and late July to October, and rare to uncommon November to March. Distribution and habitat use as for Short-billed Dowitcher. Flocks of 20-70 are typical, but may be seen in the low 100s during migration peaks. Winter numbers are variable depending on slough flooding, and few have been present in that season in recent years.

**Common Snipe** (*Gallinago gallinago*). Rare August to September, uncommon to locally fairly common October to February, and rare to uncommon March to early May. Found throughout in flooded wetlands with moderate cover, and along the margins of open water areas and flooded agricultural fields. Usually only 1-5 found in a given area, but occasional concentrations of 20-50 birds are encountered, especially at Harkins Slough

**Wilson's Phalarope** (*Phalaropus tricolor*). Rare late June to September, and casual to rare late April to early May. Found in open water areas and at mudflats and sandflats. In recent years most have been found at Harkins Slough, with peak fall counts of 5-10 birds.

**Red-necked Phalarope** (*Phalaropus lobatus*) . Uncommon to locally fairly common late June to early October, and late April to early May. Found in open water areas and at mudflats and sandflats. Most are found at Harkins Slough and the Pajaro River mouth, with typical fall counts of 10-30 birds. Occasional flocks of several 100 are encountered in the spring, especially at the Pajaro River mouth.

**Bonaparte's Gull** (*Larus philadelphia*). Fairly common to locally abundant late March to May, rare June to August, uncommon September to early March. Occurs in open water areas and at the shores of the Pajaro River mouth. Strong coastal passage in spring migration brings 1000s to the Pajaro River mouth, where they rest and drink, and smaller flocks may be seen elsewhere in the Sloughs. Summer birds are generally limited to the Pajaro River mouth. Fall and winter birds are frequent there and at Harkins Slough.

**Mew Gull** (*Larus canus*). Rare September to early October, fairly common to locally abundant from mid-October to March, rare in April, casual May to August. Frequents the county and city landfills, open water areas, flooded agricultural fields and the shores of the Pajaro River mouth. During late fall and winter many 100s to 1000 may be found at the landfills (and adjacent Harkins Slough) and the Pajaro River mouth, with numbers at the river mouth especially high during winter storms.

**Ring-billed Gull** (*Larus delawarensis*). Uncommon to locally fairly common September to March, rare April to August. Found at the margins of open water areas. Often fairly locally distributed. Aggregate numbers in fall and winter are probably only 50-150 birds. A few remain through the summer.

**California Gull** (*Larus californicus*). Common to abundant August to April, locally uncommon May to July. Found in wetland and agricultural habitats throughout, with concentrations gathering at the county and city landfills, Harkins Slough and the Pajaro River mouth. Along with Western Gull, generally the most abundant gull in the study area. Large flocks of several 1000 are typical. Only small numbers (100-300) remain through the late spring and early summer.

**Herring Gull** (*Larus argentatus*). Uncommon to locally fairly common October to March, rare in April, and casual May to September. Found principally at the county and city landfills, Harkins Slough and the Pajaro River mouth. Winter flocks in those areas often range from 200-700 birds, with occasional larger flocks at the river mouth. Rather uncommon at other open water localities elsewhere in the study area.

**Thayer's Gull** (*Larus thayeri*) . Uncommon October to March, casual April to September. Pattern of occurrence as for Herring Gull. Peak winter counts typically 20-50 birds.

**Western Gull** (*Larus occidentalis*). Common to abundant July to May, locally fairly common in June. Found principally at the county and city landfills, Harkins Slough and the Pajaro River mouth. Along with California Gull, generally the most abundant gull in the study area. Large flocks of several 1000 are typical. Smaller numbers (300-500) remain through June. Nearest nesting areas are at Moss Landing to the south and Capitola to the north.

**Glaucous-winged Gull** (*Larus glaucescens*). Rare to uncommon September, fairly common to locally abundant October to March, uncommon in April, and rare May to August. Found principally at the county and city landfills, Harkins Slough and the Pajaro River mouth. Winter flocks in those areas often range from 200-1000 birds, with occasional larger flocks at the river mouth. Rather uncommon at other open water localities elsewhere in the study area.

**Caspian Tern** (*Sterna caspia*). Fairly common to locally common late March to September, rare in October, and casual November to January. A flock (50-200 birds) is often present at the Pajaro River mouth, and smaller numbers visit open water habitat throughout to forage. Peak numbers found in May and from late July to August. Harkins Slough typically attracts the most foraging activity in the inland part of the study area, where 20-30 birds may be found. Nests nearby at Elkhorn Slough.

**Forster's Tern** (*Sterna forsteri*). Fairly common to locally common late March to mid-September, then locally uncommon late September to mid-March. A flock (50-300 birds) is often present at the Pajaro River mouth, and smaller numbers visit open water habitat throughout to forage. Peak numbers found in May and July to August. Harkins Slough typically attracts the most foraging activity in the inland part of the study area. Wintering birds are generally limited to the Pajaro River mouth and Harkins Slough. Nests nearby at Elkhorn Slough.

**Barn Owl** (*Tyto alba*). Uncommon year round resident. Occurs throughout, frequenting all types of open habitats for foraging, especially grassland and wetlands. Woodland areas used for roosts. Nests in cavities, mostly in man-made structures, and uses nest boxes in some areas (though not documented in the study area). No estimates of the breeding population have been made, but it is probably on the order of 5 pairs.

**Western Screech-Owl** (*Otus kennicotti*). Status poorly known in the study area, but probably a locally uncommon year-round resident. Occurs in large areas of oak woodland and probably planted stands of Monterey pine that occur near oak woodland. Not recorded from the immediate vicinity of the flooded portions of the Sloughs. Nests in natural cavities, and uses nest boxes in some areas (though not documented in the study area). No estimate of breeding population.

**Great Horned Owl** (*Bubo virginianus*). Uncommon year round resident. Occurs throughout, frequenting all types of habitats for foraging, especially grassland, wetlands and open woodlands. Nests in old nests of hawks or crows, typically in a large tree. No estimates of the breeding population have been made, but it is probably on the order of 5 pairs.

**Northern Pygmy-Owl** (*Glaucidium gnoma*). Status poorly known in the study area, but probably a rare to uncommon year-round resident in the upper slough watershed. Occurs in large areas of oak woodland. Occasionally observed in the non-breeding season in riparian woodland at Harkins Slough. Nests in natural cavities. No estimate of breeding population.

**Burrowing Owl** (*Athene cunicularia*). Presently casual to rare October to February. Formerly locally uncommon through the early 1980s, decreasing to very rare and apparently irregular by 1990. Occurs in open grassland and at the margins of agricultural areas, relaying on burrows dug by mammals. California ground squirrel is a principal source of burrows in the local region. Since 1990 there have been very few specific reports, but some of the more suitable areas have no public access and are rarely ever surveyed. Second hand reports suggest some may still occasionally occur in the non-breeding season. During the 1970s and early 1980s there were a

number of records from the Struve Slough region inland of Highway 1, but none have been reported there recently and habitat conditions have been substantially degraded by development. Most recent records are from uplands between Harkins and West Struve Slough, especially north of Harkins Slough Road. The decline in the study area occurred at the same time as declines at a handful of other spots in the county where this species was formerly a regular winter visitor. Collectively, causes include habitat loss, habitat degradation, ground squirrel control programs and possibly secondary poisoning. There are no known breeding records from the Sloughs, but it is likely that this species historically nested in the study area.

**Short-eared Owl** (*Asio flammeus*). Presently casual from late October to February, with almost no reports for the last 10 years. Formerly regularly noted to the late 1980s, when 1-4 birds were wintering in the study area. Occurs in grassland and wetland habitats, with its local presence apparently most closely tied to the availability of extensive grassland. Most records are from the uplands near Harkins, Hanson, Struve and West Struve Sloughs. There are no breeding records known for the county (or even any evidence of occurrence in the nesting season), but it is possible that this species historically nested in the study area. It had been found nesting occasionally near the Salinas River mouth from 1974-1981, but not recently (Roberson and Tenney 1993).

**Belted Kingfisher** (*Ceryle alcyon*). Uncommon year-round, being most numerous August to March. Occurs in all areas of open water habitat. No breeding records known from the study area, where suitable nest sites (burrows on earthen banks or cliffs) are lacking. Nesting has been confirmed elsewhere in the Pajaro Valley, and local area breeders may commute to forage in the Sloughs. Usually only 1-2 are present in any area. Aggregate numbers in the non-breeding season are typically 5-10 birds.

**Nuttall's Woodpecker** (*Picoides nuttallii*). Uncommon year-round resident. Found in oak woodland and deciduous riparian forest, ranging also into exotic tree plantings. Most numerous in the upper slough watershed. Excavates nest cavity in snag or in dead limb of live tree. No estimate has been made for the breeding population, but it is probably on the order of 5-10 pairs.

**Downy Woodpecker** (*Picoides pubescens*). Fairly common year-round resident. Found in all woodland and forest types, being most numerous in riparian forest. Excavates nest cavity in snag or in dead limb of live tree. No estimate has been made for the breeding population, but it is probably on the order of 10-15 pairs.

**Olive-sided Flycatcher** (*Contopus cooperi*). Rare to uncommon late April to September. Small numbers of migrants pass through in April and May, and again in August and September, visiting various wooded habitats. Very small breeding population of about 3-5 pairs. Within the study area it nests high in stands of tall eucalyptus, usually in moderate to large groves with an open understory, near shorter woodland trees. Although not monitored in the study area, has shown declines in other parts of the local region.

**Western Wood-Pewee** (*Contopus sordidulus*). Rare to uncommon late April to September. Small numbers of migrants pass through in April and May, and again in August and September. Small

breeding population of about 5 pairs. Within the study area it nests high in stands of tall eucalyptus, usually in moderate to large groves. Although not monitored in the study area, has shown declines in other parts of the local region.

**Willow Flycatcher** (*Empidonax traillii*). Very rare late May to June, and rare late August to early September. Birds in the study area are strictly passage migrants. There is no historic evidence of nesting. Migrants occur mostly in riparian forest, but occasionally in other habitats.

**Pacific-slope Flycatcher** (*Empidonax difficilis*). Fairly common late March to September, occasionally common during migratory peaks, especially in September. Rare in October, and casual November to February. Migrants visits all sorts of wooded habitats, but are especially numerous in riparian. Nesting birds in the study area principally use the riparian forest and eucalyptus stands. Other wooded habitat is used where conditions are relatively mesic. Nest is built on a tree trunk, or amid an exposed tree root ball. No estimate has been made for the breeding population, but it is probably on the order of 50-60 pairs. This species has shown declines in some riparian areas in the local region.

**Black Phoebe** (*Sayornis nigricans*). Fairly common year-round resident. Found in all wetland areas, as well as other open habitats. Most closely tied to wet or mesic habitats during the breeding season. Nests made of mud affixed to man made structures, such as under eaves of sheds or buildings, or in culverts. Suitable natural substrates are lacking in the study area. No estimate has been made for the breeding population, but it is probably on the order of 40 pairs.

**Say's Phoebe** (*Sayornis saya*). Uncommon September to February, rare in March. Occurs mostly in grassland, but also uses wetlands, agricultural fields and the beach habitats of the Pajaro River mouth. Aggregate winter numbers are probably on the order of 20 birds.

**Loggerhead Shrike** (*Lanius ludovicianus*). Rare April to July, rather uncommon August to March. Occurs in all open habitats, especially grassland and wetland habitats with low vegetation. Also uses agricultural fields where they are beside grassland, especially along the margins of the fields. Very small resident nesting population, presently probably only 1 or 2 pairs. Assessment of recent breeding evidence is complicated, as juveniles that fledged elsewhere can appear in the study area in July or August. Nests are placed in shrubs or small trees, and sometimes on man-made structures. Population increases somewhat in the non-breeding season, when aggregate numbers may be 5-10 birds. Long-term declines are evident for both breeding and non-breeding seasons.

**Warbling Vireo** (*Vireo gilvus*). Uncommon to fairly common late March to mid-May and August to early October, rare late May to July, casual late October to early December. Breeding birds are limited to riparian forest. Passage migrants are most numerous in riparian forest, but also visit other wooded habitats. Breeding population has recently declined and may be extirpated or nearly so in the study area. Nests built in riparian trees. Breeding records in recent decades are from Harkins, Gallighan, Hanson and upper Watsonville Sloughs. The former breeding population was estimated in 1988 to be 10-15 pairs.

**Tree Swallow** (*Tachycineta bicolor*). Common February to April, uncommon to fairly common May to June, fairly common July to August, uncommon September, then variably rare to locally fairly common late November to January. Breeds in riparian forest, where nests are placed in cavities snags, especially cavities excavated by woodpeckers, but also in natural cavities. Breeding population ultimately limited by nest site availability, and there is evidence of recent population declines in the study area and local region. A recent estimate of the breeding population in the study area was 10-15 pairs, with most at Harkins and Hanson Sloughs. Migrants occur widely over wetlands, grassland and agricultural fields. Large flocks of several hundred may be found during northward migration. Early winter numbers are highly variable, and the species is sometimes absent at that time of year.

**Violet-green Swallow** (*Tachycineta thalassina*). Common February to April, uncommon to fairly common May to June, fairly common July to August, uncommon September, then variably rare to locally fairly common late November to January. Same general pattern of occurrence and habitat use as for Tree Swallow, but this species also nests in oak woodland, and in cavities on man- made structures in developed areas. A recent estimate of the breeding population in the study area was 25-30 pairs. Migrants occur widely over wetlands, grassland and agricultural fields. Large flocks of several hundred may be found during northward migration. Early winter numbers are highly variable, and the species is sometimes absent at that time of year.

**Oak Titmouse** (*Baeolophus inornatus*). Fairly common year-round resident. Occurs throughout in oak woodland, ranging into riparian forest and Monterey pine during the non-breeding season. Nests in natural cavities and excavates its own cavities in snags. No recent estimate of breeding population.

**Chestnut-backed Chickadee** (*Poecile rufescens*). Common year-round resident. Occurs throughout in oak woodland, riparian forest, and exotic plantings of Monterey pine, eucalyptus and other trees. Nests in natural cavities and excavates its own cavities in snags. No recent estimate of breeding population.

**Marsh Wren** (*Cistothorus palustris*). Uncommon to fairly common year-round resident in freshwater wetlands throughout, and uncommon non-breeding season visitor to brackish wetlands. Nesting birds are most common in dense, tall emergent vegetation, such as tules and cattails. The nest is attached to the wetland vegetation. No recent estimate of breeding population.

**Swainson's Thrush** (*Catharus ustulatus*). Uncommon to fairly common late April to September, rare in October. Numbers highest during migration (especially May and August). Breeding birds are limited to riparian forest with dense understory. Nests built in shrubs and trees. Evidence indicates recent declines in nesting population in the study area and local region. Migrants occur more broadly, using other wooded habitats and areas with dense understory vegetation.

**Orange-crowned Warbler** (*Vermivora celata*). Fairly common late February to July, common August to early October, uncommon late October to early February. Nests in oak woodland and riparian forest. Nests are built on the ground. Migrants occur in a variety of habitats,

especially in the late summer and early fall. Wintering birds are most often found in willow riparian.

**Yellow Warbler** (*Dendroica petechia*). Uncommon April to May, rare June to July, fairly common to common August to early October, rare to early November. Breeding birds are limited to riparian forest. Nesting was confirmed at Harkins and Hanson Sloughs, and probably occurred at upper Watsonville Slough. A 1990 estimate of the breeding population was 6-8 pairs. Numbers of nesting birds have since dwindled, and the species may now be extirpated as a breeder in the study area. Nests are built in riparian trees. Passage migrants are most numerous in riparian forest, but also visit other wooded habitats and weedy areas. Most abundant during September, when 100s of migrants pass through the study area.

**Common Yellowthroat** (*Geothlypis trichas*). Fairly common year-round resident in freshwater wetlands and adjacent riparian forest, with some in brackish wetlands during the non-breeding season. Nests built in wetlands vegetation or low in willows. Nests in all the Sloughs, being most common in dense, tall emergent vegetation. No detailed estimate of the breeding population has been made, but it probably exceeds 50 pairs. The special status subspecies Salt-marsh Yellowthroat (*G. t. sinuosa*) occurs in the fall and winter.

**Wilson's Warbler** (*Wilsonia pusilla*). Uncommon to fairly common late March to early October, rare in early November, and casual during winter. Numbers highest during migration (especially in April, May and September). Breeding birds are limited to riparian forest with dense understory. Nests built on or very near the ground. Evidence indicates recent declines in nesting population in the study area and local region. No recent estimate of breeding population. Migrants occur more broadly, using other wooded habitats and areas with dense understory vegetation.

**Savannah Sparrow** (*Passerculus sandwichensis*). Uncommon to locally fairly common September to March, rare in April. Until recently was locally uncommon April to August. Small numbers formerly nested in grasslands near Harkins Slough and Struve Slough, but apparently extirpated since the early 1990s. Migrants and wintering birds occur in grassland and in wetlands with low vegetation.

**Grasshopper Sparrow** (*Ammodramus savannarum*). Present status uncertain, but probably a rare passage migrant April to May and September to October. Until recently it was uncommon April to July, and rare August to October. Nested was confirmed in grasslands on the slopes between Harkins and Hanson Slough until in the late 1980s, and near Struve Slough until the early 1990s. The population at that time included about 6 pairs. It is presently extirpated from both these areas, but territorial birds were found in 2000 along upper Harkins Slough between Highway 1 and Buena Vista Road.

**Song Sparrow** (*Melospiza melodia*). Common to locally abundant year-round resident, with numbers augmented by migrants in the non-breeding season. Found in all types of wetlands with emergent vegetation, as well as in deciduous riparian forest and weedy areas. Grassland is used where blackberry brambles or tall exotic species (e.g., poison hemlock) provides adequate

cover and nesting substrate. Nests attached to wetland vegetation or stems of shrubs, willows or tall herbaceous growth.

**Lincoln's Sparrow** (*Melospiza lincolnii*). Uncommon to locally fairly common mid-September to March, rare in April. Found in wetlands with low vegetation, weedy areas, fallow agricultural fields, grassland and edges of riparian forest. Most abundant where shrubs or trees provide cover near open areas used for foraging.

**Black-headed Grosbeak** (*Pheucticus melanocephalus*). Uncommon to locally fairly common late March to September. Nests in riparian forest and oak woodland. Nest built in trees. Evidence suggests a recent decline in the breeding population. Most numerous at Harkins and Hanson Sloughs. No recent estimate of breeding population.

**Red-winged Blackbird** (*Agelaius phoeniceus*). Common to abundant year-round resident. Nests widely in freshwater wetlands with tall vegetation, grasslands with tall herbaceous growth (e.g., poison hemlock, wild radish, mustard) and riparian forest. Nest attached to stems of vegetation, often in colonies of varying density. No recent estimate of breeding population, but probably includes several hundred pairs. During the non-breeding season flocks forage in wetlands, grasslands, fallow agricultural fields, and at the county and city landfills. Roosts occur in wetlands and riparian. Winter numbers often highly concentrated in certain foraging areas and roost sites. Estimates of winter flocks have been as high as 20,000 birds.

**Tricolored Blackbird** (*Agelaius tricolor*). Status in flux and present status incompletely known. Formerly common to locally abundant during October to March, and locally common April to September, with nesting documented at Hanson Slough and probably occurring elsewhere. Winter numbers were concentrated in areas with cattle and at the county and city landfills. Large night roosts occurred at times at Harkins and Hanson Sloughs. Breeding season numbers were concentrated from Harkins Slough to Struve Slough. Grassland was used for foraging, and nesting occurred in riparian and large blackberry brambles. During the 1990s numbers declined in all seasons. There have been very few breeding season reports during the last 5 years (mostly flocks seen briefly) and no nesting evidence. Winter flocks have also decreased, although they still visit the county and city landfills. There is apparently now little use of other parts of the study area during the winter.

**Western Meadowlark** (*Sturnella neglecta*). Currently uncommon to locally fairly common October to early April. Until recently was locally uncommon in the breeding season as well, with nesting confirmed in grasslands near Harkins, West Struve and Struve Sloughs. Apparently now extirpated as a breeder. Non-breeding season visitors also occur in grassland, but numbers have also declined at that time of year.

**Great-tailed Grackle** (*Quiscalus mexicanus*). Recently colonized Santa Cruz County, and became established as a nesting species in the study area. First recorded in the Sloughs in 1994, and nesting confirmed in 2001 and 2002 at Watsonville Slough and the adjacent part of Struve Slough. Probably now a year-round resident, but most records from March to June. 2001 nesting population included about 9 males and 4 females. Nests attached to emergent

vegetation in freshwater wetlands. Foraging observed in wetlands and riparian forest, probably also in grasslands.

**Brown-headed Cowbird** (*Molothrus ater*). Fairly common to locally common year-round resident. Widespread March to September, then much more locally distributed October to February. Breeding birds parasitize nests in a wide variety of habitats, being numerous in all except oak woodland, and stands of eucalyptus, Monterey pine or other exotic trees. No recent estimate of the breeding population has been made, but it probably includes 150-200 birds. During the non-breeding season small to large flocks gather with blackbirds and starlings, especially at the county and city landfills and near cattle. Flock at that time of year are typically in the range of 40-250 birds, but flocks of over 500 birds have been reported. Continued population increases are indicated in both breeding and non-breeding seasons.

**American Goldfinch** (*Carduelis tristis*). Uncommon (occasionally to fairly common) year-round resident. Breeding birds are associated with areas of willow riparian habitat, such as at Harkins and Hanson Sloughs. Nests are placed in shrubs, low in trees, and in tall ruderal vegetation. More widespread in the non-breeding season, when numbers are also most variable from year to year.

## Technical Appendix H: Watsonville Sloughs Trail Master Plan

The City of Watsonville has prepared a trail master plan for creating public access footpath and bicycle trails with segments of ADA (Americans with Disabilities Act) compliant access. The proposed system is shown in attached Figure H-1 and consists of about 6 miles of proposed trails linking Upper Struve and Watsonville Sloughs to the Highway 1 area, just above Lee Road. The City Trail system is designed to eventually tie into trail systems along the Pajaro River levees and to the planned County Trail along the UPRR alignment. A Trail Master Plan feasibility assessment was prepared by SH&G Engineering in October, 2001.

Construction of the first segment in Upper Struve Slough from Pennsylvania Avenue to Main Street is set for 2004. Construction of portions of the new trail segments is currently underway as a part of several development projects. Other segments will involve upgrading existing trails or roads. The proposed segment between Main Street and Ramsey Park may be part of a larger, thirty-acre wetlands restoration project that is now entering the design phase. The lower portion of the trail system along Watsonville Slough, Reaches 3 and 4 on Figure H-1, are to be completed as part of a master development project, presently in the planning stages.

Construction of each trail segment offers opportunities for ecological restoration, including removal of exotic vegetation and planting of native communities. The trails offer many educational opportunities to involve greater public participation and awareness of the Slough's natural resources. The City of Watsonville has dedicated annual funding for construction of the trail system. Other grant monies are being sought by the City to conduct wetlands restoration projects. Additional grant monies would support revegetation efforts during construction. These projects are described in Chapter 4 of the WSCEP.

# Technical Appendix I: Proposal to Prepare a Planning and Engineering Feasibility Assessment for the Enhancement of Watsonville Slough between Highway 1 and Shell Road

This proposal is intended to provide guidance on the scope of the project, data needs, and a potential process for completion.

## Introduction and Problem Statement

Watsonville Slough drains 14 $mi^2$ from the coastal hills of southern Santa Cruz County into the Pajaro River and Monterey Bay and contains valuable wetlands habitat with high natural resource values. Watsonville Slough originates in a residential area in the City of Watsonville then flows southward through industrial and agricultural lands before crossing under Highway 1. From Highway 1 to Shell Road, Watsonville Slough flows along the northern edge of the Pajaro Valley where it is maintained as a drainage ditch bounded by highly productive agricultural lands. At Shell Road, a set of pumps, levees and a tidal gate prevent saltwater from extending upstream and protect agricultural lands between San Andreas Road and Shell Road. The Middle Watsonville Slough has significant problems with water quality and degraded habitat, but the antiquated drainage system is also failing, thereby reducing the productivity of agricultural lands.

The Watsonville Sloughs Conservation and Enhancement Plan (WSCEP) recommends an environmental and drainage enhancement project for Middle Watsonville Slough for the reach between Highway 1 and Shell Road. Based upon a preliminary scientific and engineering analysis, there appears to be a substantial opportunity to reconstruct the drainage system to improve water quality in the Slough and to enhance wetlands, native vegetation and terrestrial and aquatic wildlife, while addressing the economic needs of agricultural landowners. In the WSCEP, a conceptual plan was developed to install a system of levees separating a protected and expanded slough with landside drainage ditches to service agricultural drainage.

This proposal is designed to identify a preferred plan for the Middle Watsonville Slough Enhancement Project through engineering, environmental and planning investigations, including a series of local workshops. The objectives of this work are:

1) Identify a preferred enhancement plan and maintenance regime that meets engineering, environmental permitting and grant funding requirements and meets the needs of the affected landowners and agricultural operators;
2) Ensure that the plan has governmental agency and community support for implementation and funding;
3) Develop sufficient environmental data on biological, cultural, water quality and other resources to determine environmental benefits of alternatives and proceed with the appropriate environmental review as a next step;

4) Develop sufficient engineering data to develop the preferred plan's engineering design plans to a 10 percent complete level of detail; and
5) Create an effective implementation plan that includes a monitoring, operations and maintenance plan that meets long-term requirements of both operators and agency regulations.

The following sections describe the proposed tasks and estimated costs required to complete the planning and engineering feasibility assessment. It is anticipated that a consultant will be selected to complete the work under contract with a local agency.

### Task 1: Develop Technical Advisory Committee and Conduct Initial Workshops

The project will be directed by a Client Team, which would include the funding agency and the prime contract administrator. The Client Team and consultant project manager will work on a day-to-day basis and make administrative decisions to complete the contract and study. A Technical Advisory Committee (TAC) consisting of representatives of key stakeholders groups and agencies will be convened periodically (estimated once every two months) to help guide the project through completion. The TAC will represent affected agricultural interests, regulatory agencies, local governmental agencies, and funders.

The feasibility study will be developed in consultation with the TAC and affected agricultural operators and landowners.

Meetings with other interested stakeholders will also be held by the consultant to kick off the project. The meetings will be formatted to begin with a brief presentation followed by a period of questions and answers and development of key issues. Once completed, the results of the stakeholders meetings will be memorialized in a memorandum and distributed to the TAC members.

### Task 2: Develop Background Information

Each discipline will collect, compile and review existing information in order to gain an understanding of site conditions and the existing key issues with respect to all disciplines and to help develop an initial set of enhancement measures. This will build off data already collected through preparation of the WSCEP.

It is anticipated that the consultant team would consist of specialists in stream and wetlands restoration, civil and water resources engineering, agricultural economics, geomorphology, hydrology, water quality, environmental review (CEQA / NEPA permitting), aquatic biology, terrestrial wildlife ecology, plant ecology and revegetation, and possibly municipal finance.

Each discipline will assemble existing data for use by Client Team and consultant team members.

A list of data needs will be developed by each discipline in order to assess what information is necessary to carry the project through design and environmental review.

**Task 3: Develop Initial Schematic Feasibility Assessment**

With input from the stakeholders and the compilation and review of existing information from each discipline, the consultant team would convene and develop a set of schematic alternatives. The schematic alternatives will represent a range of possible configurations considering landowner desires, costs, environmental benefits, and ease of permitting and maintenance. A document will be prepared for circulation among the consultant team for review and revision. The consultant team members will evaluate and rate the schematic alternatives and finalize a document for circulation to the Client Team and TAC.

The primary purpose of the schematic alternatives analysis is to identify key opportunities and constraints, project benefits and impact issues from each discipline. This information will be used as the foundation for guiding the next task, the engineering feasibility assessment.

**Task 4: Develop Engineering Feasibility Assessment**

The environmental benefits and costs of the Middle Watsonville Slough Enhancement Plan will depend upon the design, engineering, and construction methods. In order to develop important details and a cost benefit analysis for a range of alternatives, engineering design information must be developed. Task 4 will result in the development of project design details important to evaluating costs, benefits and feasibility.

The engineering assessment will involve development of a hydrologic model of the watershed in order to determine the size and frequency of floods that the project will control. The hydrologic model, when linked to a hydraulic model of open channel flow, will allow analysis of flooding, sediment transport and water quality conditions and the design of facilities. A key data need will be topographic maps of the drainage system and subwatersheds. The hydraulic model will address non-storm periods and the operation of the Shell Road Pumps and tidal dam. Pumps and drainage systems will be examined in detail and accounted for in design.

Individual landowners and operators will be consulted along the project area to develop an understanding of individual landowners' desires. There may be meetings with various groups of landowners to identify and discuss land use issues associated with a revised drainage system.

In addition, restoration features will require engineering assessment, including grading and revegetation needs.

Geotechnical information will be needed to develop levee designs and to assess the characteristics of soils in areas of proposed grading. Soils will be tested for engineering factors as well as for any toxic contamination.

Utilities and property parcel information will need to be compiled and analyzed.

The product of Task 4 will be a refined schematic alternatives report incorporating the results of the engineering feasibility assessment and landowner consultations. The assessment will include project alternative cost estimates including engineering design and construction cost information from other disciplines (e.g. native vegetation restoration). The engineering feasibility will also address construction methods and feasibility in order to account for soil erosion control and water quality protection measures. A draft operations and maintenance needs and costs assessment will also be developed. The intent will be to design the project so that it does not result in major potential environmental impacts.

**Task 5: Stakeholders Workshops on Project Alternatives**

A series of stockholder's workshops will be held to present the engineering feasibility and schematic design alternatives. The stakeholders will be asked for their comments and concerns and will provide input to the selection of a preferred plan.

The landowner stakeholders group would be consulted first in order to identify an acceptable plan. The results of the landowners' workshop may guide refinement of the alternatives before holding workshops with other groups; this will avoid the presentation or circulation of infeasible plans not supported by landowners.

The next group workshops would provide input with regard to funding resources, environmental benefits and impacts, project administration, maintenance responsibilities, and costs.

The stakeholders meetings would be summarized and a final revision to the alternatives document would be made. With the information in hand, the consultant and Client Team would develop and refine a recommended preferred alternative.

**Task 6: Select and Finalize a Preferred Alternative**

The consultant team in coordination with the TAC and landowners will develop and refine a draft preferred alternative. The document would describe the project location, alignment, features, costs, environmental features, construction methods, financing and administration needs, any potential environmental impacts and implementation.

The Draft Preferred Plan document will be presented and circulated and a workshop scheduled for comment among all stakeholders groups. The comments would be compiled for the TAC for their review. Recommendations for revising and finalizing the recommended plan will be made in consultation with the TAC and Client Team.

**Task 7: Produce Final Preferred Plan Report**

The TAC and the Client Team will instruct the consultant team to complete the Preferred Plan Project document. The document will contain all of the background information necessary to support the project and to undergo environmental review. An initial checklist and recommendation for environmental documentation will be completed by the Client Team and the appropriate lead agency representative after the Final Preferred Plan document is completed.

**Estimated Project Costs**

| | |
|---|---|
| **Task 1: Develop Technical Advisory Committee and Conduct Initial Meetings** | **$ 15,000** |
| **Task 2: Develop Background Information** | **$ 30,000** |
| **Task 3: Develop Initial Schematic Feasibility Assessment** | **$ 15,000** |
| **Task 4: Develop Engineering Feasibility Assessment** | **$ 75,000** |
| **Task 5: Stakeholders Workshops on Project Alternatives** | **$ 10,000** |
| **Task 6: Select and Finalize a Preferred Alternative** | **$ 8,000** |
| **Task 7: Produce Final Preferred Plan Report** | **$ 25,000** |
| **Total Project Cost** | **$178,000** |

# Technical Appendix J: Proposal to Prepare the Upper Harkins Slough Riparian Habitat and Drainage Management Plan

## Introduction and Problem Statement

The Upper Harkins Slough Watershed (UHW), or Larkin Valley, is situated at the northern end of the Watsonville Sloughs Watershed and consists of a narrow valley bounded by steep hills. The UHW has an area of 8 $mi^2$ that is drained by Upper Harkins Slough (also called Larkin Valley Creek), a small freshwater creek that flows southward along the middle of the valley floor into a culvert at Highway 1. Below Highway 1, Harkins Slough flows through a rural area of wetlands before flowing into Watsonville Slough at the north edge of the Pajaro Valley.

The riparian and wetlands habitat surrounding Upper Harkins Slough has an unusually high wildlife value including habitats for the California red-legged frog and the Santa Cruz long toed salamander, both listed as endangered under the Federal Endangered Species Act (ESA). These habitats are also protected under State of California law and local Santa Cruz County ordinances.

Considerable urban development has occurred in Larkin Valley over the past 40+ years, gradually increasing the number of smaller parcels and rural residential homes. The area was originally small farms and ranches, but subdivisions have increased the number of developments, all of which are on individual septic systems for domestic wastewater treatment. Earth disturbance and drainage modifications without regard to cumulative effects have contributed to an increase in erosion and sediment delivery to Upper Harkins Slough and in some locations created new drainage problems downstream. Larkin Valley also has extensive grazing and horse ranching, which in combination with domestic septic systems, may contribute to nutrient pollution in Upper Harkins Slough and areas downstream. Land use has also increased the pressure on wildlife habitat.

The condition of Upper Harkins Slough, the main focus of habitat concerns in Watsonville Sloughs Watershed, varies considerably from reach to reach and is dictated by individual parcel-by-parcel land uses. Some parcels are used for grazing horses or cattle well into the riparian zone, resulting in a denuded channel. Other parcels have only a bridge crossing in the riparian zone and have become densely vegetated. In the mid and late 1990s a series of large flood events caused deepening and widening of the Harkins Slough channel; in some cases this consumed large areas of pasture as the channel deepened and widened. In other cases, the sediment released from upstream erosion has filled the channel and caused it to widen and become shallow. These channel changes not only affect uses by individual landowners, but have a dramatic effect on habitat quality as well. The deepened channel reduces soil moisture during the spring and summer months, thereby favoring drier plant species with less riparian habitat quality. The filled channel reaches have created perennial wetland areas of disorganized flow, which may reduce values for some wildlife species.

The creation and enforcement of environmental regulations have restricted land use activities such as vegetation clearing, earth grading, drainage maintenance, and building. Local road maintenance has been restricted as well, leaving erosion and road hazard problems unaddressed. While regulation has been used as a method to prevent damage, it has not resulted in a coordinated plan to restore and enhance habitats.

The Watsonville Sloughs Conservation and Enhancement Plan (WSCEP) has identified the need to create a specific management plan for Larkin Valley and Upper Harkins Slough in order to address land use and habitat conflicts and to identify measures that will enhance habitat values and water quality. The WSCEP envisions a landowner supported management plan that would develop incentives for improved and coordinated drainage management favoring enhanced habitat conditions.

### Proposed Objectives and Workplan

The objectives of the Upper Harkins Slough Riparian Habitat and Drainage Management Plan are:

1) Identify key resource issues that are in conflict with land uses.
2) Improve knowledge of the life cycle requirements of key species and how land use activity may interact (favorably or unfavorably).
3) Develop a resource needs assessment considering the extent and present condition of existing habitat for key species.
4) Identify land use activities in sensitive habitat areas and define specific land use needs (i.e. road crossings, area for grazing operations, channel maintenance).
5) Identify key regulations, regulatory agency roles and responsibilities.
6) Identify specific habitat enhancement projects that have landowner support.
7) Develop a strategy for addressing landowner needs, habitat needs and agency requirements in a coordinated fashion.

The following tasks were developed to create a management plan for Upper Harkins Slough in Larkin Valley through a planning process involving key stakeholders. The project will be directed by a Client Team, which would include the funding agency and the prime contract administrator. The Client Team and consultant project manager will work on a day-to-day basis and make administrative decisions to complete the contract and study. A Technical Advisory Committee (TAC) would be convened to represent key stakeholder groups and help guide the work and development of the Management Plan.

### Task 1: Develop Stakeholder Groups and Conduct Initial Workshops

The Upper Harkins Slough Riparian Habitat and Drainage Management Plan (HSMP) will be developed in consultation with key stakeholders and decision makers, which include local landowners, regulatory agencies, local governmental agencies, the environmental community and the community at large. The consultant in conjunction with the Client Team will develop a stakeholders list. A Technical Advisory Committee (TAC) will be convened.

Once the stakeholders have been identified, a series of stakeholders meetings will be held to kick off the project. It is anticipated that there will be a landowner group, a governmental agency group and an environmental group. The workshops will be formatted to begin with a brief presentation followed by a period of questions and answers and development of key issues. Once completed, the results of the workshop will be memorialized in a memorandum and distributed to key team members.

**Task 2: Compile Land Use, Hydrology and Habitat Data and Maps**

Scientific information must be compiled in order to assess current habitat conditions and the extent and quality of habitat for key species. This work will be based upon mapping and research compiled for the Watsonville Sloughs Resource Conservation and Enhancement Plan, but will be carried out to a greater level of detail so that site-specific conditions can be addressed. The information to be compiled would include:

- Vegetation Mapping
- Wildlife Habitat Mapping
- Aquatic Habitat Mapping

In addition to vegetation and habitat maps, the following information would be compiled to document hydrologic conditions and land use:

- Erosion and Drainage Survey
- Land Use Mapping
- Stream Condition Survey

The biological, land use and hydrology data will be compiled into a Geographic Information System (GIS) database for use in subsequent tasks.

**Task 3: Develop Resource Needs Assessment**

The Consultant team in coordination with key resource agency personnel will use the resource data compiled in Task 2 to develop a site-specific needs assessment for specific species of concern. The needs assessment would be conducted in a manner mindful of landowner desires, but aim to significantly enhance wildlife habitat conditions. The resource needs assessment would develop measures to improve habitat, wildlife populations, hydrology, and water quality.

The resources needs assessment would be compiled into a recommendations report for review by the TAC. The TAC would provide comments to finalize the document.

**Task 4: Develop Land Use / Landowners Needs Assessment**

A landowner and infrastructure needs assessment will be compiled through a survey of properties along Larkin Valley Road and interviews with landowners. The needs may range from pasture management issues to existing erosion and drainage problems and bridge crossings and road maintenance. Additionally, the Santa Cruz County Public Works Department will be interviewed with regard to road and drainage maintenance issues.

An inventory of land use needs will be compiled into a report for review by the TAC. Comments from the TAC will be incorporated into a final version.

**Task 5: Synthesize Resource Conditions Assessment with Needs Assessment**

The consultant team working with the Client Team and TAC will synthesize the needs assessments into a set of recommendations for enhancement projects, specific maintenance plans and general management of the Upper Harkins Slough riparian, wetland and other habitats. The Team will define site-specific measures that could be designed to resolve conflicts; these may be easy to identify or may be more challenging, necessitating discussions with specific landowners to revise land management practices. Depending on resource conditions and the perspective of the landowner, the simplicity of problem solutions may vary on a parcel by parcel basis.

Incentives for landowners should be developed to gain agreement on specific management measures and projects. Technical advice, funding assistance, conservation easement acquisition, implementation of grazing management, manure management, tax breaks, funds for native vegetation restoration and management should be developed into credible options for gaining landowner cooperation.

**Task 6: Develop Larkin Valley Habitat and Drainage Management Plan**

The consultant team will generate a draft recommended management plan based upon the results of prior tasks. The draft plan will include the recommended projects and other management actions with scientific and planning data, and an implementation plan.

The draft plan will be circulated to the TAC and stakeholders for review several weeks prior to a workshop where the consultant team would present and respond to questions. The workshop and review period will result in a revised and final management plan document.

An initial study will be prepared to provide a programmatic level of environmental review.

**Proposal Costs**

| | |
|---|---|
| **Task 1: Develop Stakeholders Groups and Conduct Initial Workshops** | **$ 7,000** |
| **Task 2: Compile Land Use, Hydrology and Habitat Data and Maps** | **$25,000** |
| **Task 3: Develop Resource Needs Assessment** | **$15,000** |
| **Task 4: Develop Land Use / Landowners Needs Assessment** | **$15,000** |
| **Task 5: Synthesize Resource Conditions Assessment with Needs Assessment** | **$25,000** |
| **Task 6: Develop Upper Harkins Slough Habitat and Drainage Management Plan** | **$15,000** |
| **Total Estimated Cost** | **$102,000** |

# Technical Appendix K: Conceptual Stream Stabilization Plan For Jones/Lees Property

## Background

The project site is the Jones/Lees property (APN 48-101-02), located at the intersection of Larkin Valley Road and Senda Ladera Lane in Santa Cruz County, as shown on Figure K-1 of the Conceptual Stream Stabilization Plans. The treatment area includes two unnamed creeks that meet on the project site, eventually draining to Harkins Slough. The larger of the two creeks, which we will refer to as Larkin Valley Creek, drains 1200 acres above the project site and flows along the north side of Larkin Valley Road within the project reach. The smaller of the two creeks, draining approximately 470 acres, flows southerly along the western boundary of the parcel, following Senda Ladera Lane to its confluence with Larkin Valley Creek at the Southwestern corner of the parcel.

Due to a history of disturbances both on and off-site, each of the two creeks is exhibiting signs of incision and bank instability. In many locations, the banks are vertical, unvegetated, and are sources of excessive amounts of fine sediment. As a result, pools within the project reach are filled and potential standing-water habitat is lost. Lack of vegetation on these eroding banks has led to a reduction in habitat complexity, while incision of the channels has led to a reduced connectivity with the adjacent floodplains.

## Objectives

The project's objectives are to restore the creeks to a more naturalistic state, with improved habitat values, while allowing for the continuation of existing land uses within the project site. The specific proposed actions include:

- Stabilization and revegetation of channel and banks along degraded reaches within the project site, utilizing biotechnical and biomechanical bank and streambed stabilization methods;
- Installation of protective fencing along the riparian zone;
- Creation of a designated crossing location for equipment and equestrian uses, and
- Revegetation with the appropriate native riparian species.

It is anticipated that implementation of these actions will lead to improved habitat and function through increased riparian vegetation, reduction of streambank erosion and sediment transport, and the improvement of floodplain connectivity within the project site.

## Methods

The design process included a site visit, topographic survey, base map drafting, and conceptual design. The conceptual design proposes installation of rock vortex weirs, reshaping of steep eroding banks, and revegetation utilizing native riparian species. Refer to Figures K-1 through K-5.

### Hydrology

A simplified rational method analysis was conducted to develop preliminary estimates of storm flows in the two creeks. The results are presented below.

**Table K-1**: Preliminary 10- and 100-year Storm Flow Estimates for Senda Ladera Creek

| | **10 year** | **100 year** |
|---|---|---|
| Drainage Area (acres) | 470 | 470 |
| Runoff Coefficient, C | 0.2 | 0.25 |
| P60 | 1.35 | 1.35 |
| Time of Concentration (minutes) | 25 | 25 |
| Intensity, I (inches/hour) | 1.40 | 2.09 |
| Flows, Q (cfs) | 132 | 246 |

**Table K-2**: Preliminary 10- and 100-year Storm Flow Estimates for Larkin Valley Creek

| | **10 year** | **100 year** |
|---|---|---|
| Drainage Area (Acres) | 1200 | 1200 |
| Runoff Coefficient, C | 0.2 | 0.25 |
| P60 | 1.4 | 1.4 |
| Time of Concentration (minutes) | 50 | 50 |
| Intensity, I (inches/hour) | 0.98 | 1.46 |
| Flows (cfs) | 235 | 438 |

**Table K-3**: Design Flows for Senda Ladera and Larkin Valley Creeks

| | **10 year** | **100 year** |
|---|---|---|
| Senda Ladera Creek (cfs) | 132 | 246 |
| Larkin Valley Creek below confluence with Senda Ladera Creek (cfs) | 367 | 684 |

### Restoration Strategies

To restore the streams to a naturalistic condition, various stream restoration approaches were utilized, with an emphasis on bioengineering techniques.

1. Rock vortex weirs are proposed at locations of local down-cutting to prevent further movement of these head-cuts and bank erosion. These weirs stabilize the longitudinal profile grade of the creek. This allows for controlled dissipation of hydraulic energy.
2. Steep banks will be shaped to a more stable angle to improve bank stability and reduce sediment discharge.
3. Vegetated rock slope protection is proposed on bends and at constrictions to protect the banks against accelerated flows.
4. Floodplain terraces are proposed to disperse higher flows and dissipate stream velocities and shear forces.

5. A planting plan was developed that specifies revegetation of the newly sloped banks with two classes of native riparian trees, shrubs and grasses. In the long term this vegetation will improve both bank stability and aquatic habitat.
6. A fence is proposed to keep horses from disturbing the riparian zone. A crossing is designated for horses to cross the creek with minimum impact to water quality, vegetation and bank stability.

**Construction Steps**

The remaining steps to be taken prior to project construction include:

1. Commitment of a project lead,
2. Completion of CEQA documents,
3. Acquisition of permits,
4. Completion of final engineering and revegetation plans, and
5. Commitment of funds.

**Summary**

The long-term stability of the two creeks will be improved by the proposed stream stabilization plan. The bioengineering approach chosen will provide a naturalistic appearance while satisfying hydrologic, hydraulic and habitat concerns. Greater channel stability will allow for water quality and aquatic habitat enhancement without compromising existing land uses.

# Technical Appendix L: City of Watsonville Wetlands Restoration Project

## Purpose

The goal of the project would be to provide for the restoration and enhancement of approximately 45 acres of existing wetland and upland habitat in Watsonville Slough.

## Background

The proposed project site includes the section of Watsonville Slough between Kearney Street and Main Street. Much of this area has been significantly altered over the past 100 years. It was used as a dump site in the 1930's and a significant portion of the historical wetland area was filled with construction debris. The surrounding areas have become urbanized as the City of Watsonville developed over time. The main objective of the Watsonville Slough Restoration Project is to enhance the habitat and water quality of the slough. The project also includes a variety of public education programs to reduce urban runoff into the slough system.

## Studies Supporting Slough Restoration

The Watsonville Sloughs Watershed is located within the Pajaro River Watershed, which has been listed as a Category I (Impaired) Priority Watershed by the Regional Water Quality Control Board. The need to protect and restore the Watsonville Slough System has been identified in two studies prepared for Association of Monterey Bay Area Governments (AMBAG): the *Pajaro River Watershed Water Quality Management Plan* (1998) and the *Water Resources Management Plan for the Watsonville Slough System* (1995). Both studies recommend restoration of the sloughs and recommend proactive programs that will reduce urban runoff into the sloughs.

The residents of Watsonville would also benefit greatly from the Watsonville Slough Restoration Project. The wetlands are an integral part of the community and the City has an opportunity to provide long-term assurances for the enhancement of these resources.

## References

Association of Monterey Bay Area Governments. 1998. Pajaro River Watershed Water Quality Management Plan, prepared for Pajaro River Watershed Council.

Questa Engineering Corporation (1995). Draft Water Resources Management Plan for Watsonville Slough System, Santa Cruz County, prepared for Association of Monterey Bay Area Governments**:** Section 6, Appendix D.

TECHNICAL APPENDICES

# FIGURES AND TABLES

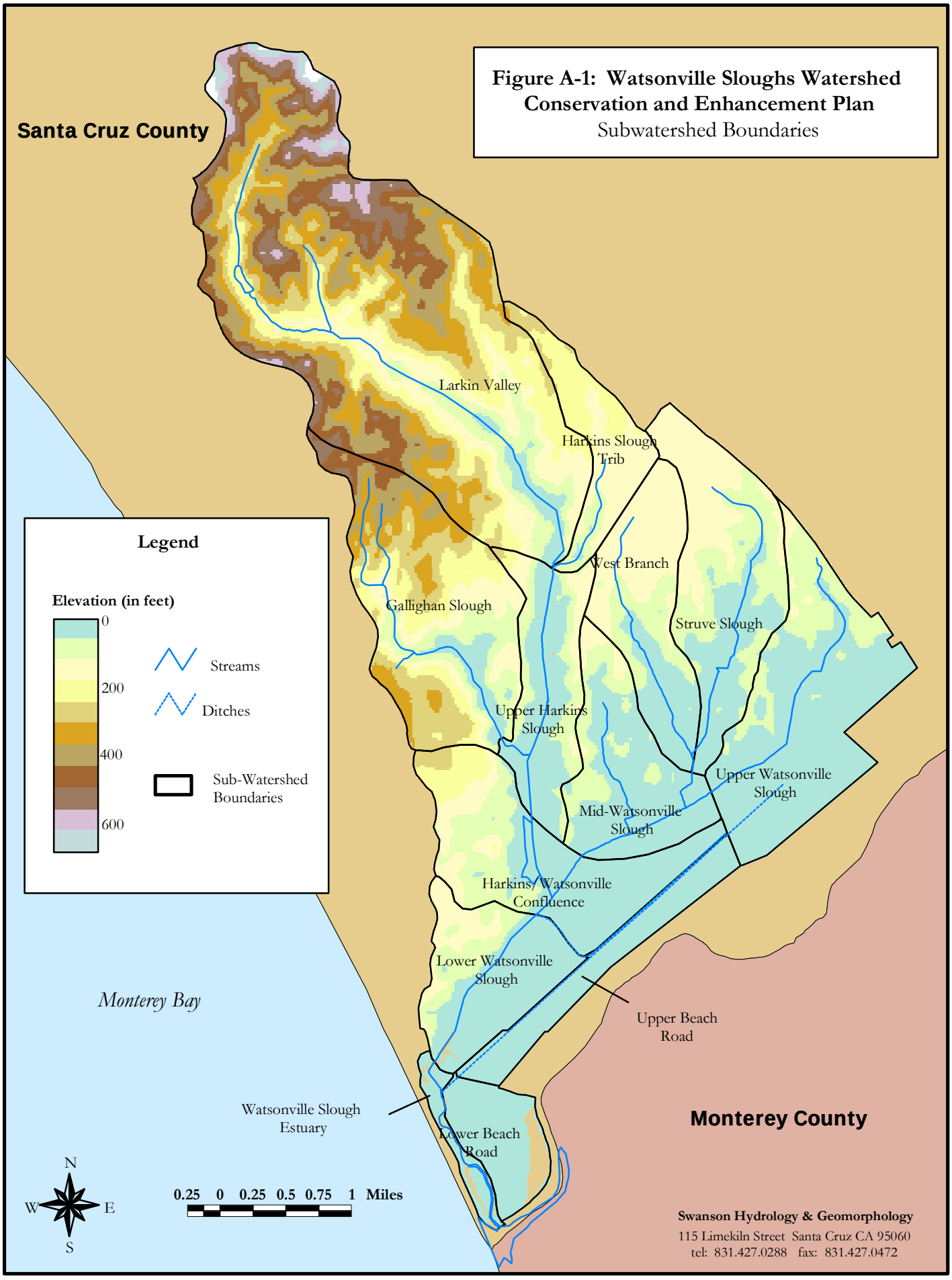
Figure A-1: Watsonville Sloughs Watershed Conservation and Enhancement Plan
Subwatershed Boundaries
Santa Cruz County
Larkin Valley
Harkins Slough Trib
West Branch
Gallighan Slough
Struve Slough
Upper Harkins Slough
Upper Watsonville Slough
Mid-Watsonville Slough
Harkins/Watsonville Confluence
Lower Watsonville Slough
Upper Beach Road
Watsonville Slough Estuary
Lower Beach Road
Monterey Bay
Monterey County
Legend
Elevation (in feet)
0
200
400
600
Streams
Ditches
Sub-Watershed Boundaries
N
W
E
S
0.25 0 0.25 0.5 0.75 1 Miles
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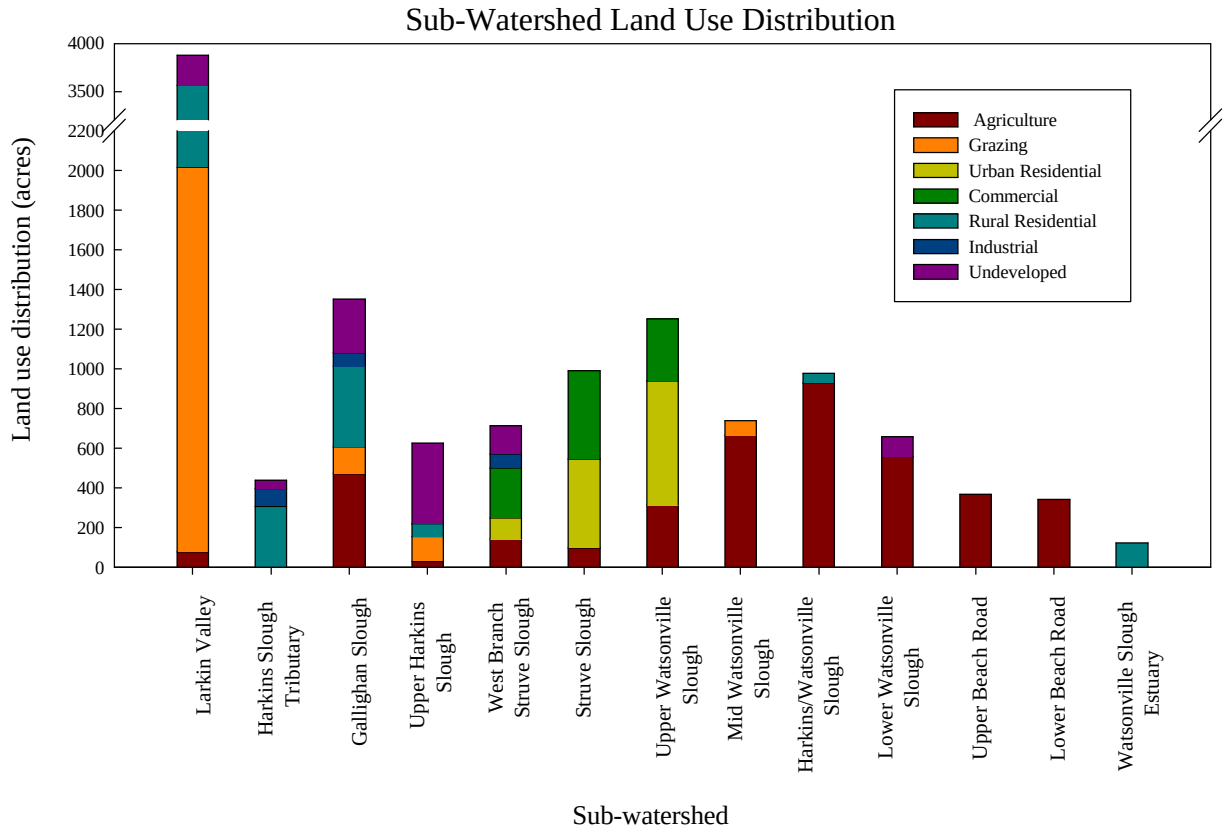
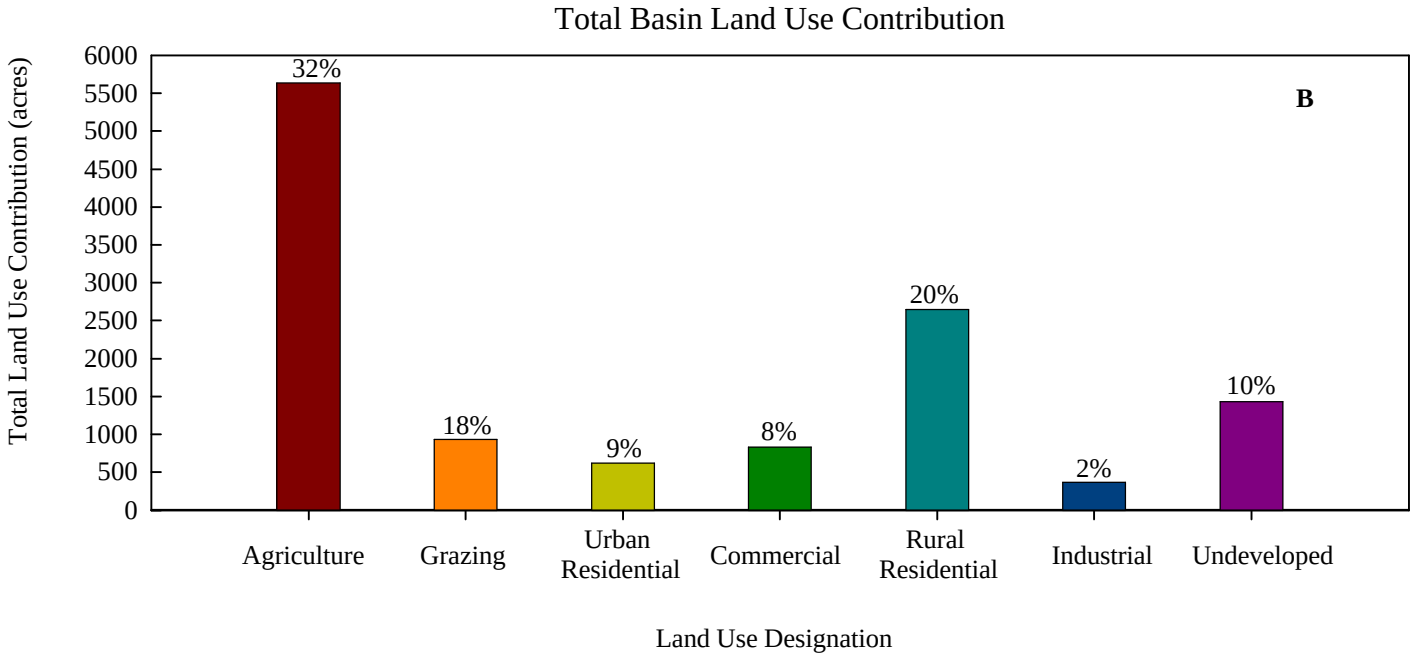
**Figure A-2: Watsonville Sloughs Watershed**

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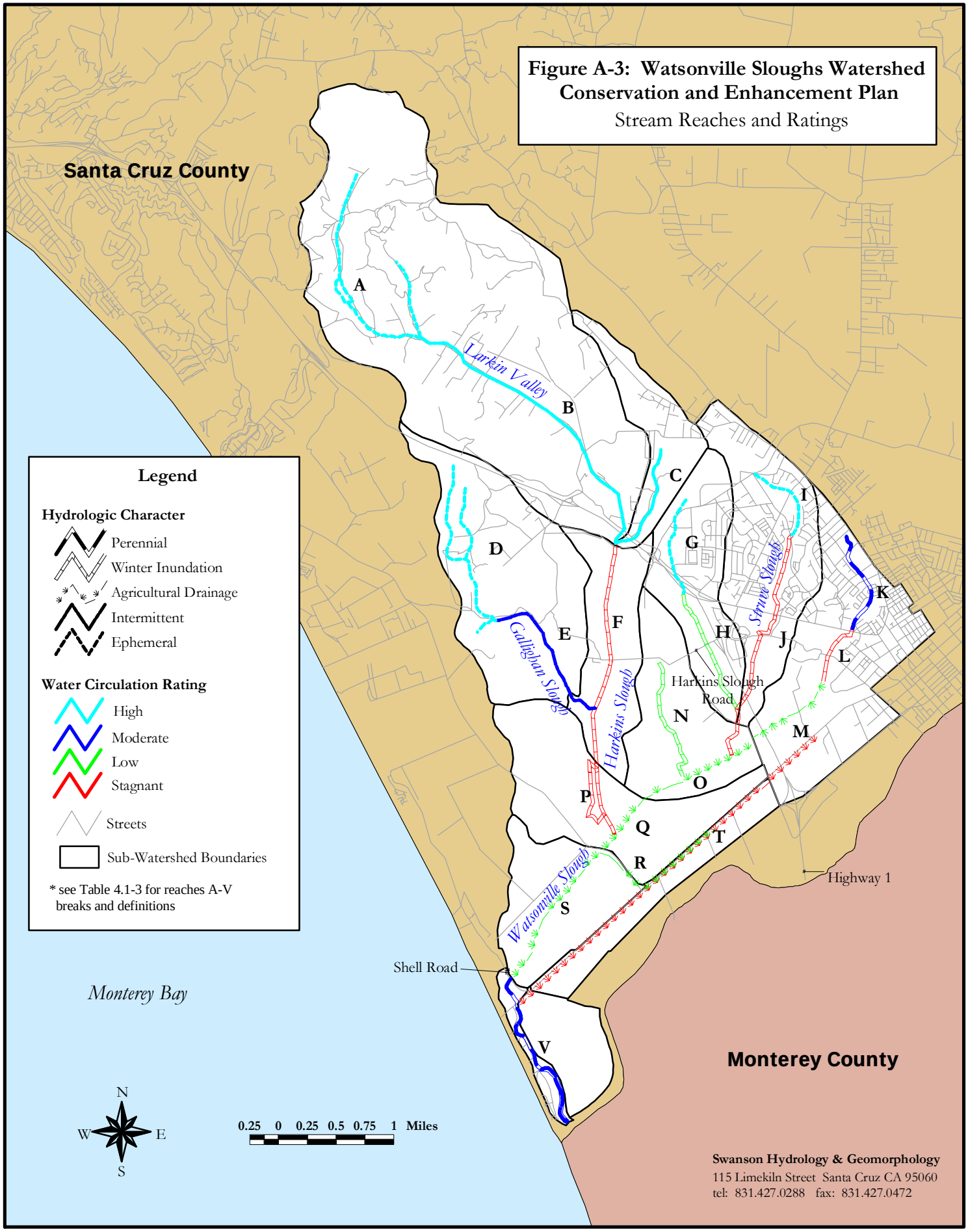
Figure A-3: Watsonville Sloughs Watershed Conservation and Enhancement Plan
Stream Reaches and Ratings
Santa Cruz County
Legend
Hydrologic Character
Perennial
Winter Inundation
Agricultural Drainage
Intermittent
Ephemeral
Water Circulation Rating
High
Moderate
Low
Stagnant
Streets
Sub-Watershed Boundaries
* see Table 4.1-3 for reaches A-V breaks and definitions
Monterey Bay
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
V
Larkin Valley
Gallighan Slough
Harkins Slough
Struve Slough
Watsonville Slough
Harkins Slough Road
Highway 1
Shell Road
Monterey County
N
W
E
S
0.25 0 0.25 0.5 0.75 1 Miles
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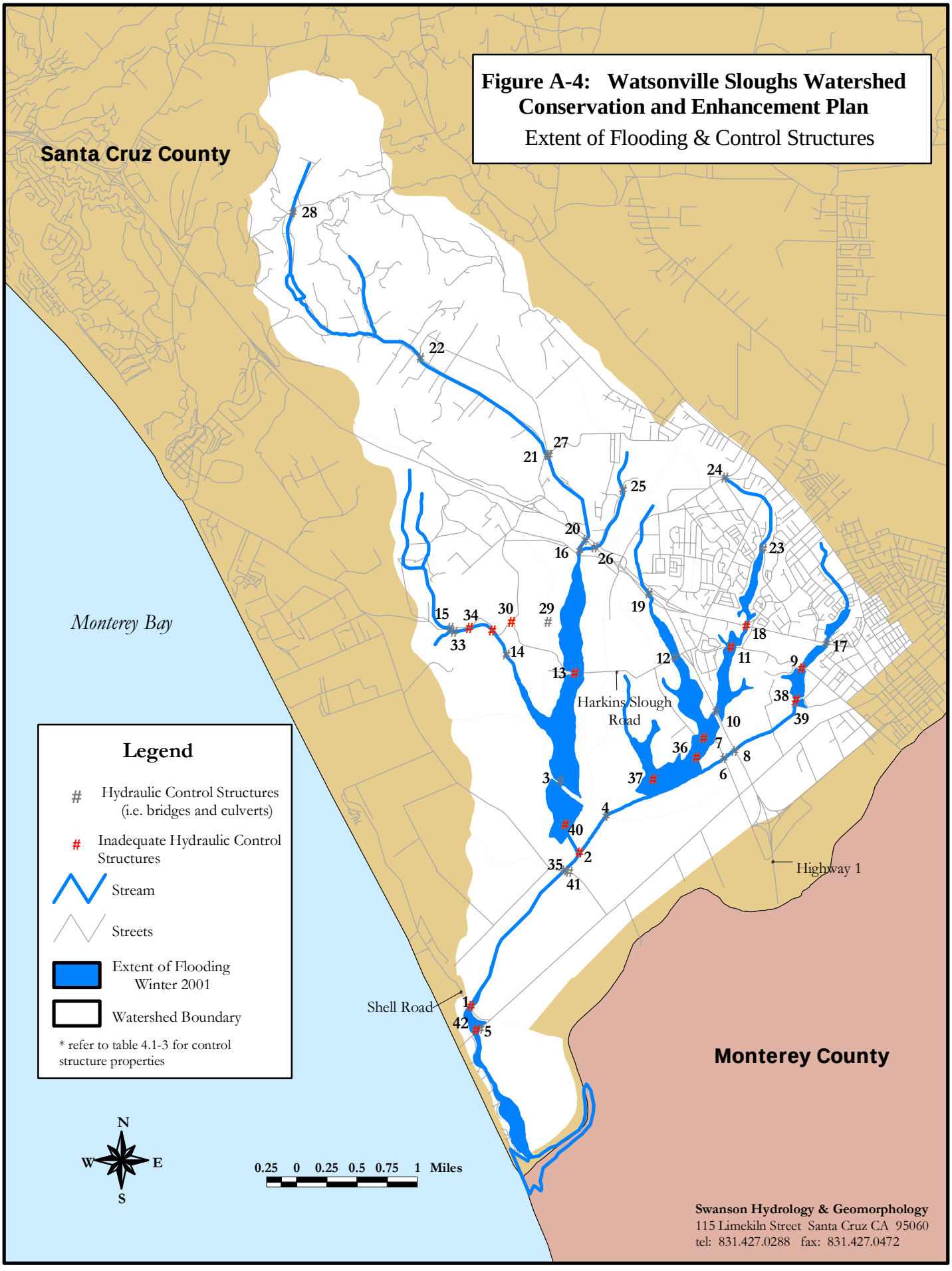
Figure A-4: Watsonville Sloughs Watershed Conservation and Enhancement Plan
Extent of Flooding & Control Structures
Santa Cruz County
Monterey Bay
Harkins Slough Road
Highway 1
Shell Road
Monterey County
Legend
Hydraulic Control Structures (i.e. bridges and culverts)
Inadequate Hydraulic Control Structures
Stream
Streets
Extent of Flooding Winter 2001
Watershed Boundary
* refer to table 4.1-3 for control structure properties
N
W
E
S
0.25 0 0.25 0.5 0.75 1 Miles
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taken January 24, 2001

**Figure A-5:** Ford Road Driveway causing major drainage constriction in Upper Watsonville Slough. Agricultural fields on left with significant winter inundation during 2001. Upstream of driveway (at right in photo above) is a large freshwater wetland with depths up to 3 feet.

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**Figure A-6** taken January 24, 2001

**Figure A-7** taken March 20, 2001

**Figure A-6:** Struve Slough at the location of YSIB2 *(see Figure A-10)*.
**Figure A-7:** View looking west from Struve Slough towards Highway 1.

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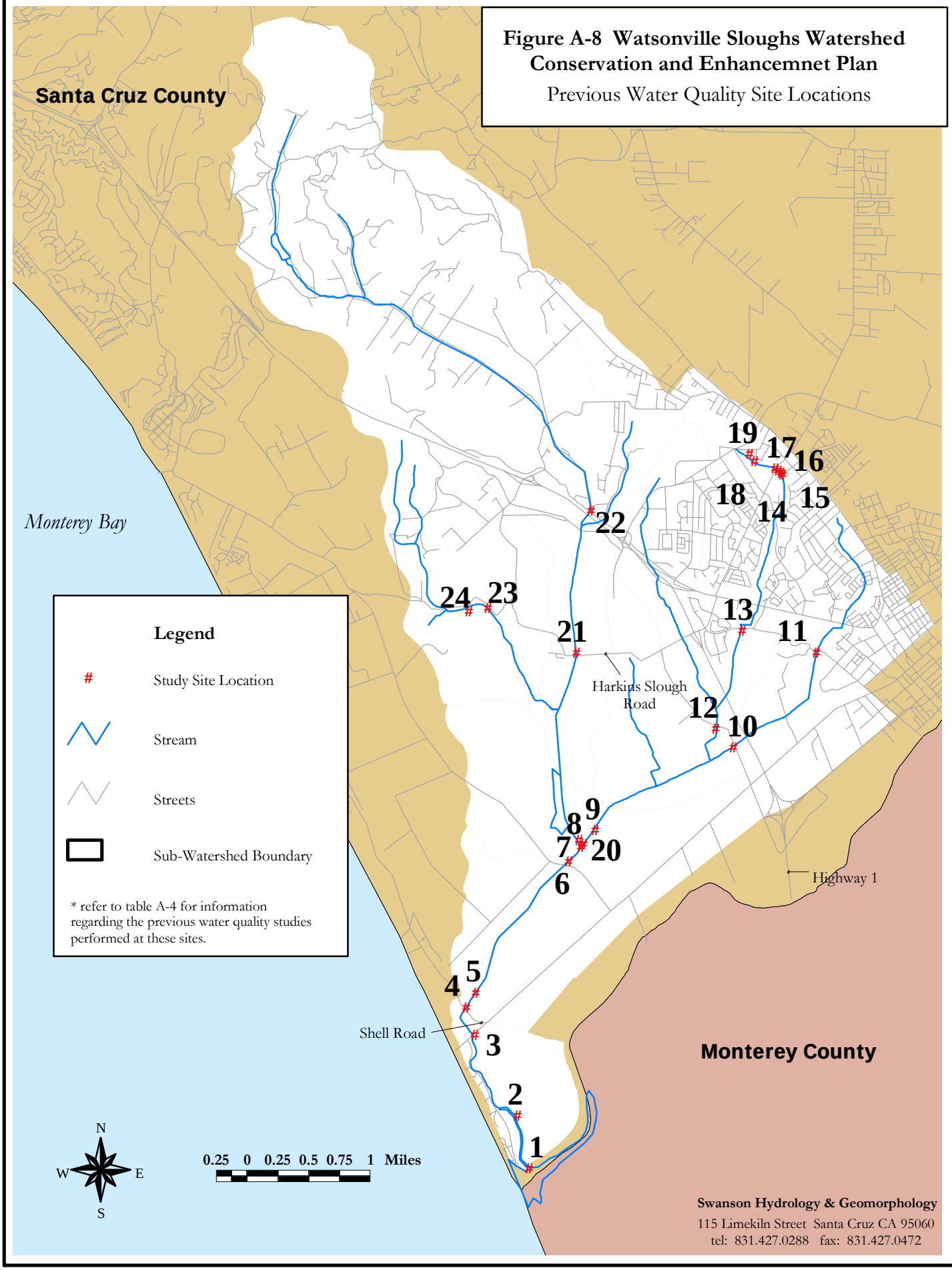
Figure A-8 Watsonville Sloughs Watershed Conservation and Enhancemnet Plan
Previous Water Quality Site Locations
Santa Cruz County
Monterey Bay
Legend
Study Site Location
Stream
Streets
Sub-Watershed Boundary
* refer to table A-4 for information regarding the previous water quality studies performed at these sites.
19
17
16
18
14
15
22
24
23
13
21
11
Harkins Slough Road
12
10
9
8
7
20
6
Highway 1
5
4
Shell Road
3
2
1
Monterey County
N
W
E
S
0.25 0 0.25 0.5 0.75 1 Miles
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Figure A-8.1: Seasonal Differences in Nutrient Concentrations in Watsonville Slough at Shell Road

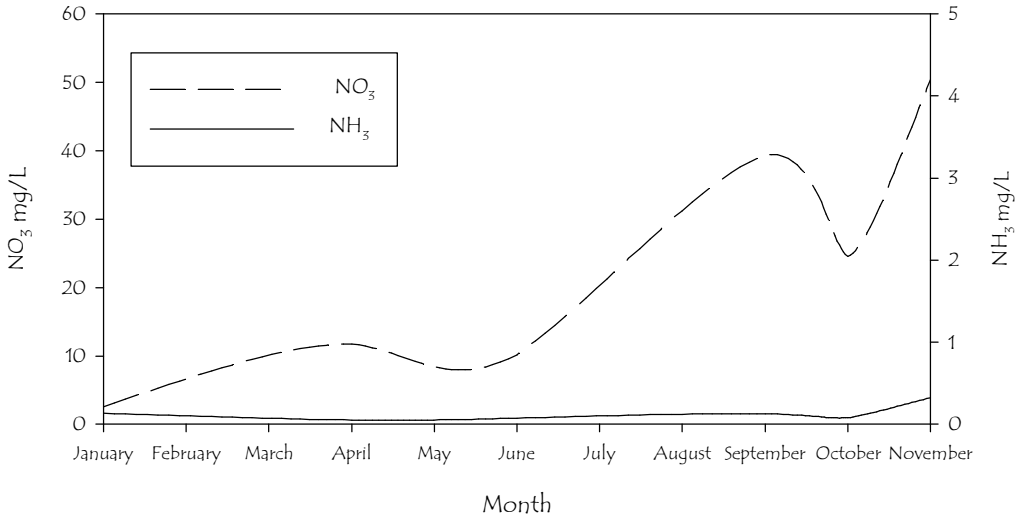
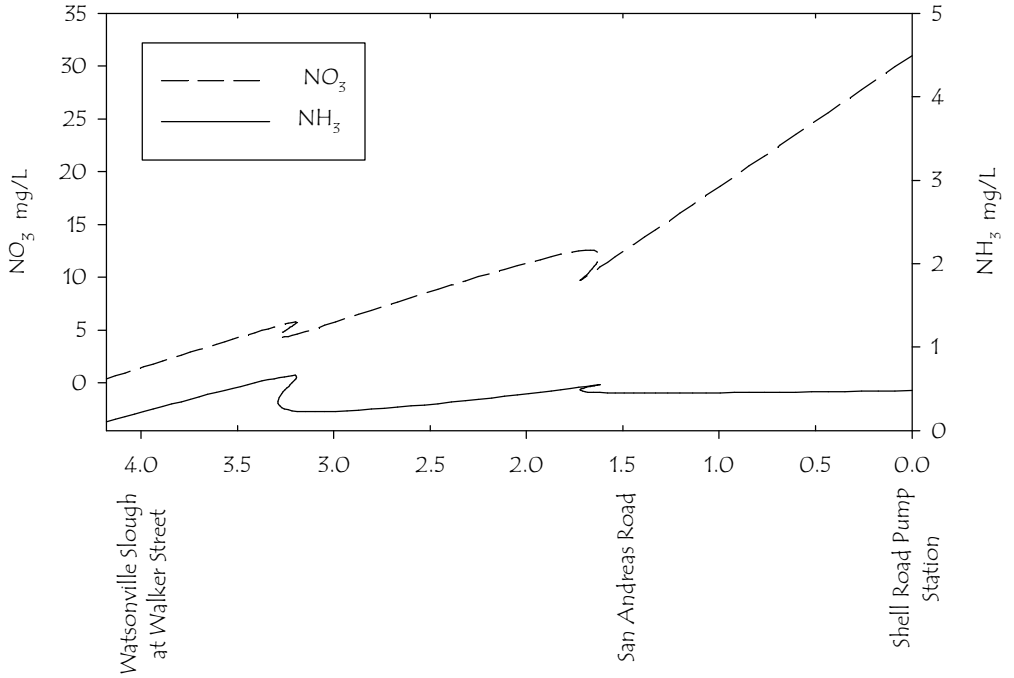



Figure A-8.2: Nutrient Concentration Differences as a Function of Distance from Shell Road Pump Station



taken February 14, 2001


**Figure A-9:** YSIA and housing prior to deployment.

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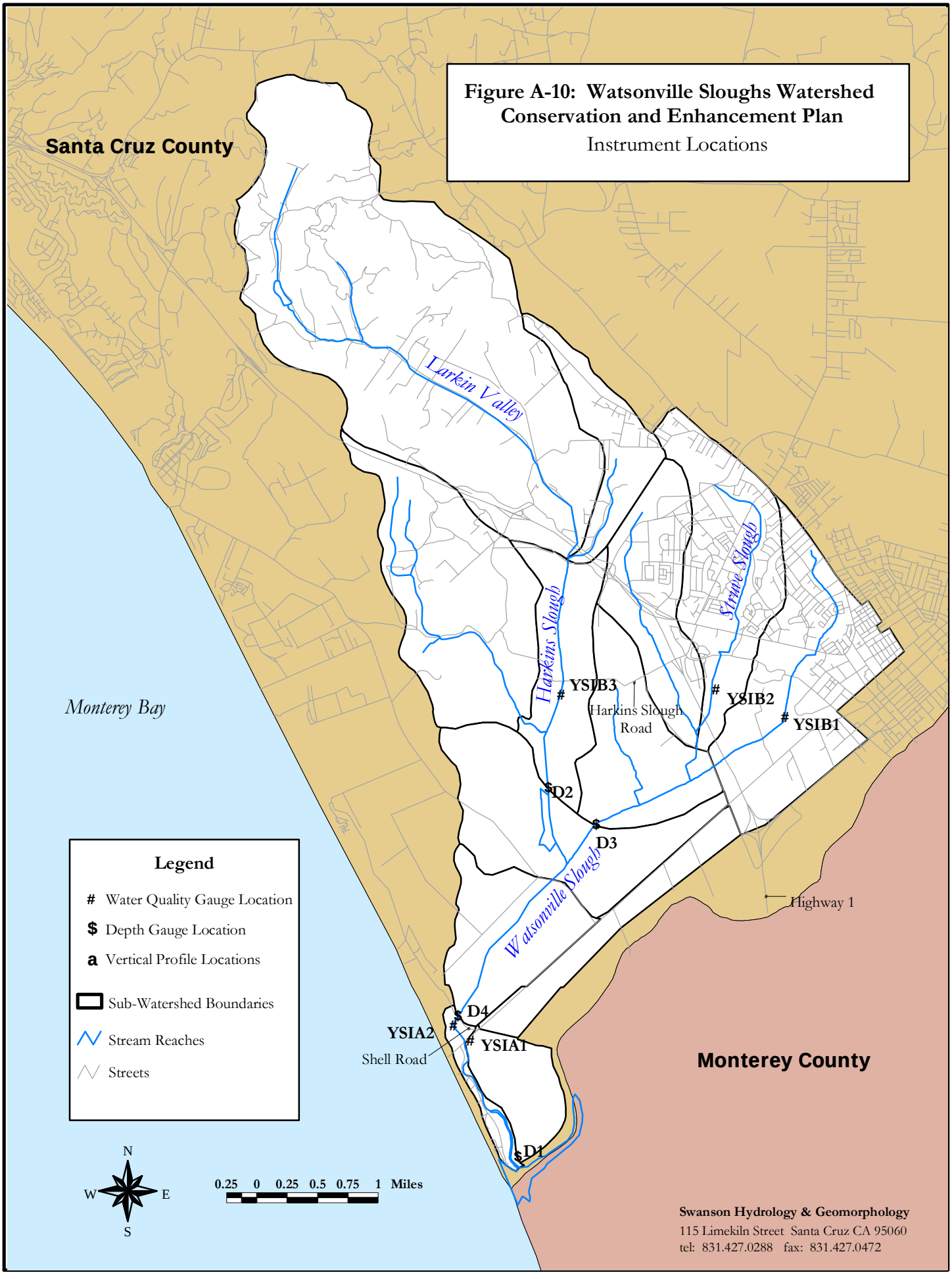
Figure A-10: Watsonville Sloughs Watershed Conservation and Enhancement Plan
Instrument Locations
Santa Cruz County
Larkin Valley
Harkins Slough
Struve Slough
Watsonville Slough
Monterey Bay
YSIB3
YSIB2
YSIB1
Harkins Slough Road
D2
D3
D4
D1
YSIA2
YSIA1
Shell Road
Highway 1
Monterey County
Legend
# Water Quality Gauge Location
$ Depth Gauge Location
a Vertical Profile Locations
Sub-Watershed Boundaries
Stream Reaches
Streets
N
W
E
S
0.25 0 0.25 0.5 0.75 1 Miles
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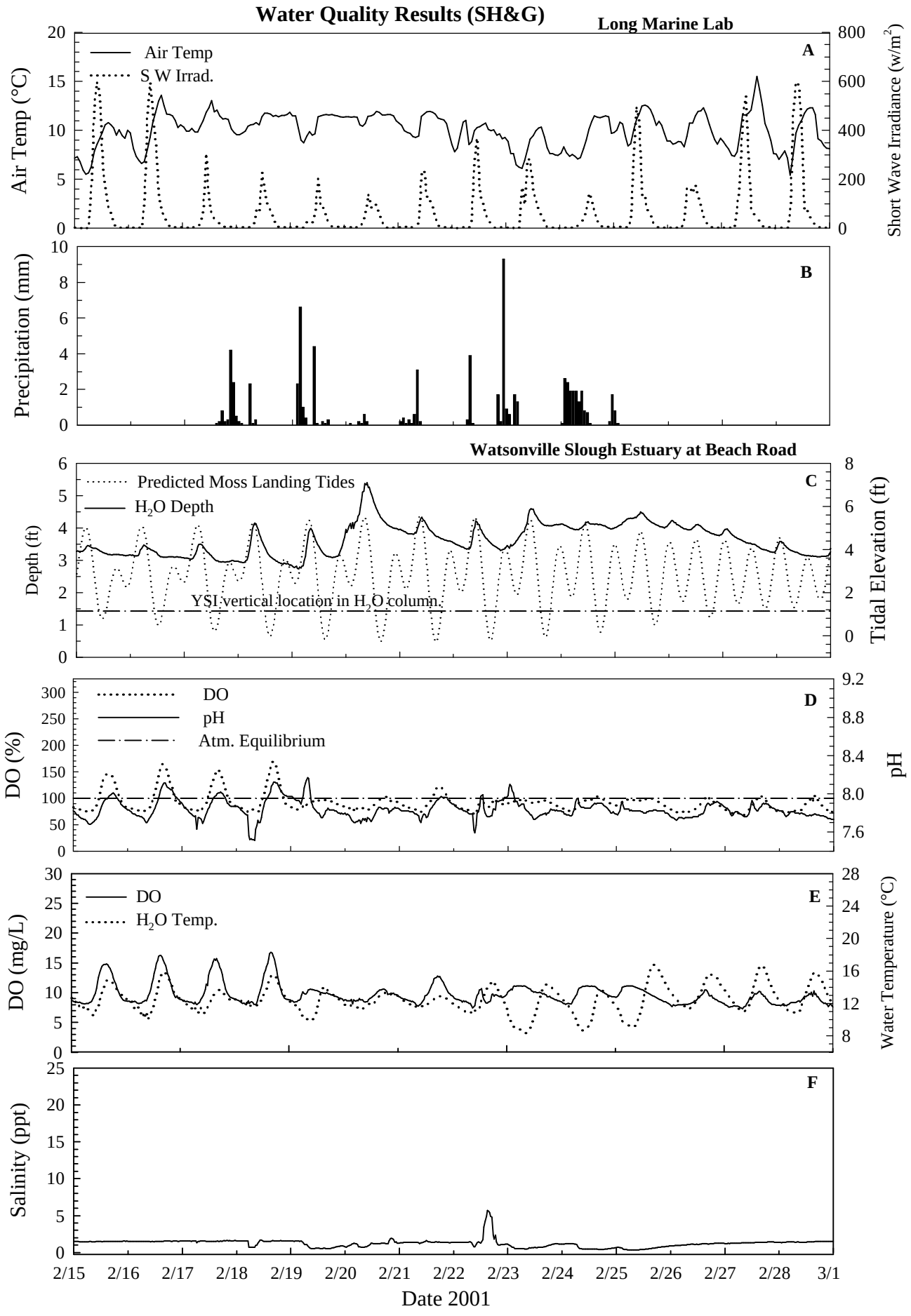
# Figure A-11: YSIA1 Feb 15 to March 1, 2001

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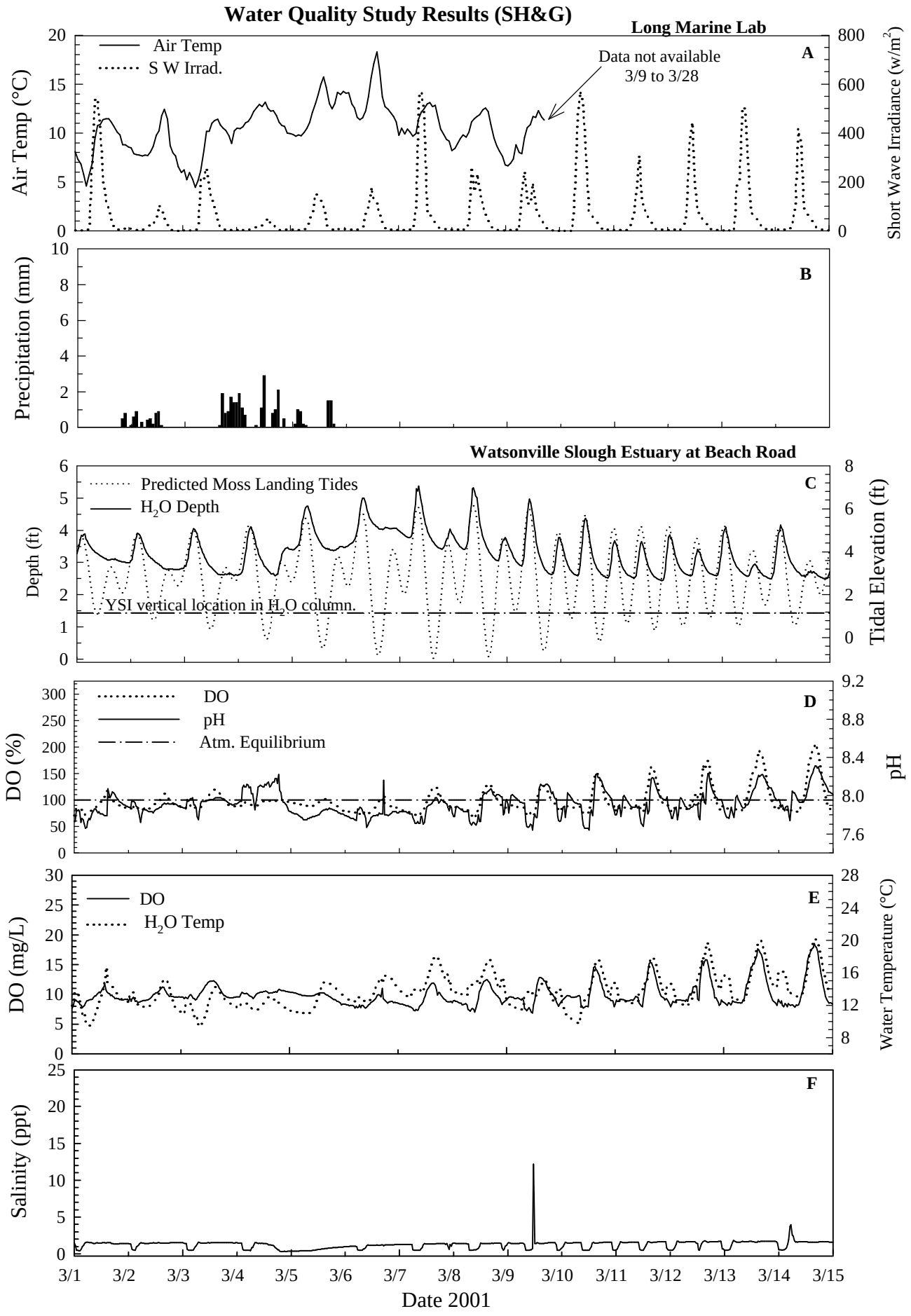
# Figure A-12: YSIA1 March 1 to March 15, 2001

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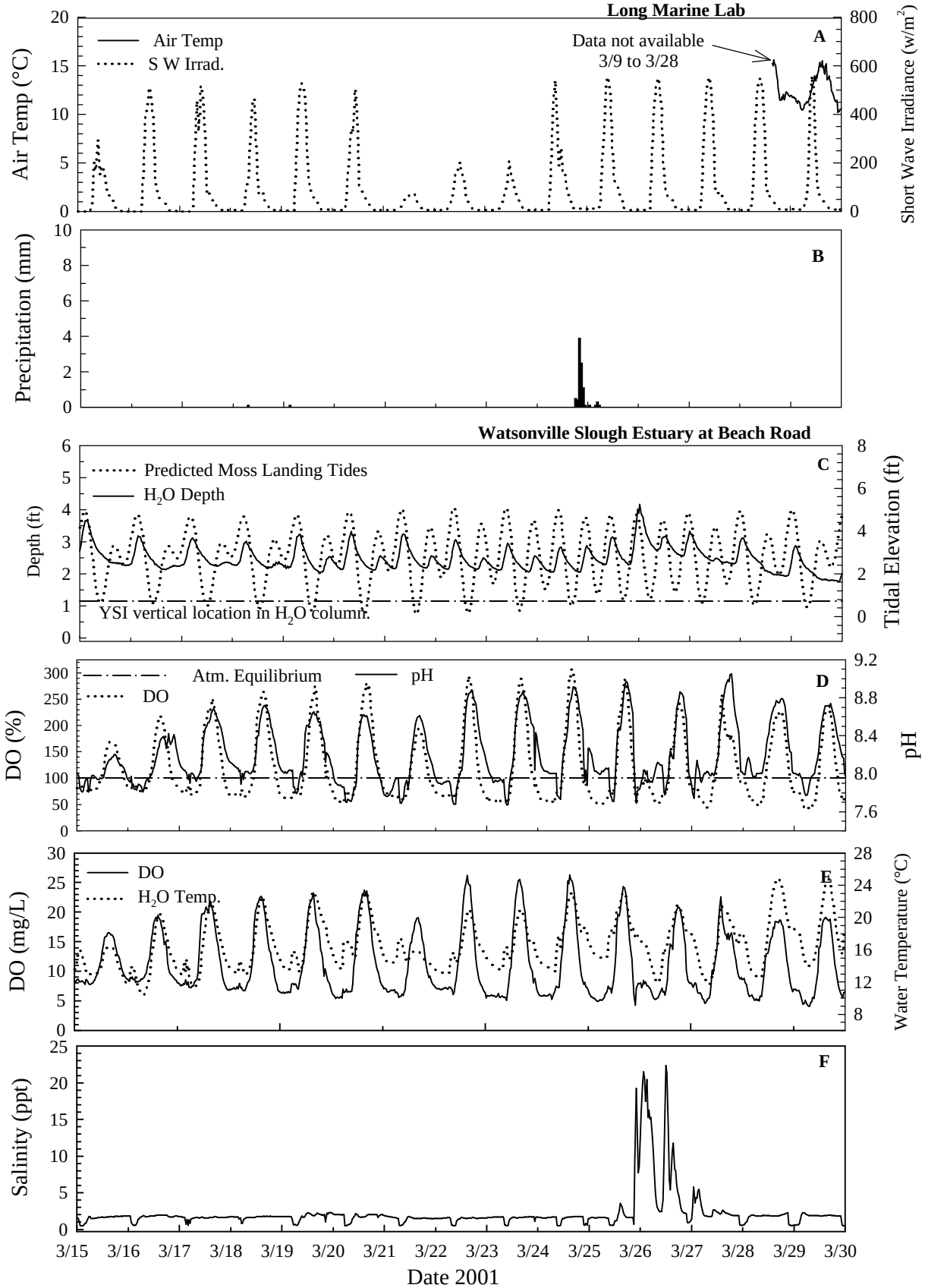
# Figure A-13: YSIA1 March 15 to March 30, 2001

## Water Quality Study Results (SH&G)

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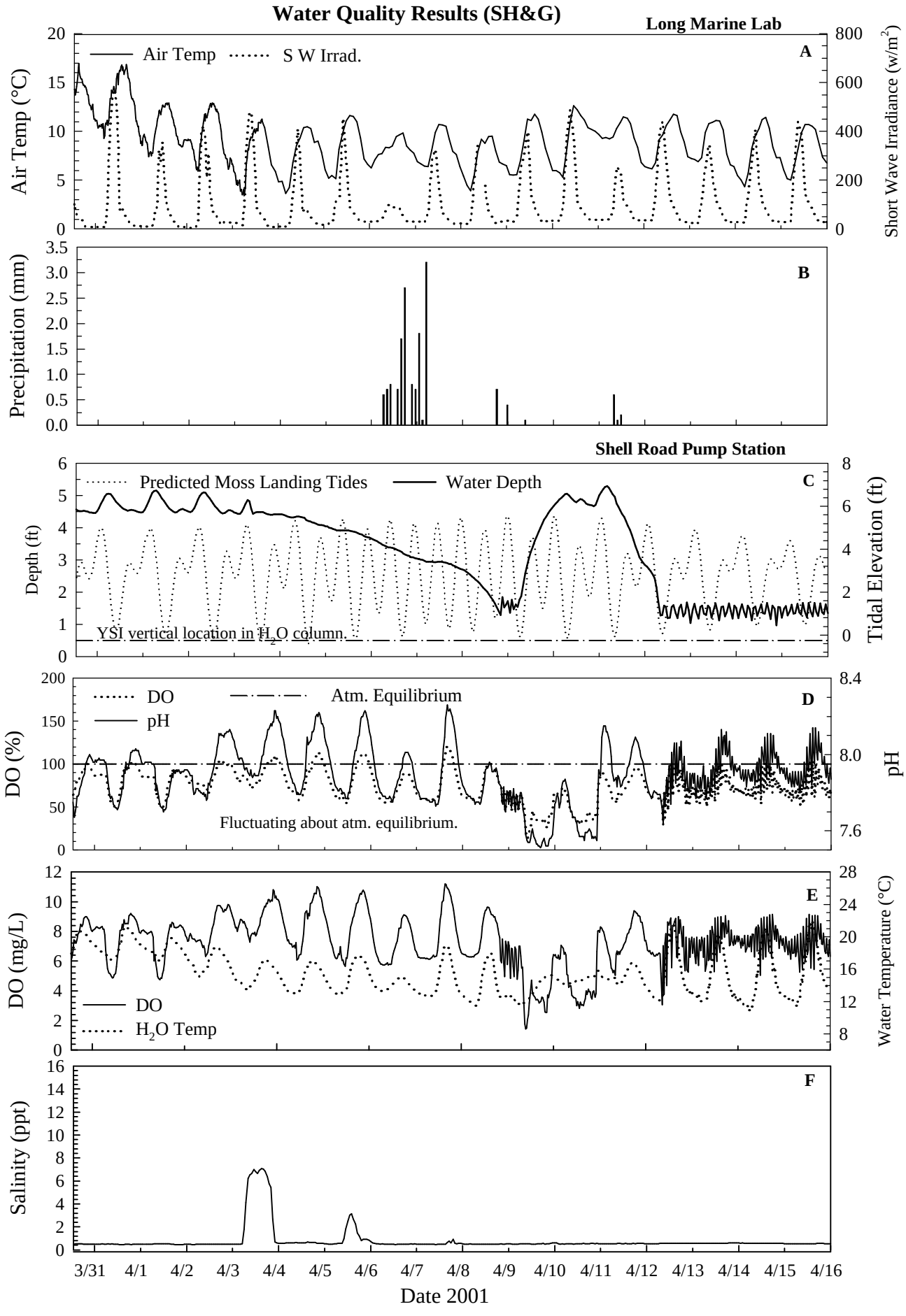
# Figure A-14: YSIA2 March 30 to April 16, 2001

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taken January 24, 2001


**Figure A-15:** Fish kill observed in Watsonville Slough at Errington Road.

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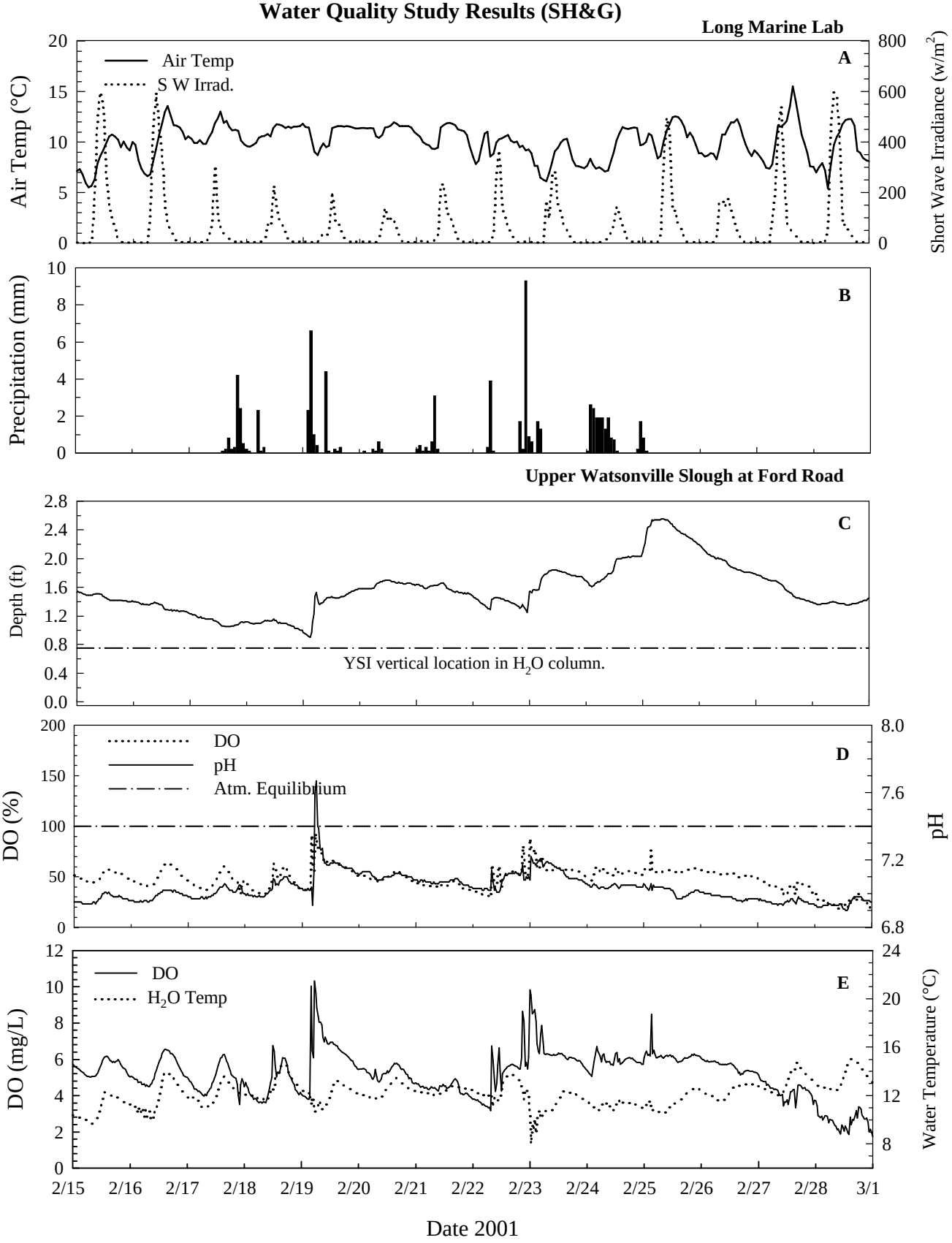
# Figure A-16: YSIB1 February 15 to March 1, 2001

## Water Quality Study Results (SH&G)

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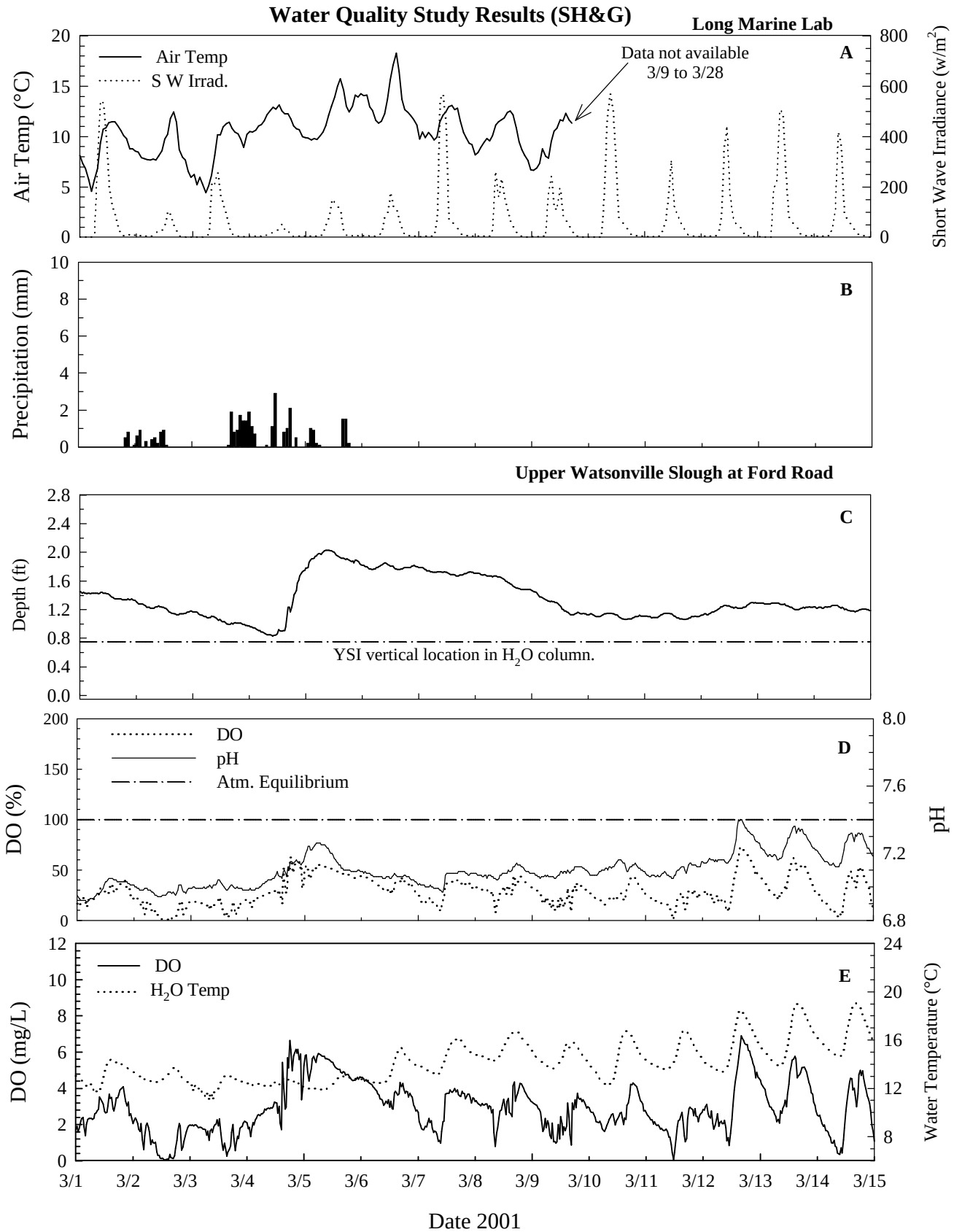
# Figure A-17: YSIB1 March 1 to March 15, 2001

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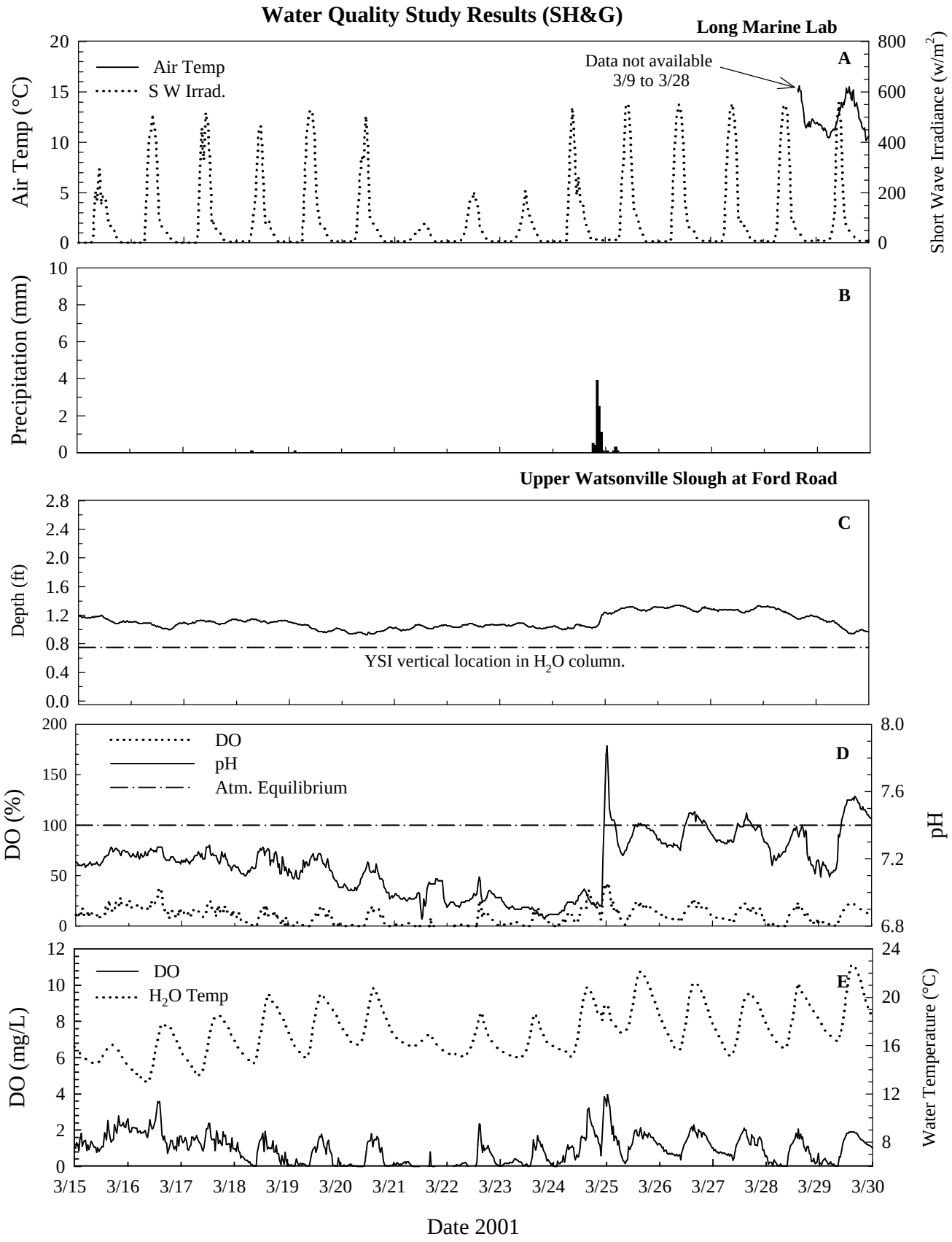
# Figure A-18: YSIB1 March 15 to March 30, 2001

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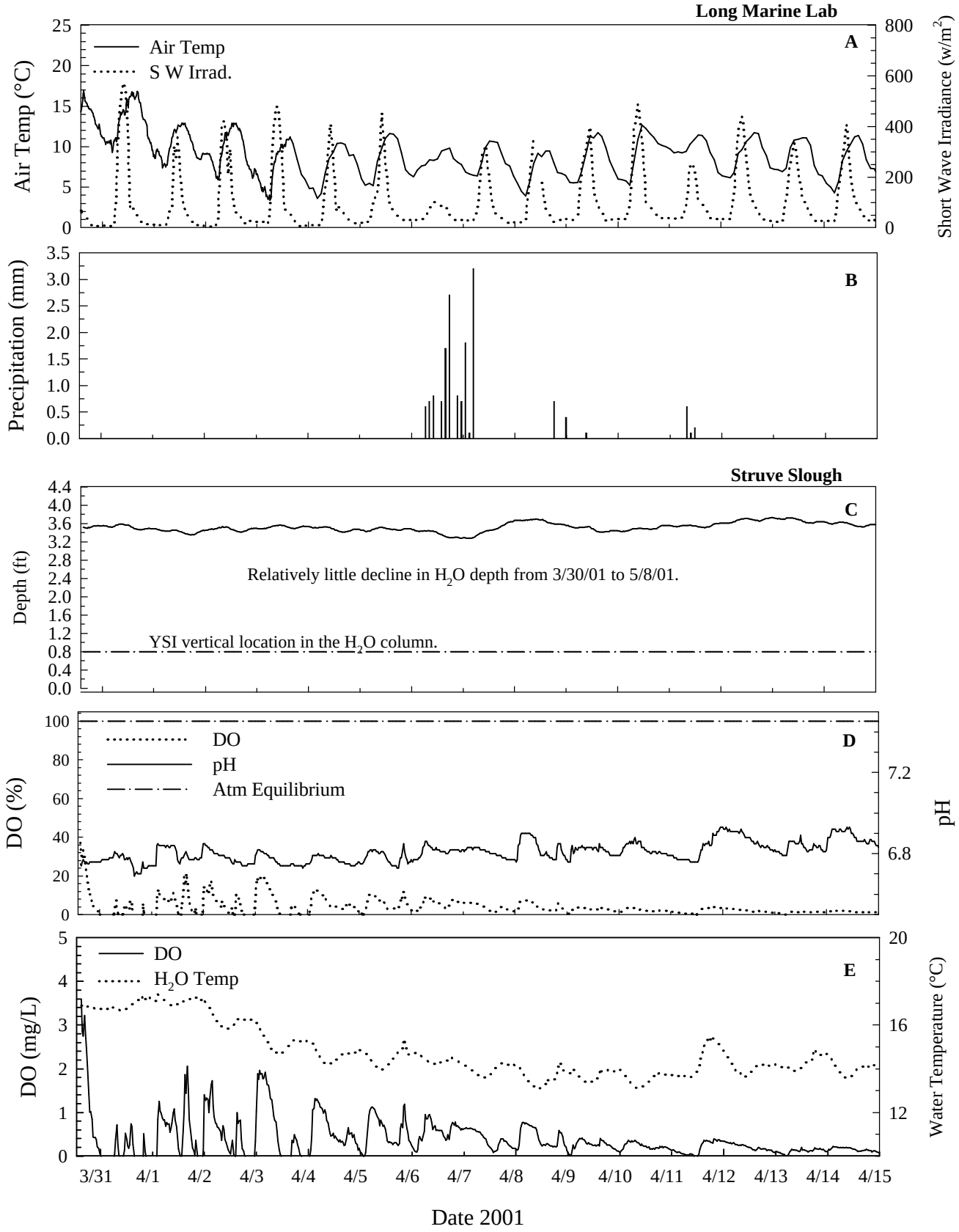
# Figure A-19: YSIB2 March 30 to April 15, 2001

## Water Quality Results (SH&G)

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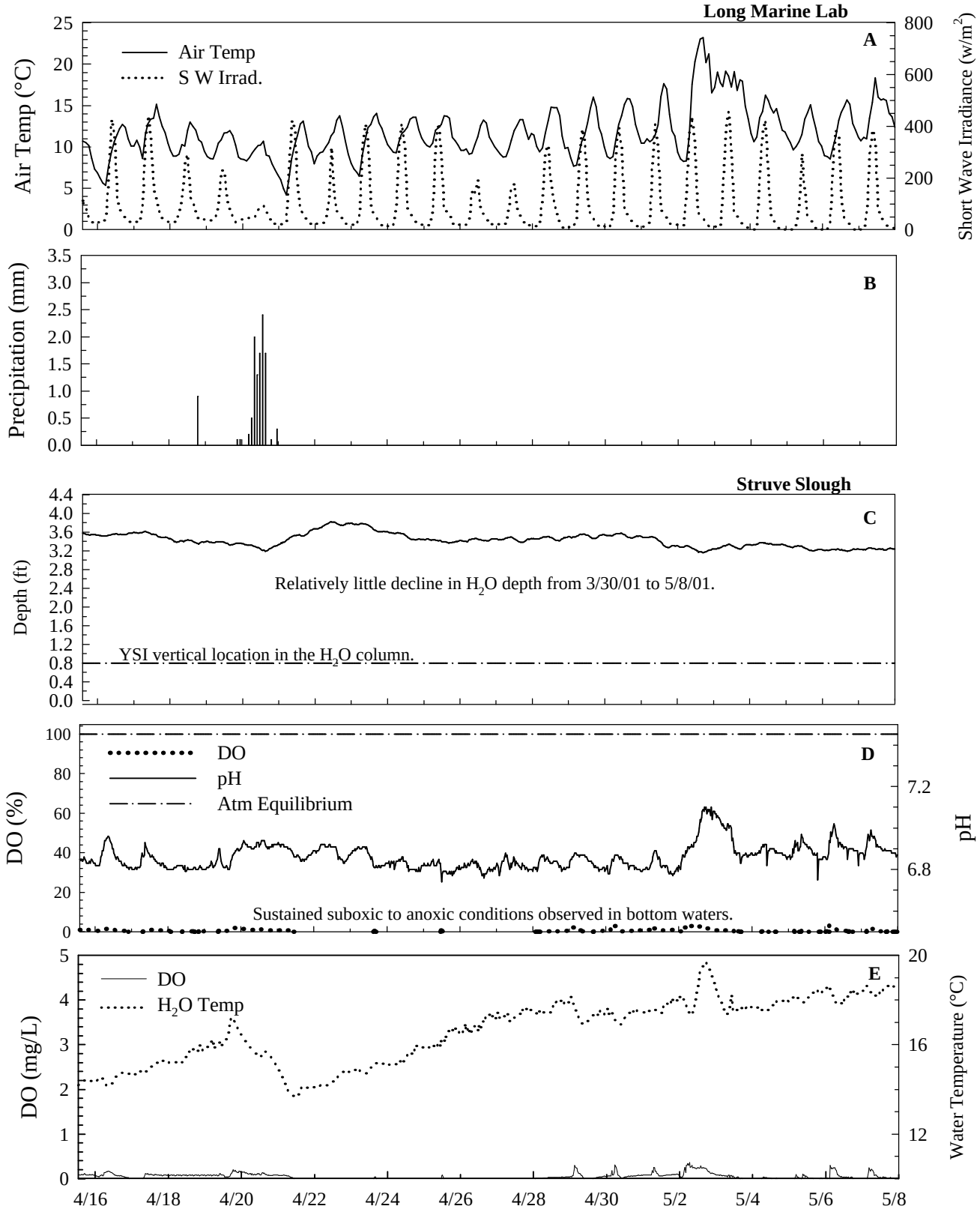
# Figure A-20: YSIB2 April 15 to May 8, 2001

## Water Quality Results (SH&G)

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taken March 20, 2001

**Figure A-21:** Extreme biomass, algae and cattail growth in Struve Slough water column.

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# Figure A-22: YSIB3 May 8 to May 31, 2001

## Water Quality Results (SH&G)

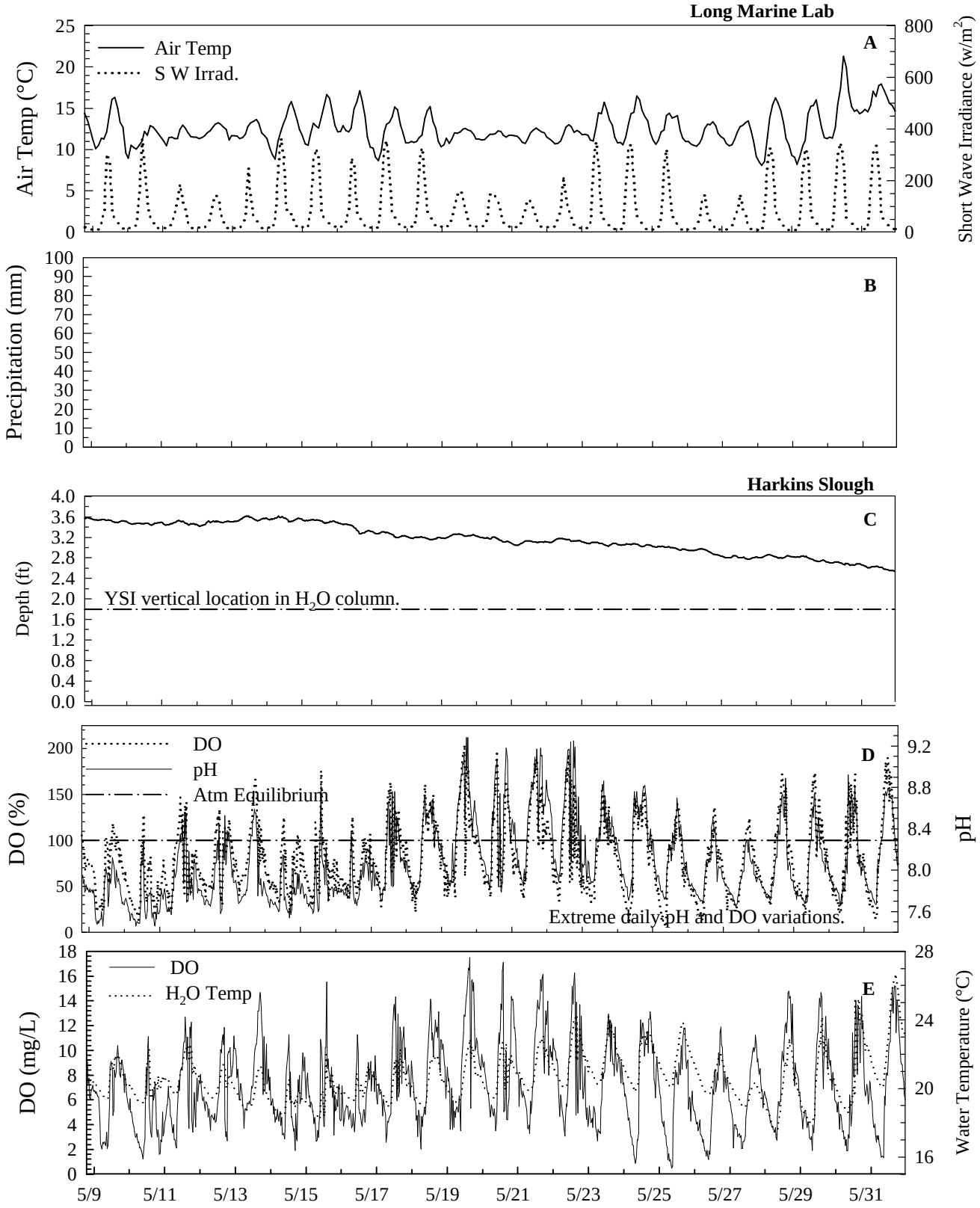


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**Figure A-23: Long Marine Lab Precipitation Data**
**Oct 2000 through May 2001**

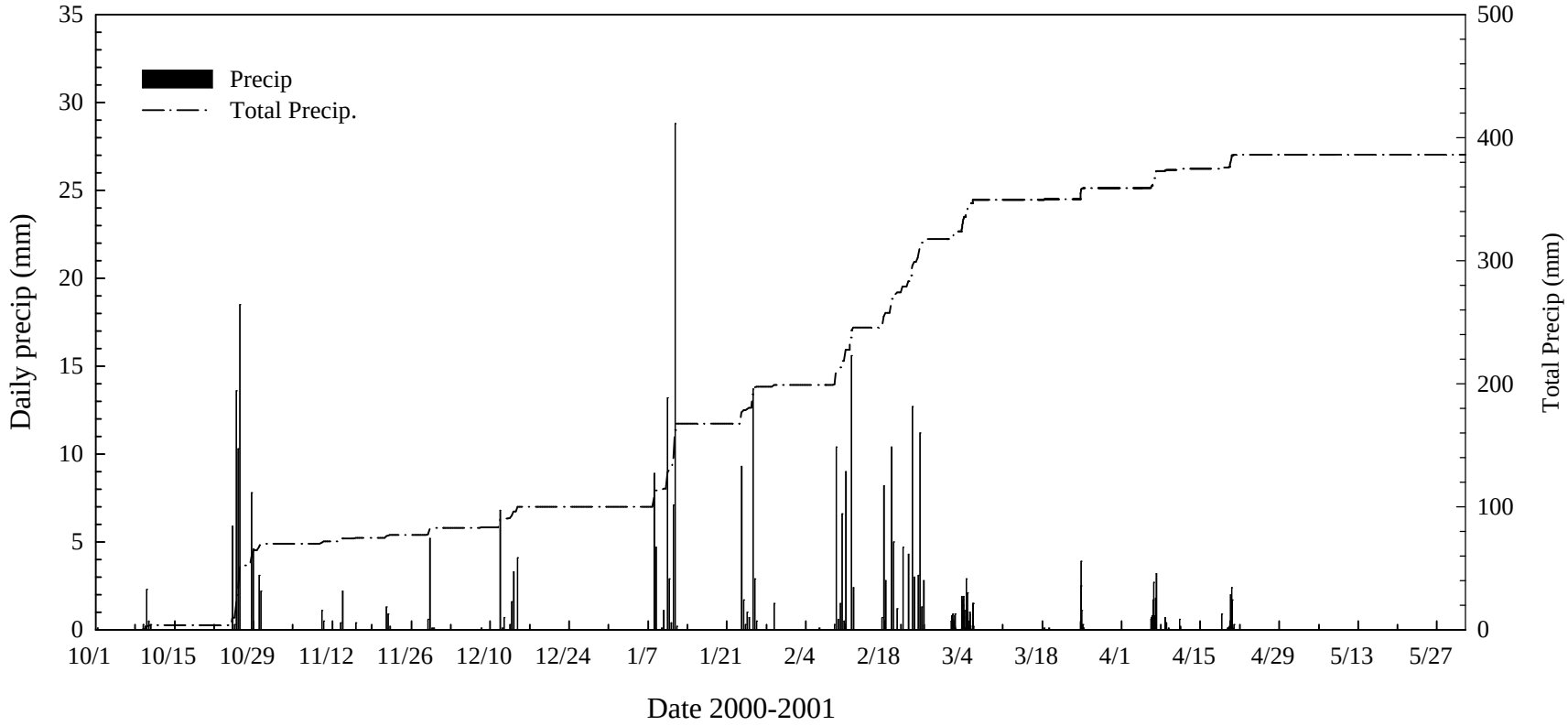

**Figure A-24: D#1** Mouth of Watsonville Slough

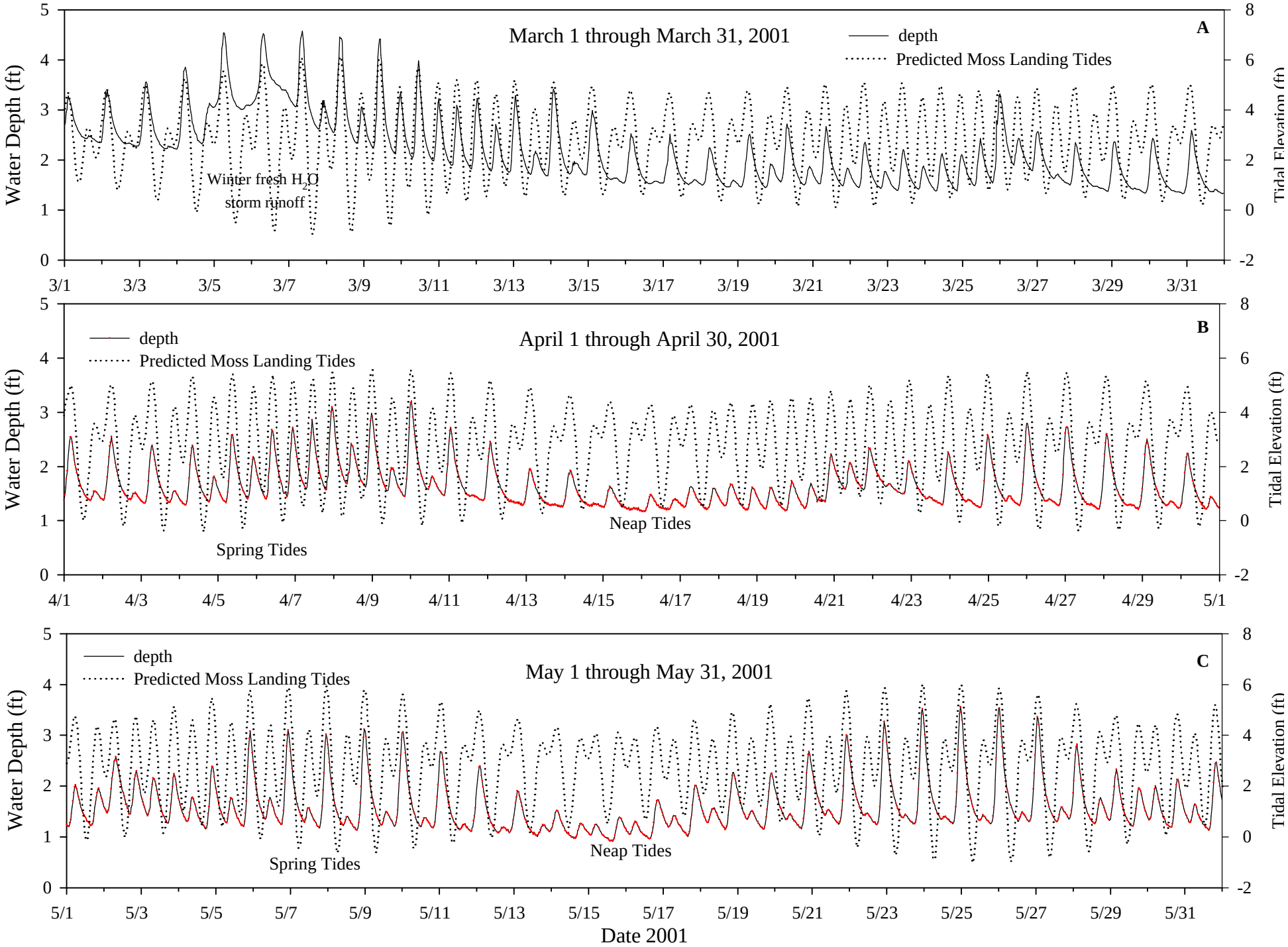


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**Figure A-25: D#2** Harkins Slough Railroad Trestle

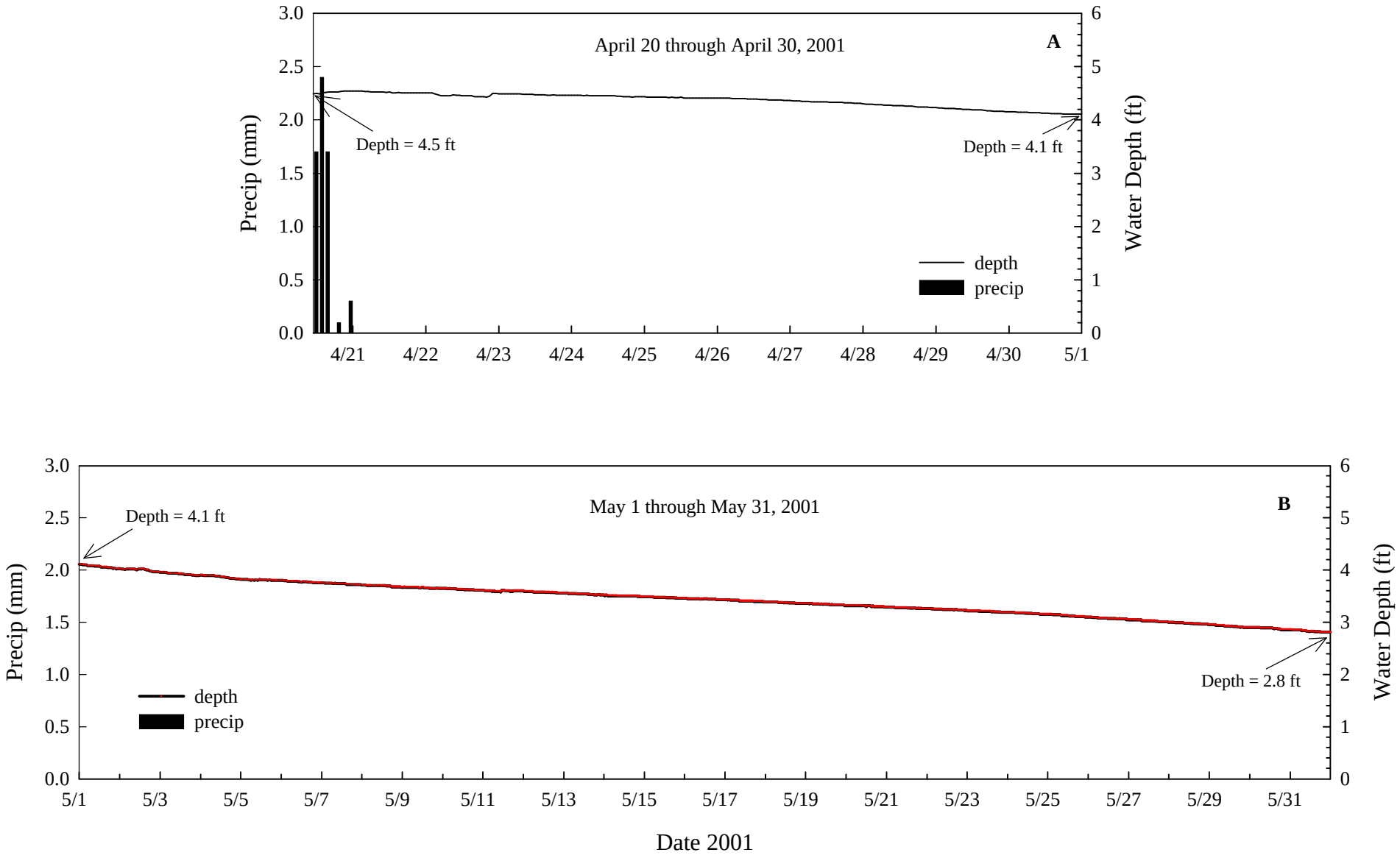


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**Figure A-26**: **D#3** Watsonville Slough Railroad Trestle

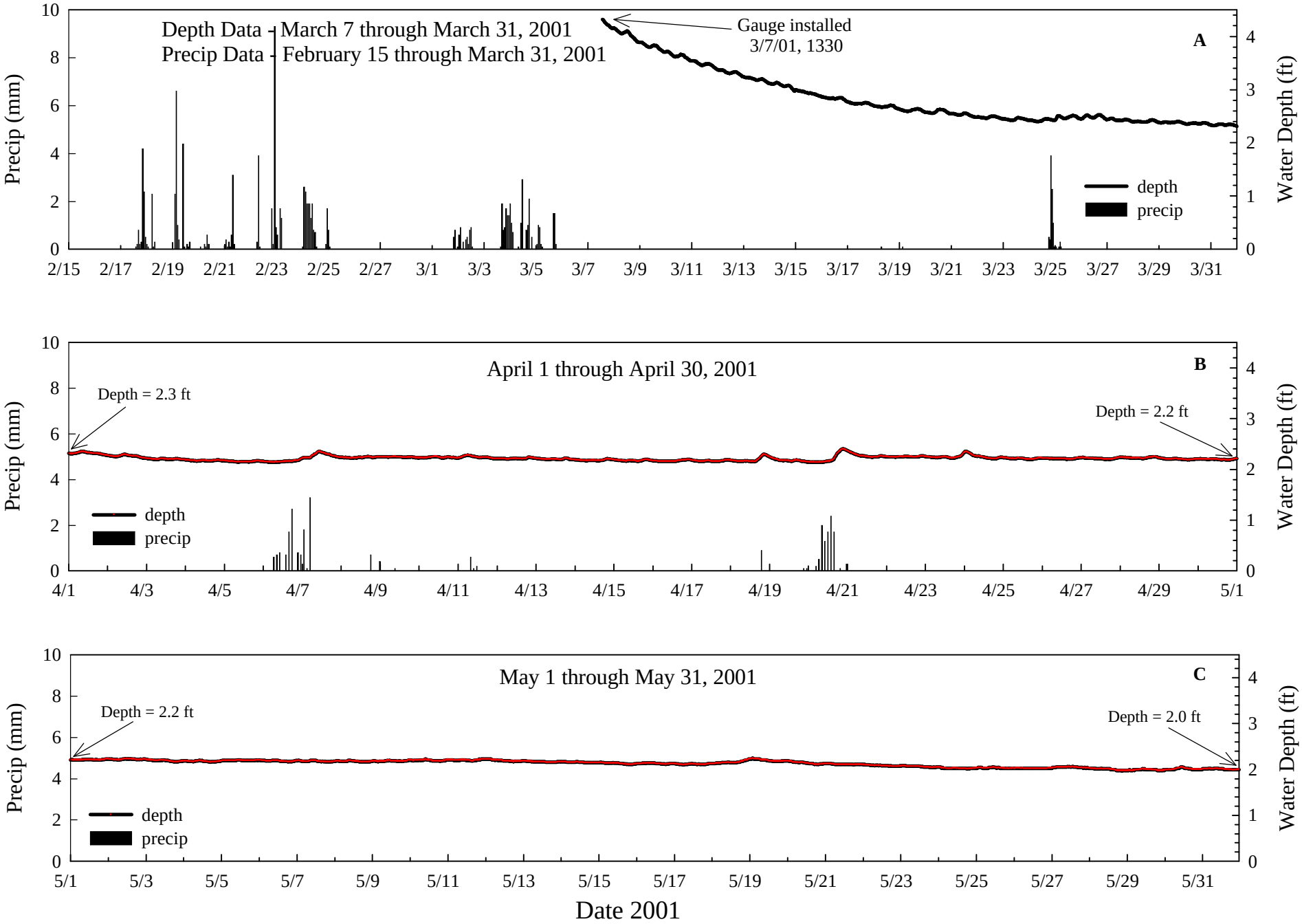

**Figure A-27: D#4 Shell Road Pump Station**

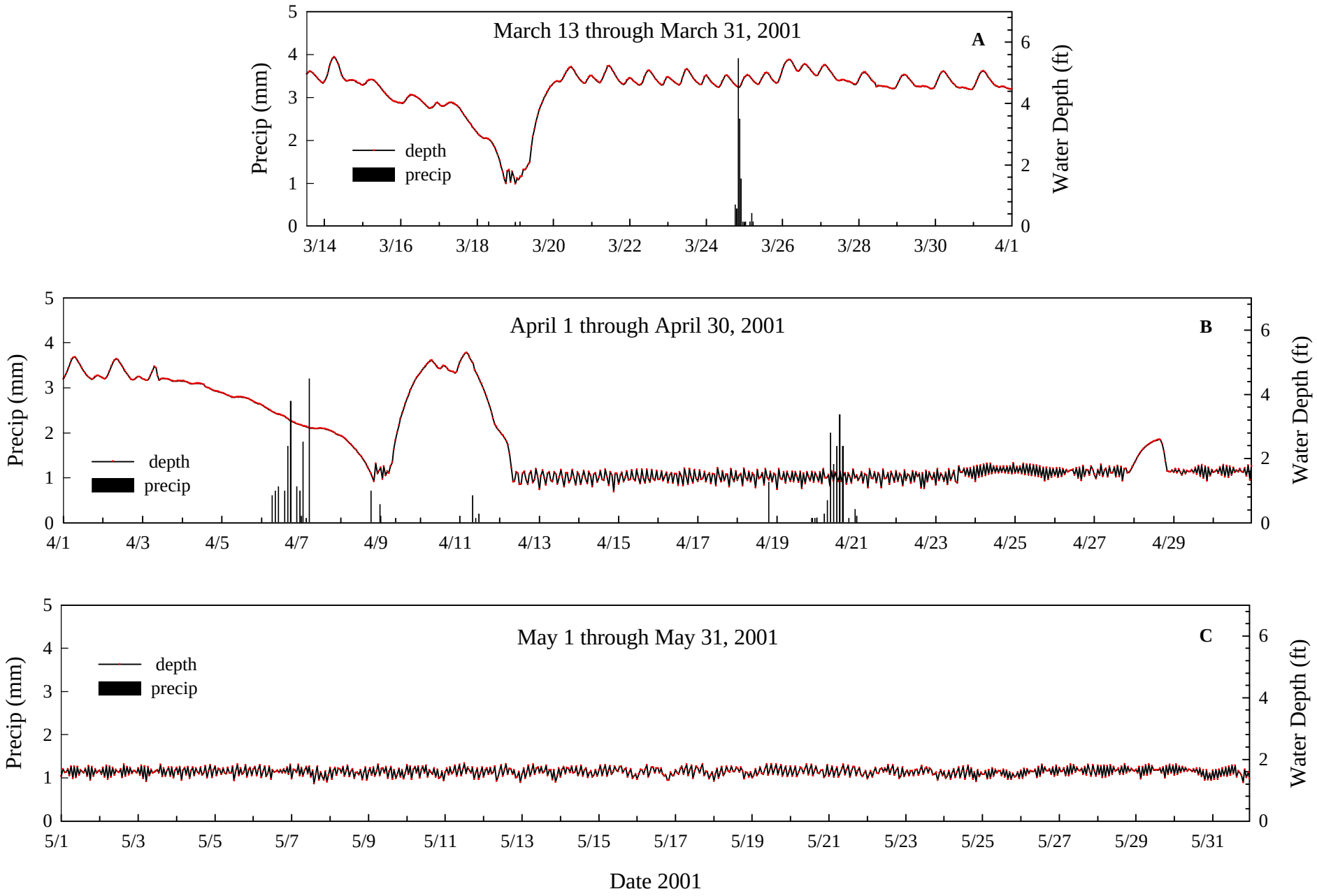


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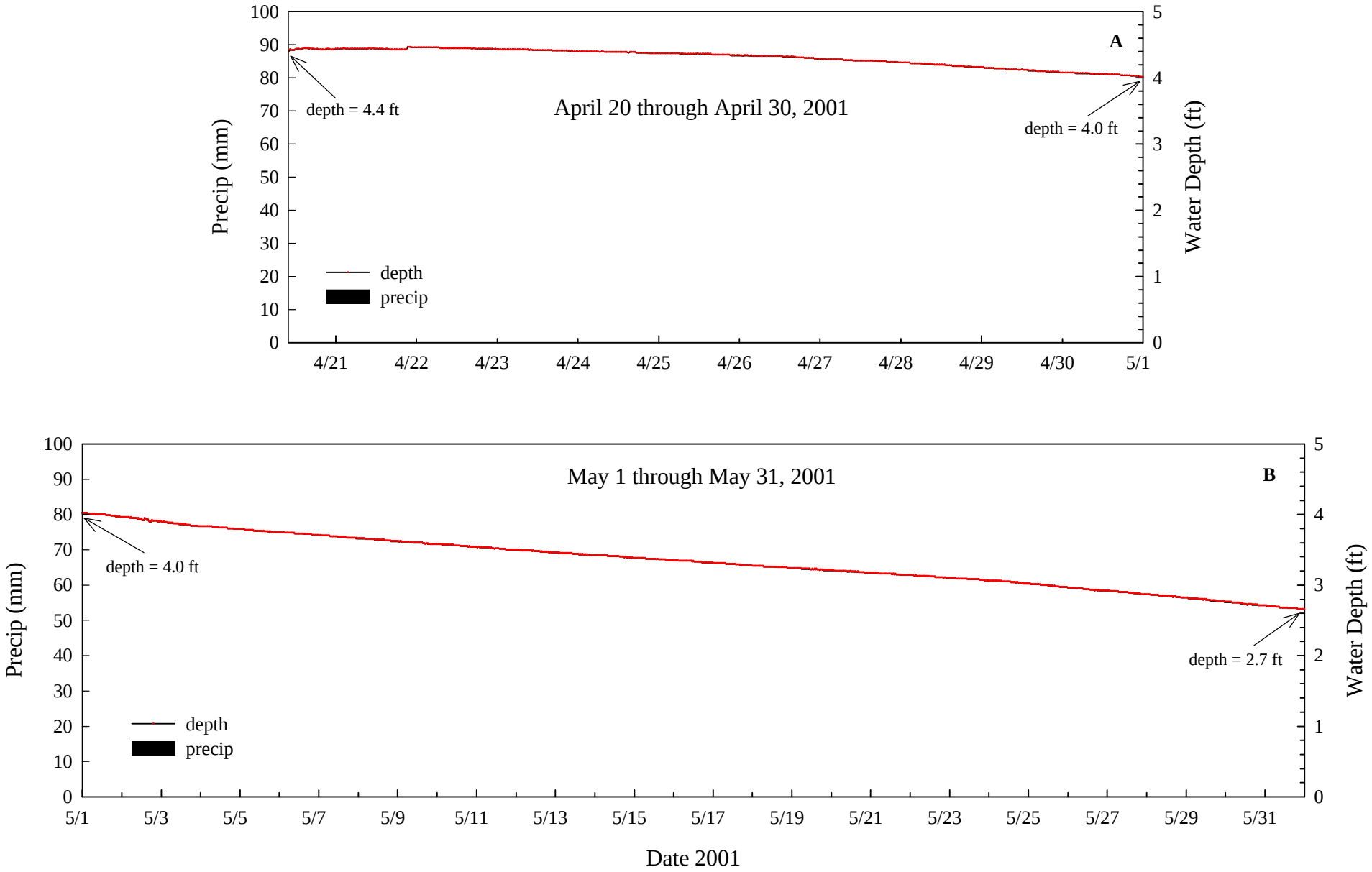
**Figure A-28: D#5** Harkins Slough near Harkins Slough Road

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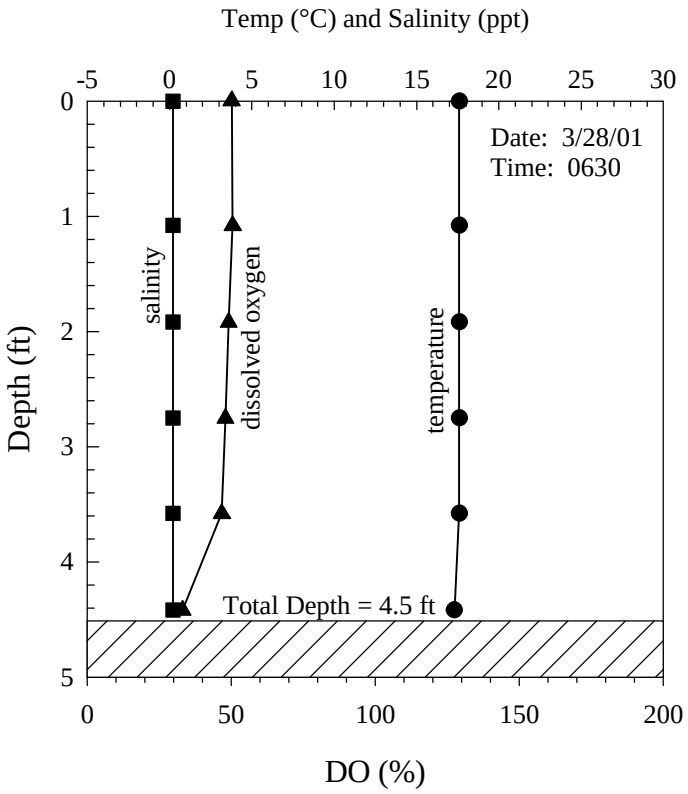
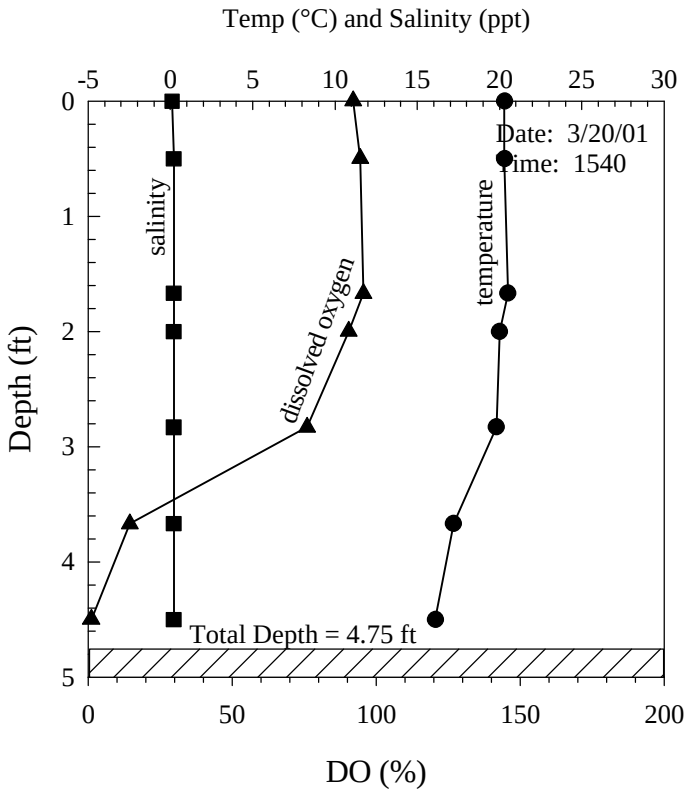
# Figure A-29: Harkins Slough Vertical Profiles - March 2001

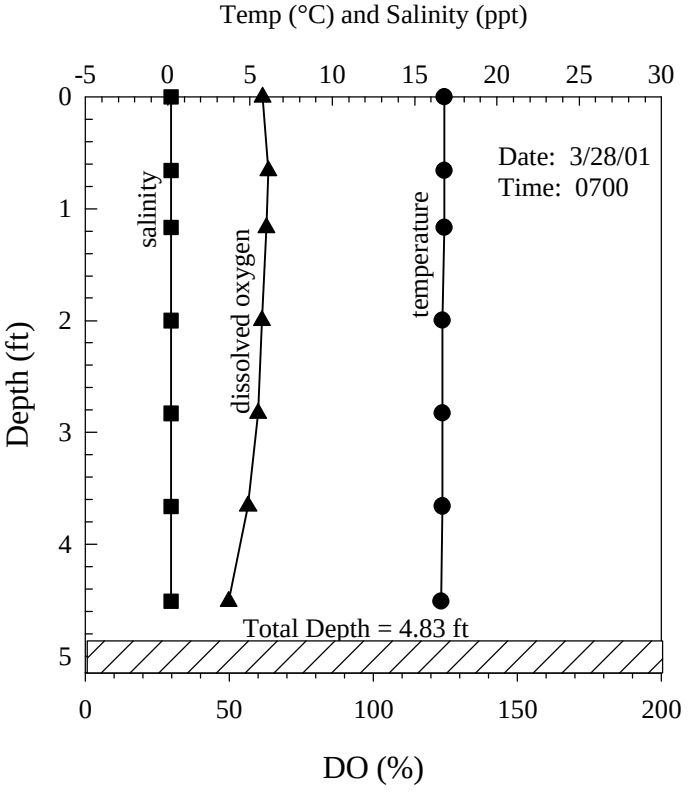
MORNING AFTERNOON

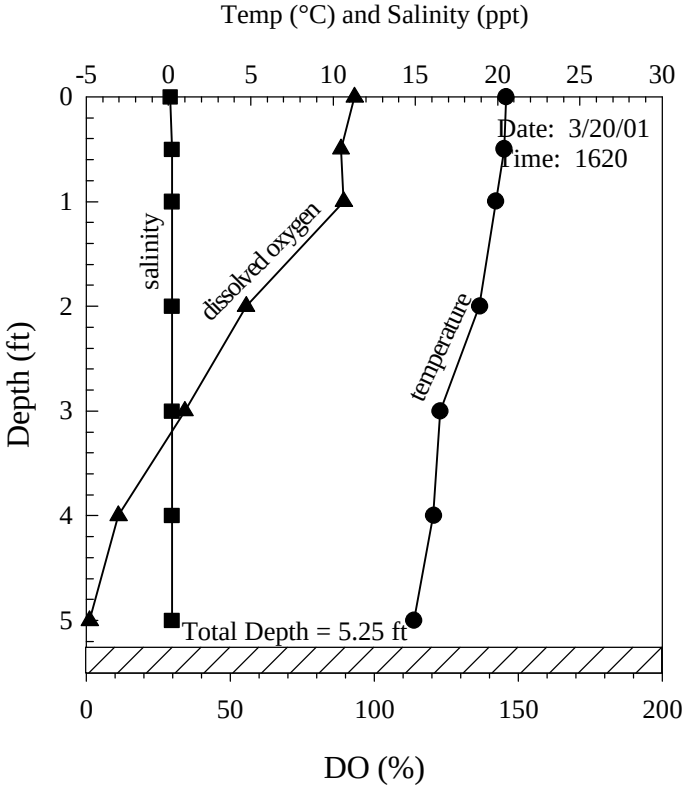
Upper Harkins Slough




Lower Harkins Slough

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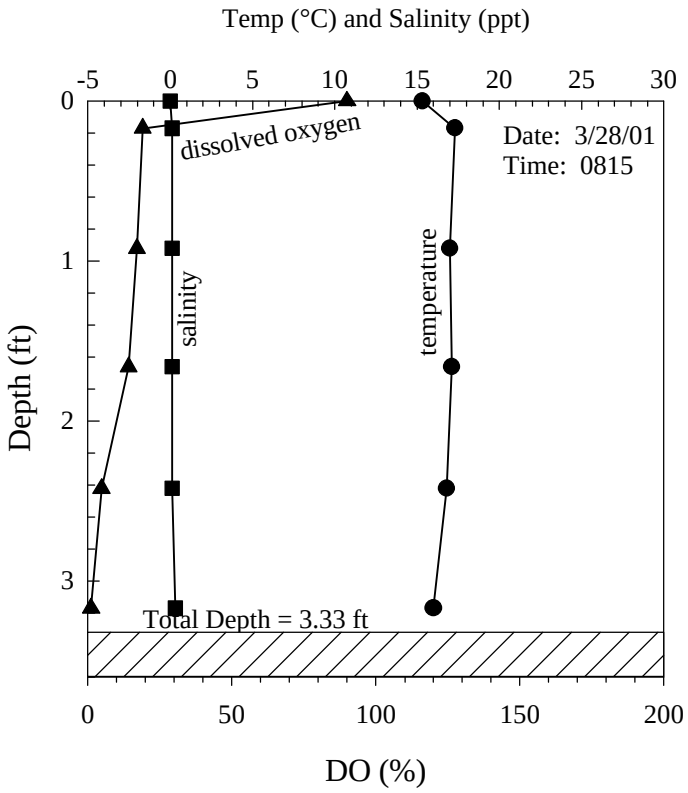
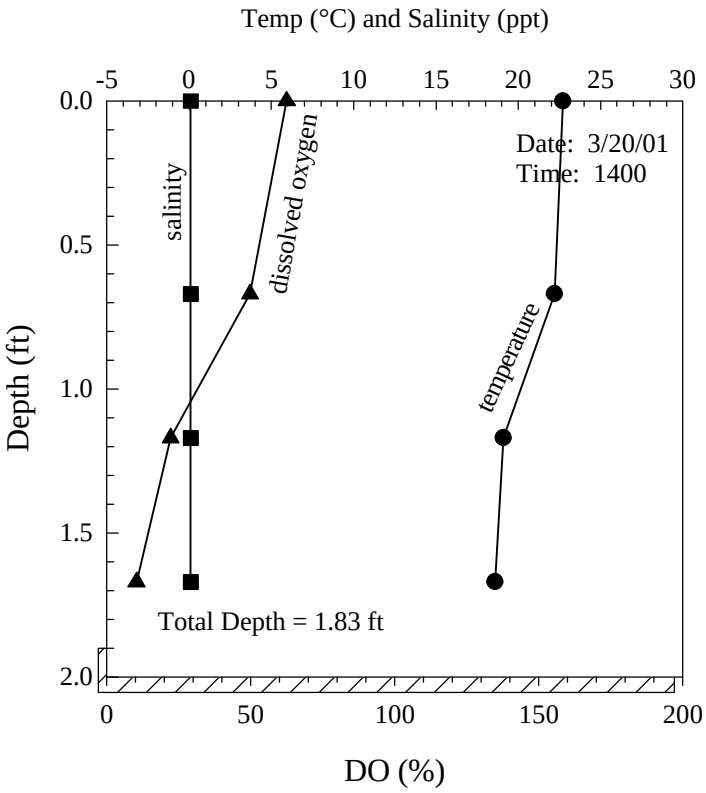
# Figure A-30: Struve Slough Vertical Profiles - March 2001

MORNING

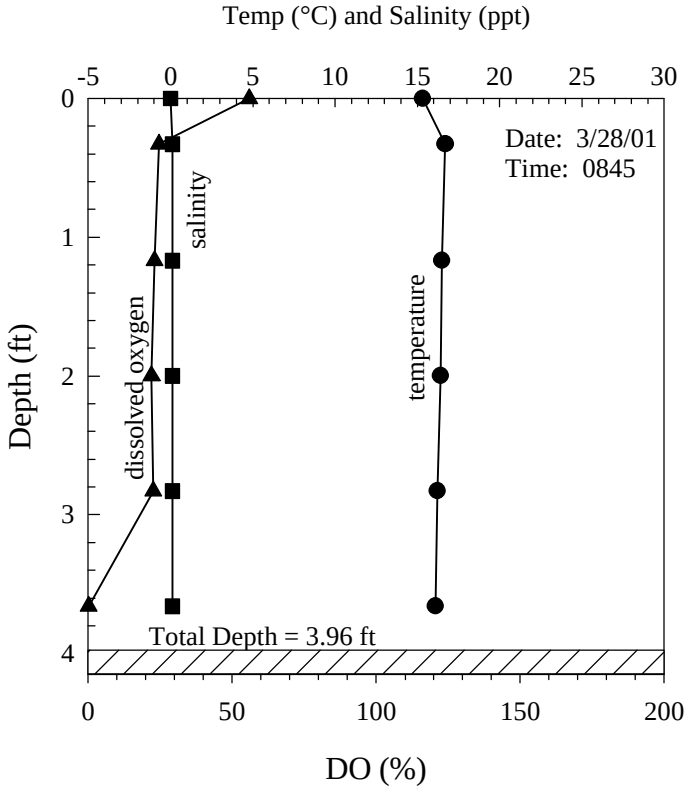
AFTERNOON

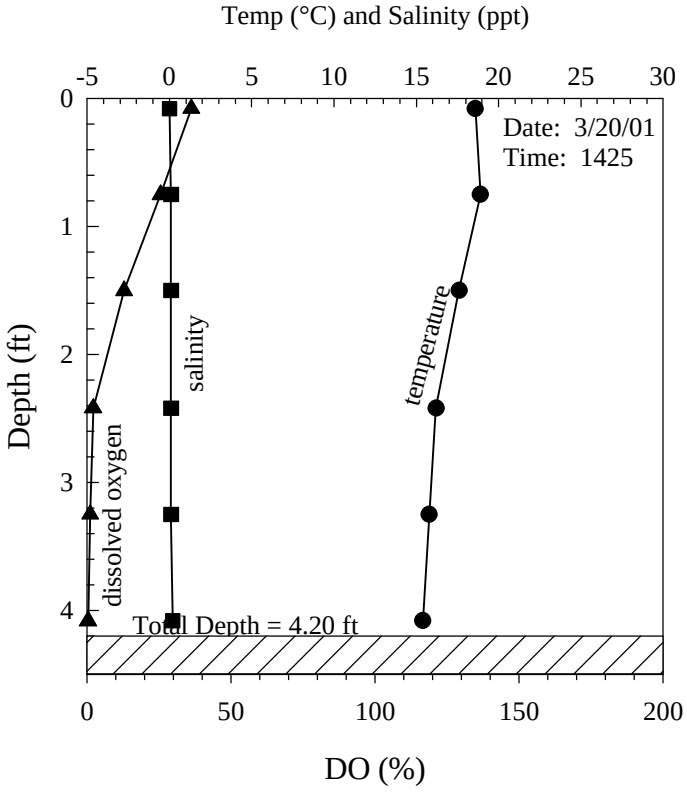
Upper Struve Slough




Lower Struve Slough near YSIB

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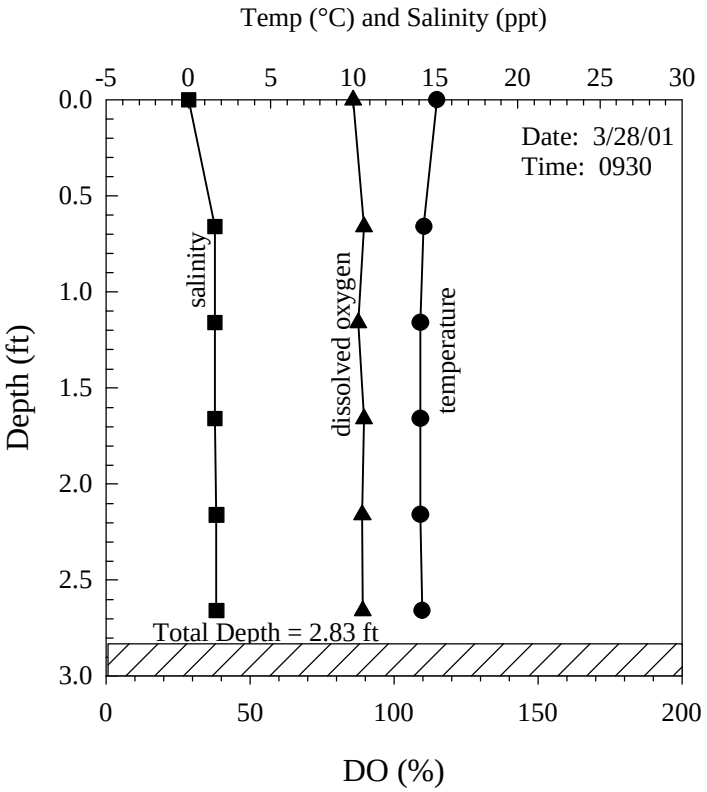
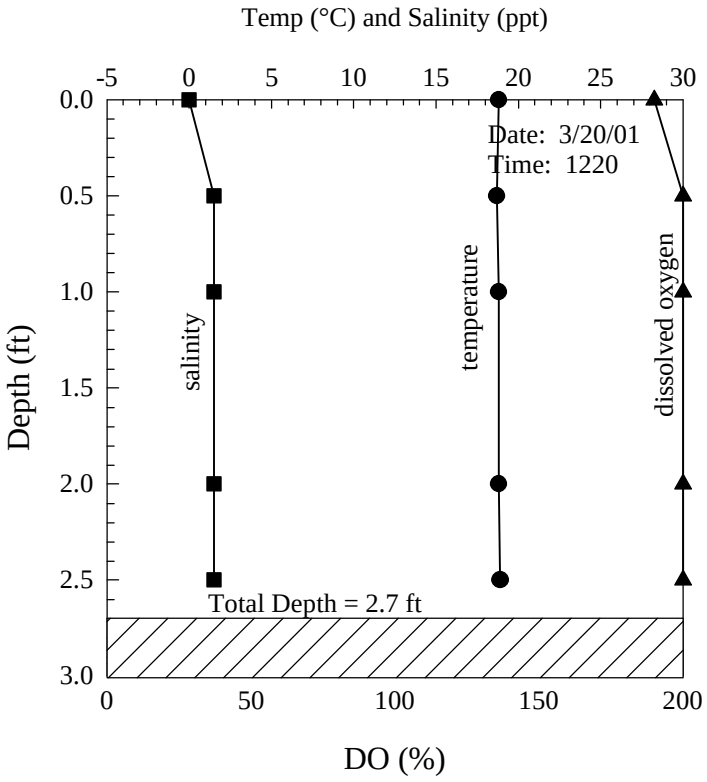
# Figure A-31: Watsonville Slough Vertical Profile - March 2001

MORNING

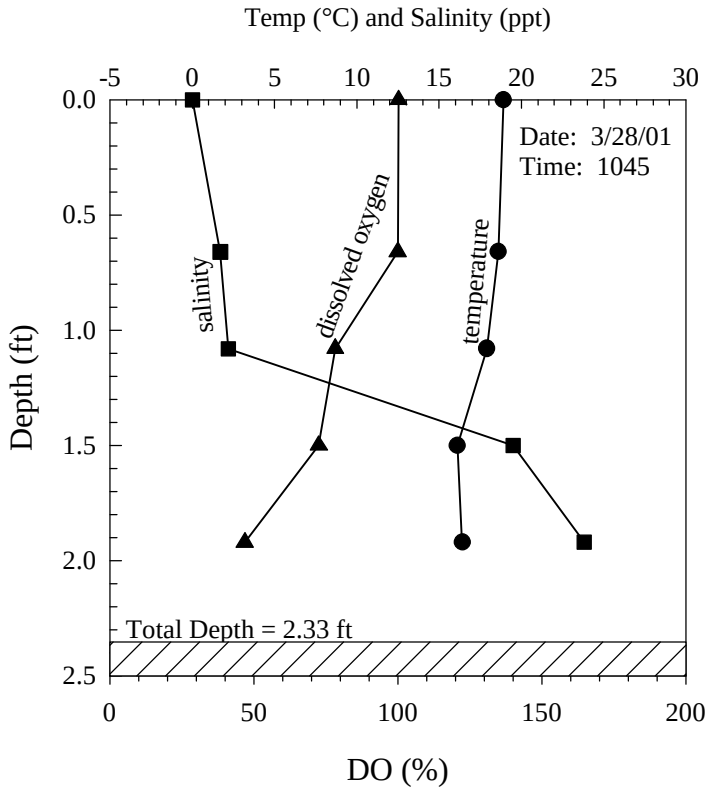
AFTERNOON

Beach Road




Mouth of Watsonville Slough



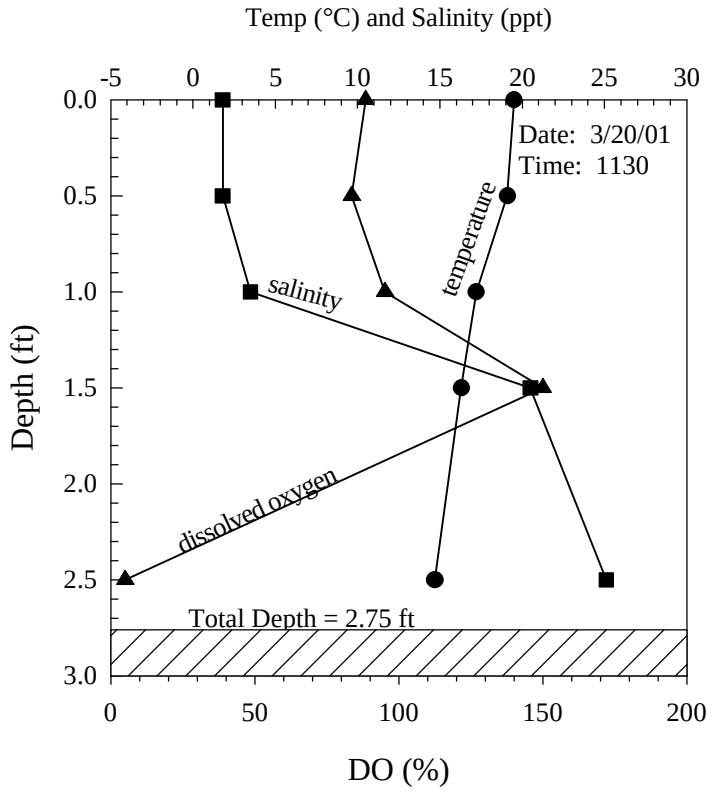




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**Table A-1: Watsonville Slough Watershed; sub-watershed designation, position, area, and land use.**

| Sub-Watershed ID | Sub-Watershed Name | Drainage Area (acres) | Sub-Watershed Area (acres) | Land Use (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Agriculture | Grazing | Urban Residential | Commercial | Rural Residential | Industrial | Undeveloped | Notes |
| LV | Larkins Valley | 3877 | 3877 | 2 | 50 | 0 | 0 | 40 | 0 | 8 | |
| WMAN | Harkins Slough Tributary | 442 | 442 | 0 | 0 | 0 | 0 | 70 | 20 | 10 | |
| GS | Gallighan Slough | 1353 | 1353 | 35 | 10 | 0 | 0 | 30 | 5 | 20 | City Dump runoff |
| UHS | Upper Harkins Slough | 6299 | 627 | 5 | 20 | 0 | 0 | 10 | 0 | 65 | |
| WB | West Branch Struve Slough | 715 | 715 | 20 | 0 | 15 | 35 | 0 | 10 | 20 | |
| SS | Struve Slough | 992 | 992 | 10 | 0 | 45 | 45 | 0 | 0 | 0 | |
| UWS | Upper Watsonville Slough | 1252 | 1252 | 25 | 0 | 50 | 25 | 0 | 0 | 0 | Cemetary runoff |
| MWS | Mid Watsonville Slough | 2445 | 738 | 90 | 10 | 0 | 0 | 0 | 0 | 0 | |
| HSWS | Harkins/Watsonville Slough Confluence | 9721 | 978 | 95 | 0 | 0 | 0 | 5 | 0 | 0 | |
| LWS | Lower Watsonville Slough | 10380 | 659 | 85 | 0 | 0 | 0 | 0 | 0 | 15 | |
| WSAG | Upper Beach Road | 368 | 368 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | |
| LWAG | Lower Beach Road | 343 | 343 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | |
| WSE | Watsonville Slough Estuary | 10505 | 125 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | Tidally influenced estuary. |
| | | **TOTAL** | 12469 | 32 | 18 | 9 | 8 | 20 | 2 | 10 | |

**Table A-2: Watsonville Slough Watershed; stream reach locations, characteristics, and ratings.**

| Reach ID | Stream Name | Watershed ID | Length (ft) | Channel Width (ft) | Channel Depth | Stream Type | Circulation Rating | Riparian Vegetation |
|---|---|---|---|---|---|---|---|---|
| A | Upper Larkins Valley | LV | 10300 | 4 | 1 | 5 | High | 4 |
| B | Lower Larkins Valley | LV | 14557 | 6 | 1 | 4 | High | 2 |
| C | Harkins Slough Trib | WMAN | 5400 | 5 | 1 | 4 | High | 2 |
| D | Upper Gallighan Slough | GS | 8540 | NA | NA | 5 | High | 4 |
| E | Lower Gallighan Slough | GS | 5900 | 4 | 2 | 4 | Moderate | 3 |
| F | Upper Harkins Slough | UHS | 7690 | NA | 7 | 2 | **Stagnant** | 3 |
| G | Upper West Branch | WB | 4700 | 2 | 1 | 5 | High | 1 |
| H | Lower West Branch | WB | 5980 | NA | 1 | 2 | Low | 3 |
| I | Upper Struve Slough | SS | 4280 | 5 | 1 | 5 | High | 2 |
| J | Lower Struve Slough | SS | 11385 | NA | 5 | 2 | **Stagnant** | 1 |
| K | Watsonville Slough Headwaters | UWS | 5092 | NA | NA | 1 | Moderate | 6 |
| L | Watsonville Slough Marsh | UWS | 2950 | NA | 3 | 2 | **Stagnant** | 6 |
| M | Watsonville Slough N of Hwy 1 | UWS | 4456 | 8 | 2 | 3 | Low | 1 |
| N | Hanson Slough | MWS | 6087 | NA | NA | 2 | Low | 5 |
| O | Mid Watsonville Slough | MWS | 5810 | 13 | 3 | 3 | Low | 1 |
| P | Lower Harkins Slough | HSWS | 3010 | NA | 4 | 2 | **Stagnant** | 1 |
| Q | Mid Watsonville Slough | HSWS | 3402 | 25 | 5 | 3 | Low | 1 |
| R | Beach Rd N Ditch | HSWS | 10187 | 13 | 3 | 3 | Low | 1 |
| S | Lower Watsonville Slough | LWS | 7730 | 30 | 6 | 3 | Low | 1 |
| T | Beach Rd S Ditch | UBR | 18495 | 15 | 2.5 | 3 | **Stagnant** | 1 |
| V | Watsonville Slough Estuary | WSE | 6766 | 75 | 6 | 1 | Moderate | 3 |

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## Table A-3: Watsonville Slough Watershed; control structure identification, location, and rating.

Table A-3

| Control ID | Watershed ID | Reach ID | Type and Quantity | Width (ft) | Height (ft) | Diameter (ft) | Rating | Description |
|---|---|---|---|---|---|---|---|---|
| 1 | LWS | S | pump station | NA | NA | NA | **1** | Shell Road Pump Station: eliminates tidal flushing up estuary. Stagnant water with minimal habitat value N of Pump Station |
| 2 | HSWS | P | pump station | NA | NA | NA | **1** | Harkins Slough Pump Station |
| 3 | UHS | F | Bridge | 40 | 12 | NA | 4 | South Pacific RR trestle above Harkins Slough; Adequate when cleared of debris; large debris pile constricting N side of control structure |
| 4 | MWS | O | 2 CMP | NA | NA | 5.5 | 4 | South Pacific RR Crossing at Watsonville Slough |
| 5 | WSE | V | 1 CC Tide gate | NA | NA | 5.5 | 4 | Confluence of Beach Road agricultural drainage and Watsonville Slough Estuary |
| 6 | UWS | M | 2 CMP | NA | NA | 4.5 | 4 | Watsonville Slough at Lee Road; cmp half-full of sediment. |
| 7 | SS | J | culverts, road | NA | NA | NA | **1** | Struve Slough at Lee Road: Winter road closure. Road now control structure constricting flow, 2/2001 approx 150' of Rd inundated with depths up to 2.5'. |
| 8 | UWS | M | Overpass | NA | NA | NA | 4 | Watsonville Slough at Highway 1; overpass has no effect on drainage. |
| 9 | UWS | L | culverts, road | Innundated | Innundated | Innundated | **1** | Watsonville Slough at Harkins Slough Road: Winter road closure, Road is control structure, poor channel delineation and dense vegetation N of Harkins Slough Rd to Main St. |
| 10 | SS | J | Bridge | NA | NA | NA | 4 | Highway 1 at Struve Slough; overpass has sufficient clearance. |
| 11 | SS | J | 2 CMP Road | Innundated | Innundated | Innundated | **1** | Harkins Slough Road at Struve Slough: Winter Road Closure, 2/2001 approx. 60' of Rd inundated with depth up to 2.5'. |
| 12 | WB | H | CMP | Inaccessable | Inaccessable | Inaccessable | 5 | Harkins Slough Road at West Branch, culvert clogged. |
| 13 | UHS | F | 1 CB Road | 6 | 6 | NA | **1** | Harkins Slough Road at Harkins Slough. Yearly road closure. Road acting as control structure constricting flow, 2/2001 approx. 150' of Rd inundated with depths up to 2.5'. |
| 14 | GS | E | 1 CMP | NA | NA | 1 | 4 | City Dump subsurface discharge point directly into Gallighan Slough |
| 15 | GS | E | 1CMP | NA | NA | 3 | 4 | Buena Vista Drive at Gallighan Slough |
| 16 | UHS | F | Bridge | 30 | 6 | NA | 4 | Upper Harkins Slough at Ramport Rd. Confluence of LV & WMAN. Adequate when cleared of debris; all flow constricted to a width of 10.5' due to piles of debris. |
| 17 | UWS | K | 2 CC | NA | NA | 5.5 | 4 | Main Street at Watsonville Slough: Extensive invasive blackberry growth at outflow of structure |
| 18 | SS | J | 1 CMP | NA | NA | 3 | **1** | Main Street at Struve Slough, properly sized culvert, but placed at wrong elevation resulting in 3' head cut (erosion) downstream. |
| 19 | WB | G | CB | 2 | 2 | NA | 4 | Highway 1 at West Branch |
| 20 | LV | B | Overpass | NA | NA | NA | 4 | Highway 1 at Harkins Slough |
| 21 | LV | B | Bridge | 7.2 | 18 | NA | 4 | Buena Vista Drive at Harkins Slough |
| 22 | LV | B | CMP | NI | NI | NI | 6 | Larkin Valley crossing Larkin Valley Rd |
| 23 | SS | I | CMP | NI | NI | NI | 6 | Pennsylvania Drive at Struve Slough |
| 24 | SS | I | 1 CMP | NA | NA | 3.5 | 4 | Airport Blvd. at Upper Struve Slough |
| 25 | WMAN | C | 2 CC | NA | NA | 3.5 | 4 | Harkins Trib beneath Jennings Industrial Park |
| 26 | WMAN | C | 1 CB | 3.5 | 4 | NA | 4 | Harkins Trib at Hwy 1 |
| 27 | LV | B | 1 CMP | 3.5 | 5.5 | NA | 4 | Draining S. portion of Buena Vista Rd/ Intersection of Buena Vista Rd, Larkin Valley Rd. |
| 28 | LV | A | NA | 7 | 5 | NA | 4 | Larkin Valley at White Rd |
| 29 | GS | E | 1 CMP | NA | NA | 1 | 6 | Outfall of pumped water from County Dump property into road side ditch that eventually goes underground and surfaces at control structure 14 |
| 30 | GS | E | 1 CB | 3 | 7 | NA | 2 | Buena Vista Rd at County Dump entrance; only 1.5 ft of clearance due to siltation. |
| 32 | GS | E | 1 CMP | NA | NA | 3 | 2 | Intersection of Gallighan Slough and road on dump property |
| 33 | GS | E | 1 CMP | NA | NA | 1 | 4 | Culvert draining agricultural fields is perched by 4' with an extremely high sediment load in water. Simultaneous erosion and sedimentation in Buena Vista roadside ditch. |
| 34 | GS | E | 1 CMP | NA | NA | 2 | 2 | Beneath Whiskey Hill Rd @ Buena Vista Rd, clogged due to high sediment load from 33 |
| 35 | HSWS | Q | Bridge | 35 | 30 | NA | 4 | San Andreas Rd at Watsonville Slough: 25' of water clearance |
| 36 | MWS | O | 2 90 turns | NA | NA | NA | **1** | 2 90° turns in stream channel, high amount of sedimentation, visual high spots |
| 37 | MWS | O | 3 90 turns | NA | NA | NA | **1** | 3 90° turns in stream channel, high amount of sedimentation, visual high spots |
| 38 | UWS | M | 2 CMP | NA | NA | 3.5 | 3 | Watsonville Slough at 356 Kearney Rd driveway. Culverts improperly placed at too high an elevation. Driveway acting as dam, creating inundation N of driveway. |
| 39 | UWS | M | Storm Drain Outlet | NA | NA | 0.5 | 5 | Stormdrain outlet discharging directly into Watsonville Slough |
| 40 | HSWS | Q | 1 90 turn | NA | NA | NA | **1** | Confluence of drainage ditch West of Harkins Slough proper and Harkins Slough. High siltation, visual high spot |
| 41 | HSWS | R | Confluence | NA | NA | NA | 5 | Confluence of Beach Rd drainage ditch and Watsonville Slough at San Andreas Rd; no control structure. |
| 42 | WSE | V | 6 CC | NA | NA | 5.5 | 3 | Beach Rd at Watsonville Slough Estuary: restrict full tidal mixing and debris preventing proper operation |

*NA: Not Applicable; NI: No Information

**Index of Control Structure Function**

| Rating | Description |
|---|---|
| 1 | major drainage constriction |
| 2 | clogged/ inoperable |
| 3 | inadequately sized |
| 4 | adequately sized |
| 5 | not applicable |
| 6 | no information |

**Index of Control Structure Types**

| ID | Description |
|---|---|
| CC | Concrete circular culvert |
| CB | Concrete box culvert |
| CMP | Corrogated metal pipe culvert |

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**Table A-4: Summary of Previous Water Quality Studies within Watsonville Slough Watershed**

| Sample Site [a] | Sampling Date [b] | Source Agency [c] | $H_2O$ Sample Analysis [d] | | | | Tissue Analysis [e] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Hydrographic [f] | Nutrients [g] | Trace Metals [h] | Organo-chlorines [i] | Organism | Trace Metals [h] | Organo-chlorines [i] |
| 1 | 11/17/82 | SMW | | | | | Mussels | | X |
| | 11/17/89 | SMW | | | | | Mussels | | X |
| | 11/28/83 | SMW | | | | | Mussels | | X |
| | 12/12/79 | HSA | X | | X | | | | |
| | 1/27/86 | SMW | | | | | Mussels | | X |
| | 4/22/80 | HSA | X | | X | | | | |
| | | | | | | | | | |
| 2 | 5/29/80 | LCP | | | | X | | | |
| | 11/94-04/96 | Hunt, et al. | | | | | Crustaceans | X | X |
| | | | | | | | | | |
| 3 | 10/5/95 | Questa (A44) | X | X | | X | | | |
| | 10/13/94 | DEH | X | | | | | | |
| | 11/15/94 | Questa (A44) | X | X | X | X | | | |
| | 11/22/94 | DEH | X | | | | | | |
| | 12/12/94 | DEH | X | | | | | | |
| | 12/14/94 | Questa (A44) | X | X | X | X | | | |
| | 12/21/87 | DEH | X | | | | | | |
| | 1/21/95 | PVWMA | X | | X | X | | | |
| | 2/1/88 | DEH | X | | | | | | |
| | 2/6/95 | DEH | X | | | | | | |
| | 2/18/95 | PVWMA | X | | | | | | |
| | 4/3/95 | PVWMA | X | | | | | | |
| | 4/3/95 | DEH | X | | | | | | |
| | 5/1/95 | DEH | X | | | | | | |
| | 5/9/97 | HSA | X | | X | | | | |
| | 5/29/80 | LCP | | | | X | | | |
| | 6/5/95 | DEH | X | | | | | | |
| | 6/13/89 | DEH | X | | | | | | |
| | 7/5/95 | DEH | X | | | | | | |

| Sample Site [a] | Sampling Date [b] | Source Agency [c] | $H_2O$ Sample Analysis [d] | | | | Tissue Analysis [e] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Hydrographic [f] | Nutrients [g] | Trace Metals [h] | Organo-chlorines [i] | Organism | Trace Metals [h] | Organo-chlorines [i] |
| **3 (cont.)** | 7/11/94 | DEH | X | | | | | | |
| | 7/31/95 | DEH | X | | | | | | |
| | 8/6/97 | HSA | X | | X | | | | |
| | 9/7/94 | Questa (A44) | X | X | X | X | | | |
| | 9/12/94 | DEH | X | | | | | | |
| | 9/24/96 | HSA | X | | X | | | | |
| | 11/94-04/96 | Hunt, et al. | | | | | Crustaceans | X | X |
| | | | | | | | | | |
| **4** | 10/5/95 | Questa (A41) | X | X | | | | | |
| | 10/8/96 | HSA | X | X | | | | | |
| | 10/18/94 | PVWMA | X | | | | | | |
| | 10/25/96 | HSA | X | X | | | | | |
| | 10/29/96 | HSA | X | X | | | | | |
| | 11/5/96 | HSA | | | | | Clams | X | X |
| | 11/15/94 | Questa (A41) | X | X | X | X | | | |
| | 11/19/96 | HSA | X | X | | | | | |
| | 11/19/97 | HSA | X | X | | | | | |
| | 12/14/94 | Questa (A41) | X | X | X | X | | | |
| | 1/3/97 | HSA | X | X | | | | | |
| | 1/3-5/97 | HSA | X | X | | | | | |
| | 1/21/95 | PVWMA | X | | | | | | |
| | 1/29/97 | HSA | X | X | | | | | |
| | 1/29-31/97 | HSA | X | X | | | | | |
| | 2/2/88 | SMW | | | | | Mussels | | X |
| | 2/18/95 | PVWMA | X | | | | | | |
| | 3/10/98 | SMW | | | | | Mussels | | X |
| | 4/3/95 | PVWMA | X | | | | | | |
| | 4/6/84 | HSA | X | | X | | | | |
| | 4/8/97 | HSA | X | X | | | | | |
| | 4/8/98 | HSA | X | X | | | | | |
| | 5/9/97 | HSA | X | | X | | | | |
| | 5/18/81 | HSA | X | | X | | | | |

| Sample Site [a] | Sampling Date [b] | Source Agency [c] | $H_2O$ Sample Analysis [d] | | | | Tissue Analysis [e] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Hydrographic [f] | Nutrients [g] | Trace Metals [h] | Organo-chlorines [i] | Organism | Trace Metals [h] | Organo-chlorines [i] |
| **4 (cont.)** | 5/23/77 | HSA | X | | X | | | | |
| | 5/29/80 | HSA | X | | X | | | | |
| | 5/29/80 | LCP | | | | X | | | |
| | 6/16/97 | HSA | X | X | | | | | |
| | 6/30/80 | LCP | | | | X | | | |
| | 8/6/97 | HSA | X | | X | | | | |
| | 9/7/94 | Questa (A41) | X | X | X | X | | | |
| | 9/17/97 | HSA | X | X | | | | | |
| | 9/19/96 | HSA | X | X | | | | | |
| | 9/24/96 | HSA | X | | X | | | | |
| | 9/28/82 | HSA | X | | X | | | | |
| | | | | | | | | | |
| **5** | 11/94-04/96 | Hunt, et al. | | | | | Crustaceans | X | X |
| | | | | | | | | | |
| **6** | 10/5/95 | Questa (A32) | X | X | | | | | |
| | 10/8/96 | HSA | X | X | | | | | |
| | 10/8-9/96 | HSA | X | X | | | | | |
| | 10/18/94 | PVWMA | X | | | | | | |
| | 10/23-25/96 | HSA | X | X | | | | | |
| | 10/25/96 | HSA | X | X | | | | | |
| | 10/29/96 | HSA | X | X | | | | | |
| | 10/29-31/96 | HSA | X | X | | | | | |
| | 11/5/96 | HSA | | | | | Clams | X | X |
| | 11/15/94 | PVWMA | X | | | | | | |
| | 11/15/94 | Questa (A32) | X | X | X | X | | | |
| | 11/19/96 | HSA | X | X | | | | | |
| | 11/19/97 | HSA | X | X | | | | | |
| | 11/19-21/96 | HSA | X | X | | | | | |
| | 12/8/94 | PVWMA | X | | | | | | |
| | 12/14/94 | Questa (A32) | X | X | X | X | | | |
| | 1/3/97 | HSA | X | X | | | | | |

| Sample Site [a] | Sampling Date [b] | Source Agency [c] | $H_2O$ Sample Analysis [d] | | | | Tissue Analysis [e] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Hydrographic [f] | Nutrients [g] | Trace Metals [h] | Organo-chlorines [i] | Organism | Trace Metals [h] | Organo-chlorines [i] |
| **6 (cont.)** | 1/21/95 | PVWMA | X | | X | X | | | |
| | 1/29/97 | HSA | X | X | | | | | |
| | 2/18/95 | PVWMA | X | | | | | | |
| | 2/25/95 | PVWMA | | | | X | | | |
| | 4/3/95 | PVWMA | X | | X | X | | | |
| | 4/8/97 | HSA | X | X | | | | | |
| | 4/8/98 | HSA | X | X | | | | | |
| | 4/8-10/97 | HSA | X | X | | | | | |
| | 6/5/85 | TSMP | | | | | Fish | X | X |
| | 6/15/84 | TSMP | | | | | Fish | | X |
| | 6/16/97 | HSA | X | X | | | | | |
| | 6/16-18/97 | HSA | X | X | | | | | |
| | 8/12/92 | TSMP | | | | | Fish | X | |
| | 9/7/94 | Questa (A32) | X | X | X | X | | | |
| | 9/17/97 | HSA | X | X | | | | | |
| | 9/19/96 | HSA | X | X | | | | | |
| | | | | | | | | | |
| **7** | 10/18/94 | PVWMA | X | | | | | | |
| | 11/15/94 | PVWMA | X | | X | X | | | |
| | 12/8/94 | PVWMA | X | | | | | | |
| | 1/21/95 | PVWMA | X | | X | X | | | |
| | 2/18/95 | PVWMA | X | | | | | | |
| | 3/7/95 | PVWMA | | | | X | | | |
| | 4/3/95 | PVWMA | X | | X | X | | | |
| | | | | | | | | | |
| **8** | 11/26/86 | SMW | | | | | Clams | | X |
| | 12/6/85 | SMW | | | | | Clams | | X |
| | 2/3/88 | SMW | | | | | Clams | | X |
| | 6/5/88 | TSMP | | | | | Fish | | X |
| | | | | | | | | | |
| **9** | 4/6/84 | HSA | X | | X | | | | |

| Sample Site [a] | Sampling Date [b] | Source Agency [c] | $H_2O$ Sample Analysis [d] | | | | Tissue Analysis [e] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Hydrographic [f] | Nutrients [g] | Trace Metals [h] | Organo-chlorines [i] | Organism | Trace Metals [h] | Organo-chlorines [i] |
| **9 (cont.)** | 4/22/80 | HSA | X | | X | | | | |
| | 5/9/97 | HSA | X | | X | | | | |
| | 5/18/81 | HSA | X | | X | | | | |
| | 5/27/85 | HSA | X | | X | | | | |
| | 8/6/97 | HSA | X | | X | | | | |
| | 9/24/96 | HSA | X | | X | | | | |
| | 9/28/82 | HSA | X | | X | | | | |
| | | | | | | | | | |
| **10** | 10/5/94 | Questa (A34) | X | X | X | | | | |
| | 11/15/94 | Questa (A34) | X | X | X | X | | | |
| | 11/22/94 | DEH | X | | | | | | |
| | 12/12/94 | DEH | X | | | | | | |
| | 12/14/94 | Questa (A34) | X | X | X | | | | |
| | 2/6/95 | DEH | X | | | | | | |
| | 5/1/95 | DEH | X | | | | | | |
| | 5/9/97 | HSA | X | | X | | | | |
| | 6/5/95 | DEH | X | | | | | | |
| | 7/28/88 | TSMP | | | | | Fish | | X |
| | 7/31/95 | DEH | X | | | | | | |
| | 8/6/97 | HSA | X | | X | | | | |
| | 9/7/94 | Questa (A34) | X | X | X | X | | | |
| | 9/24/96 | HSA | X | | X | | | | |
| | | | | | | | | | |
| **11** | 10/2/86 | TSMP | | | | | Fish | | X |
| | 10/5/94 | Questa (A42) | X | X | X | | | | |
| | 10/25/96 | HSA | X | | X | | | | |
| | 11/15/94 | Questa (A42) | X | X | X | X | | | |
| | 11/19/97 | HSA | X | X | | | | | |
| | 12/14/94 | Questa (A42) | X | X | X | | | | |
| | 4/8/98 | HSA | X | X | | | | | |
| | 5/9/97 | HSA | X | | X | | | | |

| Sample Site [a] | Sampling Date [b] | Source Agency [c] | $H_2O$ Sample Analysis [d] | | | | Tissue Analysis [e] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Hydrographic [f] | Nutrients [g] | Trace Metals [h] | Organo-chlorines [i] | Organism | Trace Metals [h] | Organo-chlorines [i] |
| **11 (cont.)** | 8/6/97 | HSA | X | | X | | | | |
| | 9/7/94 | Questa (A42) | X | X | X | X | | | |
| | 9/24/96 | HSA | X | | X | | | | |
| | | | | | | | | | |
| **12** | 10/5/94 | Questa (A61) | X | X | X | | | | |
| | 10/8/96 | HSA | X | X | | | | | |
| | 10/13/94 | DEH | X | | | | | | |
| | 10/25/96 | HSA | X | X | | | | | |
| | 10/29/96 | HSA | X | X | | | | | |
| | 11/15/94 | Questa (A61) | X | X | X | X | | | |
| | 11/19/96 | HSA | X | X | | | | | |
| | 11/19/97 | HSA | X | X | | | | | |
| | 11/22/94 | DEH | X | | | | | | |
| | 12/12/94 | DEH | X | | | | | | |
| | 12/14/94 | Questa (A61) | X | X | X | | | | |
| | 1/3/97 | HSA | X | X | | | | | |
| | 1/29/97 | HSA | X | X | | | | | |
| | 2/6/95 | DEH | X | | | | | | |
| | 2/11/92 | DEH | X | | | | | | |
| | 2/25/92 | DEH | X | | | | | | |
| | 4/3/95 | DEH | X | | | | | | |
| | 4/8/97 | HSA | X | X | | | | | |
| | 4/8/98 | HSA | X | X | | | | | |
| | 5/1/95 | DEH | X | | | | | | |
| | 5/9/97 | HSA | X | | X | | | | |
| | 5/29/80 | HSA | X | | X | | | | |
| | 6/5/95 | DEH | X | | | | | | |
| | 6/16/97 | HSA | X | X | | | | | |
| | 7/5/95 | DEH | X | | | | | | |
| | 7/11/94 | DEH | X | | | | | | |
| | 7/31/95 | DEH | X | | | | | | |
| | 8/6/97 | HSA | X | | X | | | | |

| Sample Site [a] | Sampling Date [b] | Source Agency [c] | $H_2O$ Sample Analysis [d] | | | | Tissue Analysis [e] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Hydrographic [f] | Nutrients [g] | Trace Metals [h] | Organo-chlorines [i] | Organism | Trace Metals [h] | Organo-chlorines [i] |
| **12 (cont.)** | 9/7/94 | Questa (A61) | X | X | X | X | | | |
| | 9/12/94 | DEH | X | | | | | | |
| | 9/17/97 | HSA | X | X | | | | | |
| | 9/19/96 | HSA | X | X | | | | | |
| | | | | | | | | | |
| **13** | 10/5/94 | Questa (A62) | X | X | X | | | | |
| | 11/15/94 | Questa (A62) | X | X | X | X | | | |
| | 12/14/94 | Questa (A62) | X | X | X | | | | |
| | | | | | | | | | |
| **14** | 4/11/89 | DEH | X | | | | | | |
| | | | | | | | | | |
| **15** | 4/4/898 | DEH | X | | | | | | |
| | | | | | | | | | |
| **16** | 3/13/90 | DEH | X | | | | | | |
| | | | | | | | | | |
| **17** | 4/4/89 | DEH | X | | | | | | |
| | 4/11/89 | DEH | X | | | | | | |
| | | | | | | | | | |
| **18** | 3/6/90 | DEH | X | | | | | | |
| | 3/13/90 | DEH | X | | | | | | |
| | 3/20/90 | DEH | X | | | | | | |
| | 3/27/90 | DEH | X | | | | | | |
| | | | | | | | | | |
| **19** | 4/4/89 | DEH | X | | | | | | |
| | 4/11/89 | DEH | X | | | | | | |
| | 4/18/89 | DEH | X | | | | | | |
| | 4/25/89 | DEH | X | | | | | | |
| | 5/2/89 | DEH | X | | | | | | |
| | 5/16/89 | DEH | X | | | | | | |
| | | | | | | | | | |

| Sample Site [a] | Sampling Date [b] | Source Agency [c] | $H_2O$ Sample Analysis [d] | | | | Tissue Analysis [e] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Hydrographic [f] | Nutrients [g] | Trace Metals [h] | Organo-chlorines [i] | Organism | Trace Metals [h] | Organo-chlorines [i] |
| **20** | 11/5/96 | HSA | | | | | Clams | X | X |
| | 12/12/79 | HSA | X | | X | | | | |
| | 4/6/84 | HSA | X | | X | | | | |
| | 4/22/80 | HSA | X | | X | | | | |
| | 5/18/81 | HSA | X | | X | | | | |
| | 5/23/77 | HSA | X | | X | | | | |
| | 5/27/85 | HSA | X | | X | | | | |
| | 5/29/80 | LCP | | | | X | | | |
| | 6/5/85 | TSMP | | | | | Fish | | X |
| | 6/30/80 | LCP | | | | X | | | |
| | 7/28/88 | TSMP | | | | | Fish | | X |
| | 9/28/82 | HSA | X | | X | | | | |
| | 11/94-04/96 | Hunt, et al. | | | | | Crustaceans | X | X |
| | | | | | | | | | |
| **21** | 10/8/96 | HSA | X | X | | | | | |
| | 10/13/94 | DEH | X | | | | | | |
| | 10/25/96 | HSA | X | | X | | | | |
| | 10/25/96 | HSA | X | X | | | | | |
| | 10/29/96 | HSA | X | X | | | | | |
| | 11/15/94 | Questa (A21) | X | X | X | X | | | |
| | 11/19/96 | HSA | X | X | | | | | |
| | 11/19/97 | HSA | X | X | | | | | |
| | 11/22/94 | DEH | X | | | | | | |
| | 11/26/86 | SMW | | | | | Clams | | X |
| | 12/12/94 | DEH | X | | | | | | |
| | 12/14/94 | Questa (A21) | X | X | X | | | | |
| | 1/3/97 | HSA | X | X | | | | | |
| | 1/29/97 | HSA | X | X | | | | | |
| | 2/2/88 | SMW | | | | | Clams | | X |
| | 2/6/90 | DEH | X | | | | | | |
| | 2/6/95 | DEH | X | | | | | | |

| Sample Site [a] | Sampling Date [b] | Source Agency [c] | $H_2O$ Sample Analysis [d] | | | | Tissue Analysis [e] | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Hydrographic [f] | Nutrients [g] | Trace Metals [h] | Organo-chlorines [i] | Organism | Trace Metals [h] | Organo-chlorines [i] |
| **21 (cont.)** | 2/25/92 | DEH | X | | | | | | |
| | 4/6/84 | HSA | X | | X | | | | |
| | 4/8/97 | HSA | X | X | | | | | |
| | 4/8/98 | HSA | X | X | | | | | |
| | 5/1/95 | DEH | X | | | | | | |
| | 5/9/97 | HSA | X | | X | | | | |
| | 6/5/95 | DEH | X | | | | | | |
| | 6/16/97 | HSA | X | X | | | | | |
| | 6/30/80 | LCP | | | | X | | | |
| | 7/11/94 | DEH | X | | | | | | |
| | 7/31/95 | DEH | X | | | | | | |
| | 8/6/97 | HSA | X | | X | | | | |
| | 9/7/94 | Questa (A21) | X | X | X | X | | | |
| | 9/12/94 | DEH | X | | | | | | |
| | 9/17/97 | HSA | X | X | | | | | |
| | 9/19/96 | HSA | X | X | | | | | |
| | | | | | | | | | |
| **22** | 12/14/94 | Questa (A29) | X | X | X | X | | | |
| | | | | | | | | | |
| **23** | 11/15/94 | Questa (A13) | X | X | X | X | | | |
| | 12/14/94 | Questa (A13) | X | X | X | X | | | |
| | 5/29/80 | LCP | | | | X | | | |
| | 6/30/80 | LCP | | | | X | | | |
| | | | | | | | | | |
| **24** | 6/30/80 | LCP | | | | X | | | |

Footnotes for Table A-4

| Footnote Symbol | Description |
|---|---|
| a | Sample Site: Refer to Figure 4.2.1 for sample site locations. |
| b | Sampling Date: Dates of sample are organized by season. Fall: October – December; Winter: January – March; Spring: April – June; Summer: July – September. |
| c | Source Agency: Refers to the report presented by consulting firm or government agency. See Table 4.2.3 for complete citations. |
| d | $H_2O$ Sample Analysis: Data provided from spot water sampling. Water was collected at said location within Watsonville Slough Watershed. |
| e | Tissue Analysis: Data obtained for a particular time period from transplanted organisms to said location in Watsonville Slough Watershed. |
| f | Hydrographic: Water quality data that may include: turbidity, pH, dissolved oxygen, temperature, conductivity, minerals analysis, the presence of oil & grease and/or fecal coliform bacteria. |
| g | Nutrients: Nutrients may include ammonia ($NH_3$), nitrate and nitrite ($NO_x$) and phosphate ($HPO_4^{2-}$). |
| h | Trace Metals: Trace metals may include Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Se and Zn. |
| i | Organochlorines: Organochlorines may include DDT, Dicloran, Endosulfan Sulfate, Iprodione, Dacthal, Oxyfluorfen, Toxaphene, Chlordane, PCB, HCB, Diazinon, Dieldren, Chlorpyrifos, Oxydiazon and Heptachlor Epoxide. |

References cited in Table A-4

| Acronym | Citation |
|---|---|
| **DEH** | Santa Cruz County Department of Environmental Health Recent Coliform Bacteria Testing as cited in: Questa Engineering Corporation (1995). Water Resources Management Plan for Watsonville Slough System, Santa Cruz County, prepared for Association of Monterey Bay Area Governments**:** Section 6, Appendix D. |
| **HSA** | Summary and Conclusions of Water Quality Sampling for Toxic Substances in Watsonville Sloughs. Santa Cruz County, Santa Cruz County Environmental Health Service Water Quality Laboratory. |
| **Hunt, et al** | J. W. Hunt, B. S. A., B. M. Phillips, R. S. Tjeerdema, H. M. Puckett, V. deVlaming (1999). "Patterns of aquatic toxicity in an agriculturally dominated coastal watershed in California." Agriculture, Ecosystems, and Environment **75**: 75-91. |
| **LCP** | (1980). Pesticide Tests in the South County Sloughs. Santa Cruz County, Local Coastal Program**:** 1-2, 31. |
| **PVWMA** | Pajaro Valley Water Management Agency Water Quality Sampling Summary as cited in: Questa Engineering Corporation (1995). Water Resources Management Plan for Watsonville Slough System, Santa Cruz County, prepared for Association of Monterey Bay Area Governments**:** Section 6, Appendix D. |
| **Questa** | Questa Engineering Corporation (1995). Water Resources Management Plan for Watsonville Slough System, Santa Cruz County, prepared for Association of Monterey Bay Area Governments**:** Section 6, Appendix D. |
| **SMW** | State Mussel Watch Data Reports 1977-1993 as cited in: Summary and Conclusions of Water Quality Sampling for Toxic Substances in Watsonville Sloughs. Santa Cruz County, Santa Cruz County Environmental Health Service Water Quality Laboratory. |
| **TSMP** | Toxic Substances Monitoring Program Data Reports 1977-1991 as cited in: Summary and Conclusions of Water Quality Sampling for Toxic Substances in Watsonville Sloughs. Santa Cruz County, Santa Cruz County Environmental Health Service Water Quality Laboratory. |

**Figure H-1**

# Trail Master Plan

Access, Alignments, Lookouts, Parking and Crossings Including Proposed Actions


## LEGEND

**Trail Type/Proposed Action**

- Blaze New Trail
- Modify Existing Road
- Modify Existing Trail
- Proposed Boardwalk
- Street Crossing
- Seasonal Bridge Under-Crossing With Gated Access Control
- City Limits
- Access Points
- Vista Lookouts
- Parking

Data sources:

**NOTES**

ADA routes and locations of access points were determined during field investigations by Swanson Hydrology & Geomorphology, July-August 2001.

Street names and city limits provided by the City of Watsonville.

Imagery by Airphoto USA, Inc. acquired in 2001 and provided by the City of Watsonville.


*Map produced by:*
Swanson Hydrology & Geomorphology
115 Limekiln Street Santa Cruz, CA 95060
tel: 831.427.0288 fax: 831.427.0472


Scale
1:9600 or 1 inch = 800 ft

1000 0 1000 2000 Feet


October 2001

# CONCEPTUAL STREAM STABILIZATION PLAN

## FOR JONES / LEE PROPERTY

APN 49-101-62

PREPARED AT THE REQUEST OF

## COUNTY OF SANTA CRUZ PLANNING DEPARTMENT

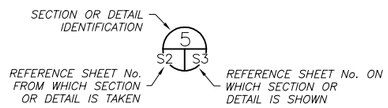
IN ASSOCIATION WITH

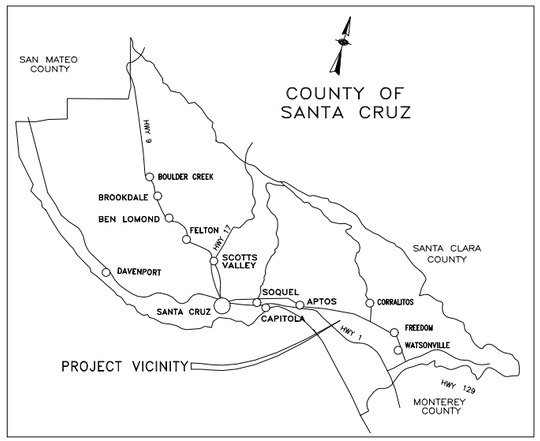
## WATSONVILLE SLOUGHS WATERSHED RESOURCE CONSERVATION AND ENHANCEMENT PLAN

### SHEET INDEX



### SECTION AND DETAIL CONVENTION



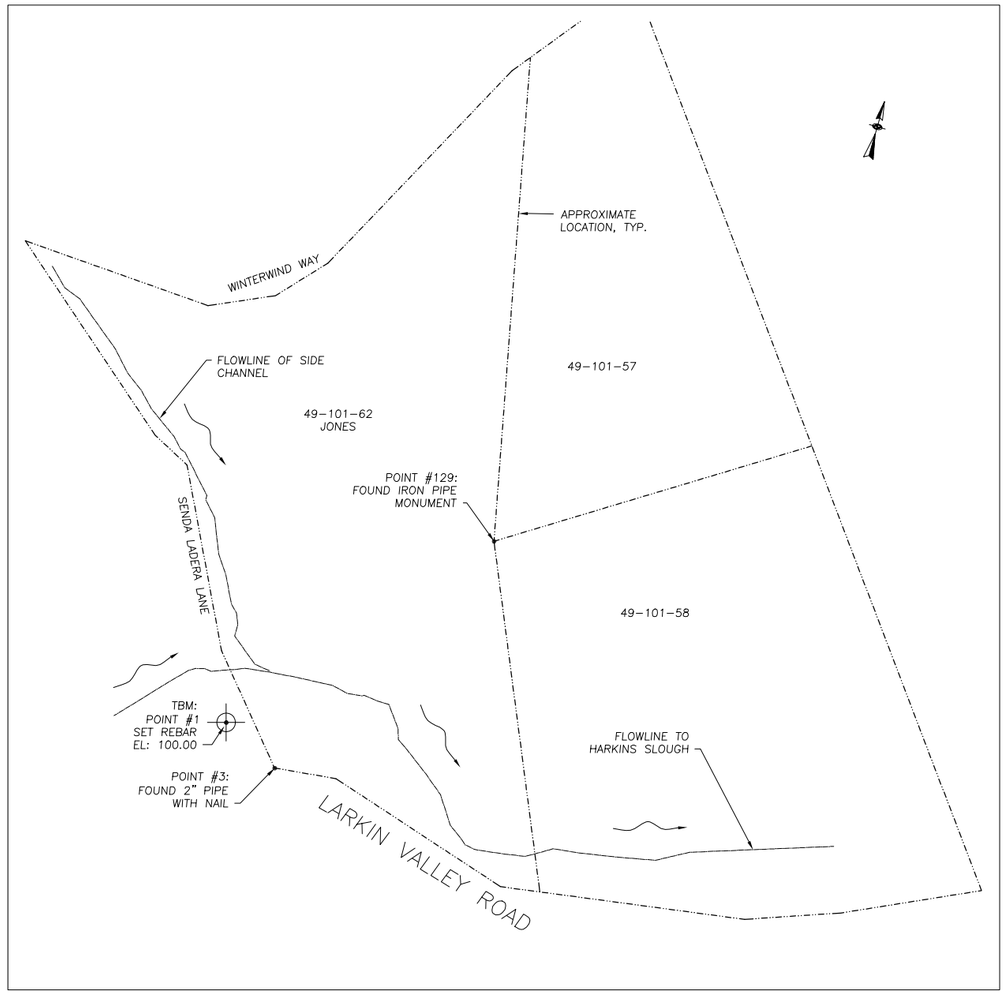




## COUNTY MAP

N.T.S.

### LEGEND

| | |
|---|---|
| N | NEW |
| EL | ELEVATION |
| C.Y. | CUBIC YARD |
| E | EXISTING |
| GALV. | GALVANIZED |
| TYP. | TYPICAL |
| STA | STATION |
| CMP | CORRUGATED METAL PIPE |
| WSL | WATER SURFACE ELEVATION |
| LF | LINEAR FEET |
| CONST. | CONTRUCT |
| CMP | CORRUGATED METAL PIPE |




## VICINITY MAP

SCALE: 1"=100'

### GENERAL NOTES

1) PLANS PREPARED AT THE REQUEST OF:
DONNA BRADFORD, RESOURCE PLANNER IV
COUNTY OF SANTA CRUZ PLANNING DEPARTMENT
RESOURCE CONSERVATION DISTRICT
8045 SOQUEL DRIVE
APTOS, CA 95003

2) BASIS OF BEARINGS: BEST FIT OF FOUND MONUMENTS TO RECORD OF SURVEY MAP VOL. 43 PAGE 48. AND TAX ASSESSOR'S MAP NO. 49–10. SURVEY ORIENTATED ABOUT POINT #129 AND ROTATED TO MATCH POINT #3, AS SHOWN ON THIS SHEET. THIS IS NOT A BOUNDARY SURVEY. PROPERTY LINES SHOWN HEREON WERE COMPILED FROM RECORD INFORMATION AND ARE SUBJECT TO CHANGE, PENDING THE RESULTS OF A TRUE BOUNDARY SURVEY. IT SHALL BE THE RESPONSIBILITY OF THE CLIENT TO DETERMINE BOUNDARY LOCATIONS AND TO OBTAIN ALL NECESSARY EASEMENTS AND PERMISSIONS FOR PERMITTING, CONSTRUCTION AND MAINTENANCE PURPOSES.

3) ELEVATION DATUM: ASSUMED ELEVATION OF 100.00 AT POINT #1 AS SHOWN ON THIS SHEET.

4) FIELD WORK WAS PERFORMED BY SH&G ENGINEERING IN AUGUST, 2002.

5) ENGINEERING DESIGNS SHOWN ON THESE PLANS ARE OF A PRELIMINARY AND CONCEPTUAL NATURE ONLY. THESE DESIGNS ARE SHOWN TO CONVEY GENERAL IDEAS AND APPROACHES. DESIGN DETAILS ARE NOT FINAL, AND ARE NOT DRAWN TO SCALE. THESE DESIGNS ARE NOT TO BE USED FOR CONSTRUCTION PURPOSES.

6) ALL DISTURBED AREAS TO BE REVEGETATED, PER REVEGETATION PLAN, PREPARED BY OTHERS.

### APPROXIMATE GRADING QUANTITIES

| | CUT | FILL | NET |
|---|---|---|---|
| MAIN CHANNEL | 300 | 50 | 250 CUT |
| SIDE CHANNEL | 1000 | 500 | 500 CUT |
| NET | 1300 | 550 | 750 CUT |

ALL FIGURES EXPRESSED IN CUBIC YARDS

GRAPHIC SCALE
100 0 50 100 200 400
( IN FEET )
1 inch = 100 ft.

| Rev | Date | By |
|---|---|---|
| | NOT FOR CONSTRUCTION | |


SH&G
115 Limekiln Street, Santa Cruz, CA 95060
weld@swansonh2o.com (831)-427-0288
A division of Swanson Hydrology & Geomorphology


Figure K 1

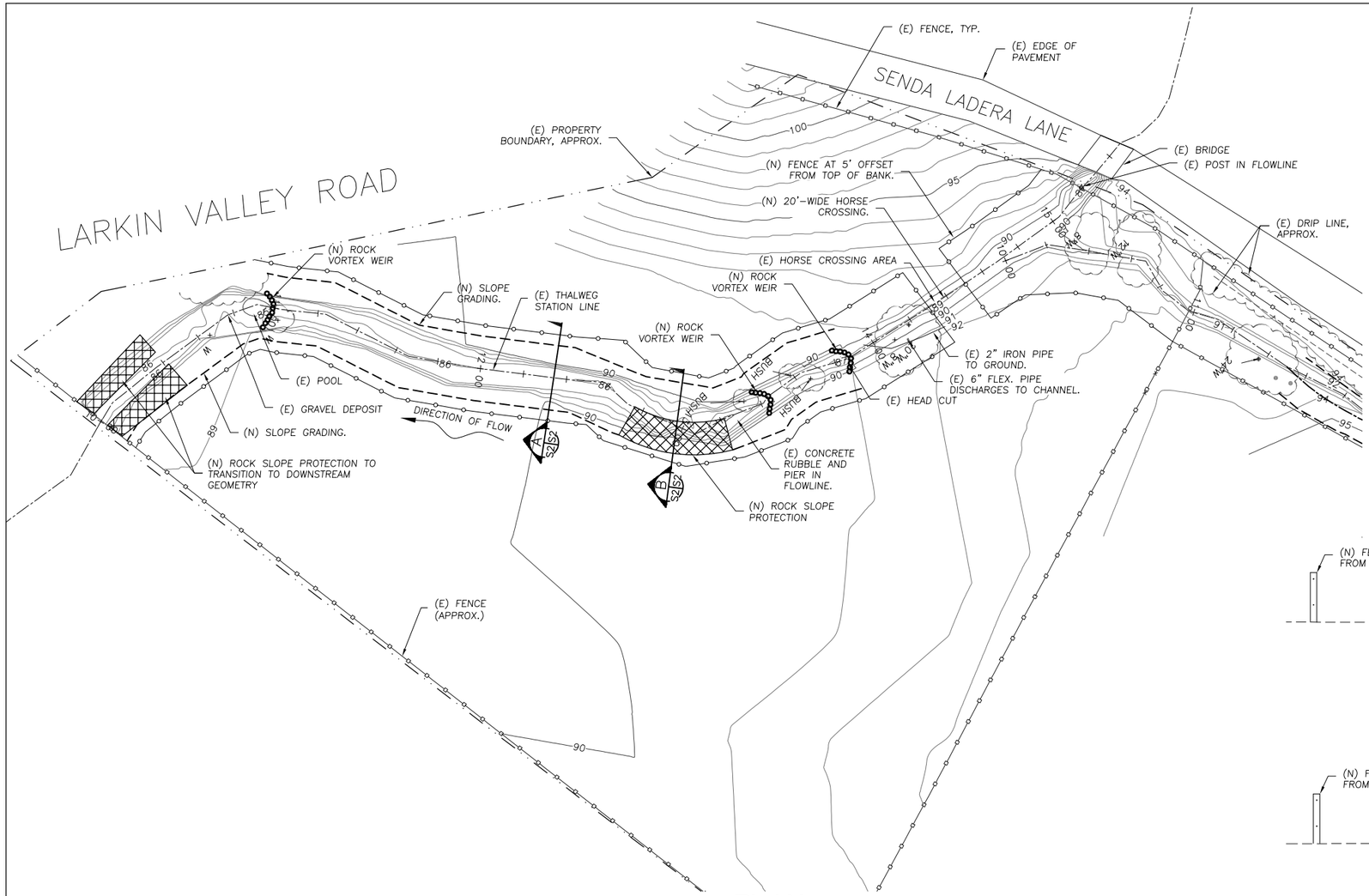
PREPARED AT THE REQUEST OF
SANTA CRUZ COUNTY

COVER SHEET
VICINITY MAP AND GENERAL NOTES

WATSONVILLE SLOUGHS
CONCEPTUAL STREAM STABILIZATION PLAN

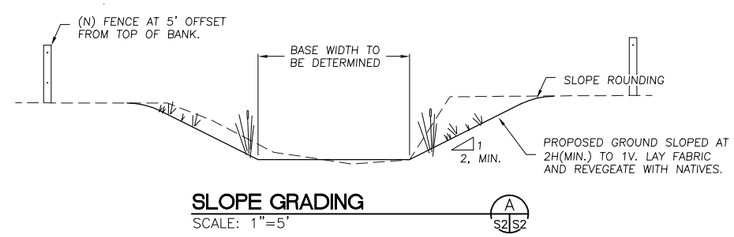
Date 11/02
Scale AS SHOWN
Project 02–311

C1




## PLAN
1"=30'

GRAPHIC SCALE
30 0 15 30 60 120
( IN FEET )
1 inch = 30 ft.




## SLOPE GRADING
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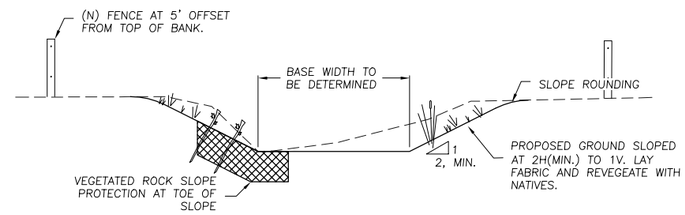


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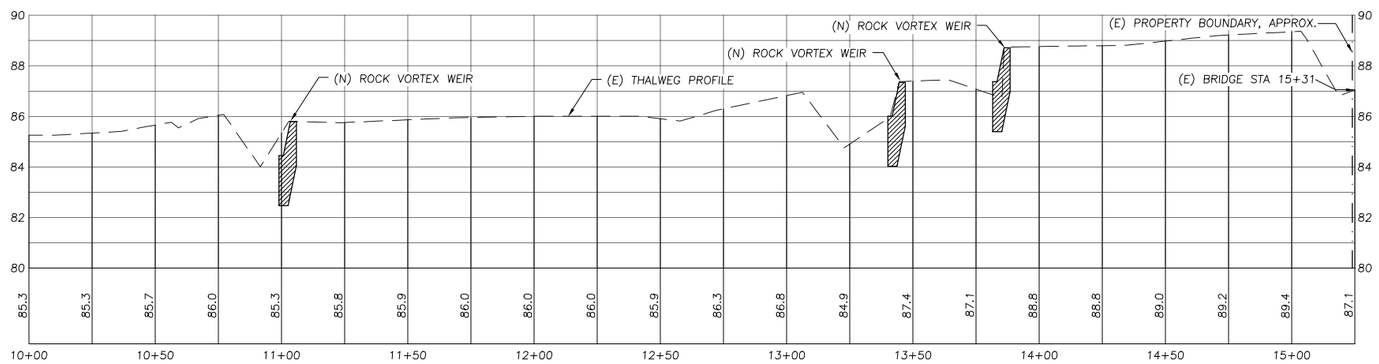
SCALE: 1"=5'  (B S2|S2)




## PROFILE
1"=30'H, 1"=3'V

| Rev | Date | By |
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**Figure K 2**

PREPARED AT THE REQUEST OF
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JONES SITE
MAIN CHANNEL
CONCEPTUAL
RESTORATION
PLAN

WATSONVILLE SLOUGHS
CONCEPTUAL STREAM
STABILIZATION PLAN

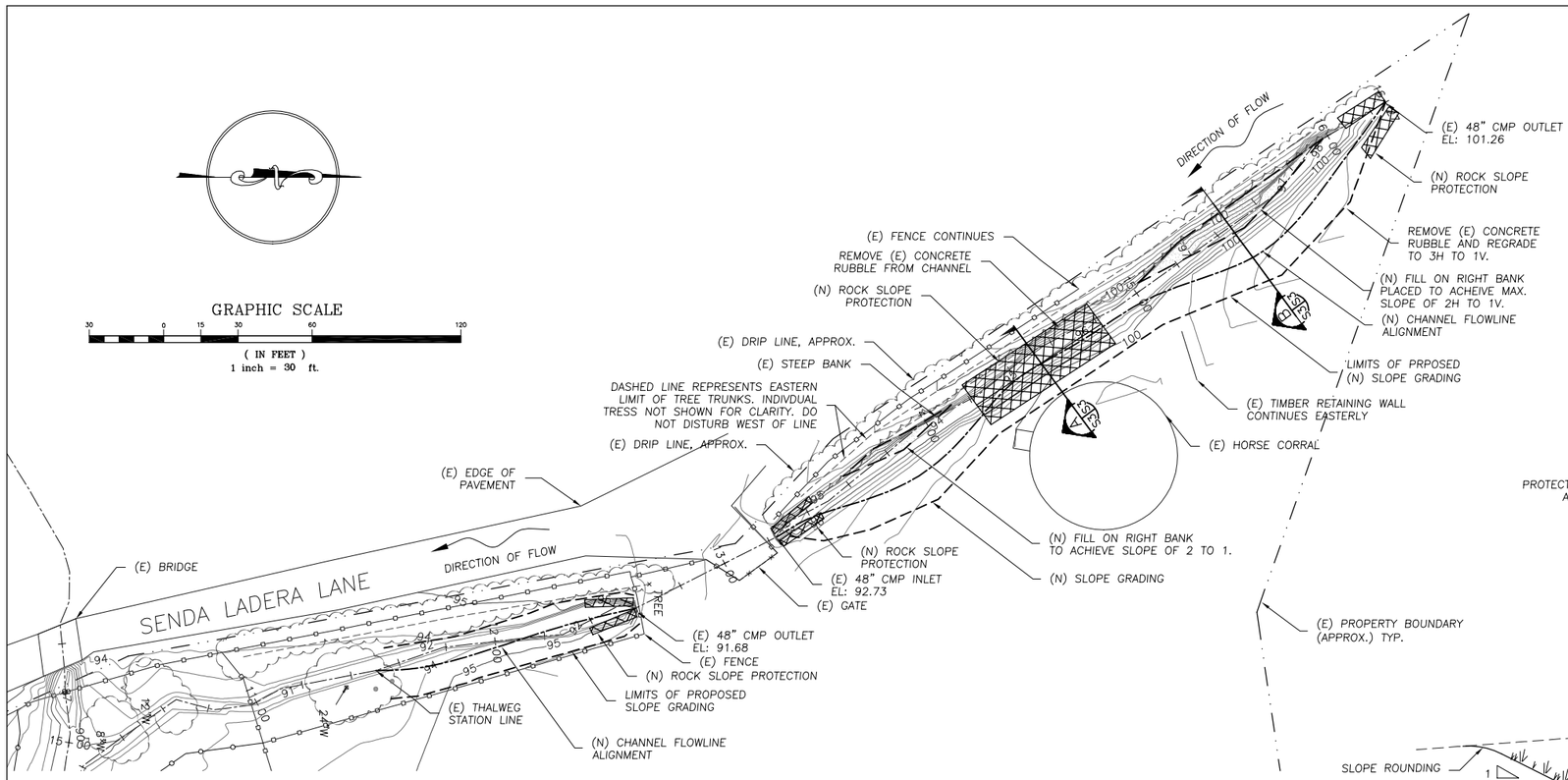
Date 11/02
Scale AS SHOWN
Project 02-311

C2

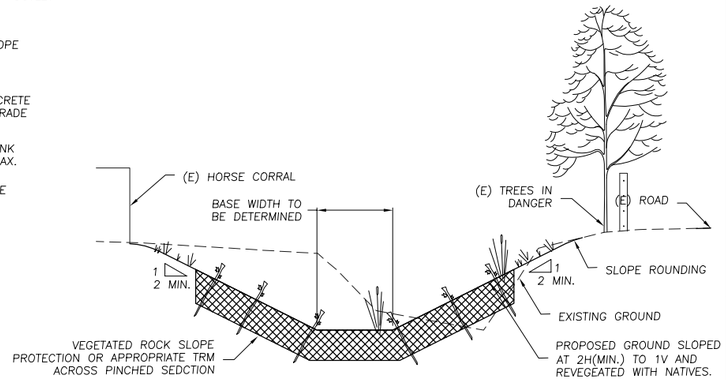
GRAPHIC SCALE

30 0 15 30 60 120

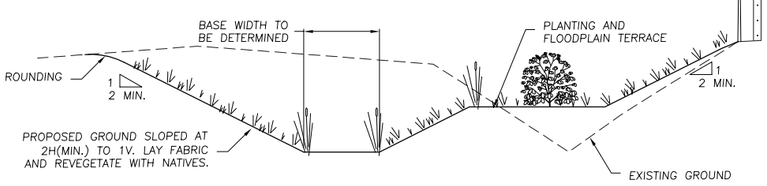
( IN FEET )
1 inch = 30 ft.



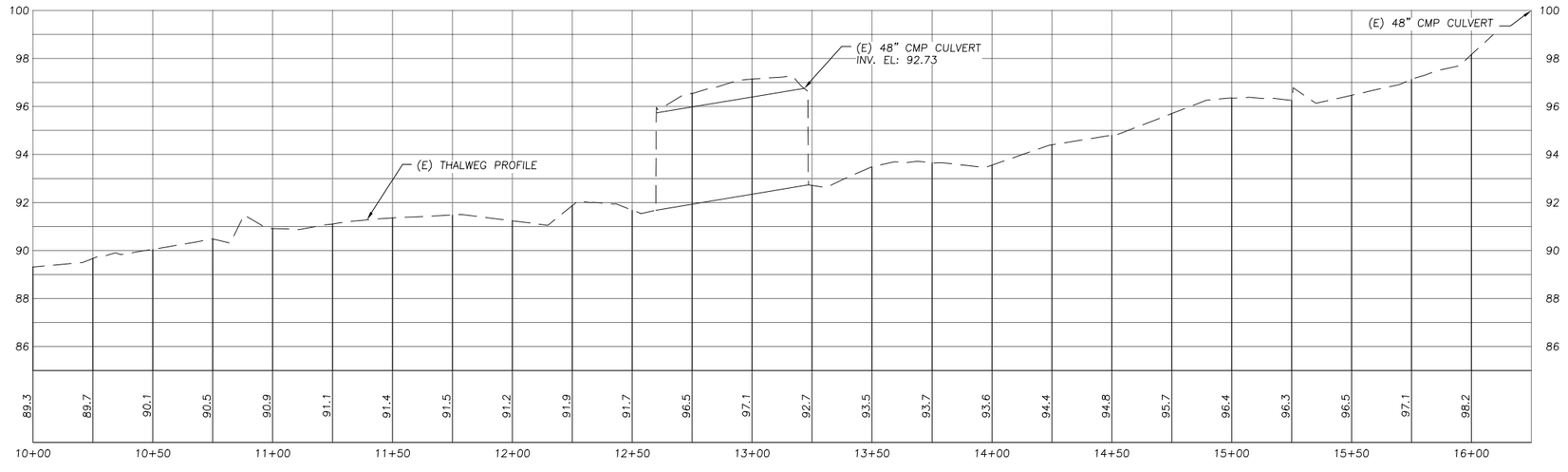

## PLAN
1"=30'




## ROCK SLOPE PROTECTION
SCALE: 1"=5'




## SLOPE GRADING
SCALE: 1"=5'




## PROFILE
1"=30'H, 1"=3'V

| Rev | Date | | By |
|---|---|---|---|
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Figure K 3

PREPARED AT THE REQUEST OF
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JONES SITE
SIDE CHANNEL
CONCEPTUAL
RESTORATION
PLAN

WATSONVILLE SLOUGHS
CONCEPTUAL STREAM
STABILIZATION PLAN

Date 11/02
Scale AS SHOWN
Project 02-311

C3

LEGEND

- TOE OF SLOPE/WILLOW RIPARIAN REVEGETATION AREA
- MID TO UPPER SLOPE RIPARIAN REVEGETATION AREA
- ROCK SLOPE REVEGETATION AREA

GRAPHIC SCALE

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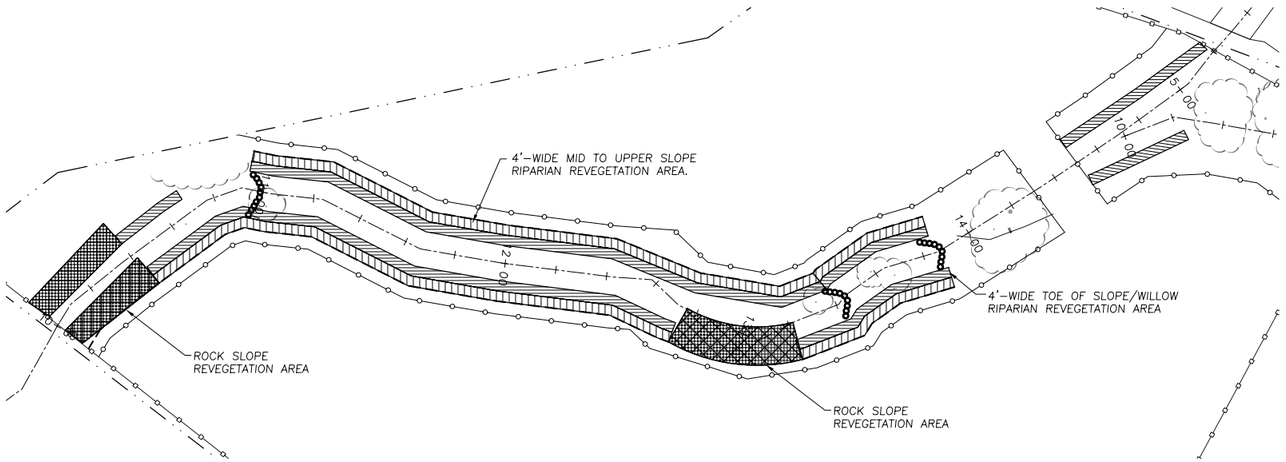
( IN FEET )
1 inch = 30 ft.




## PLANTING PLAN
1"=30'

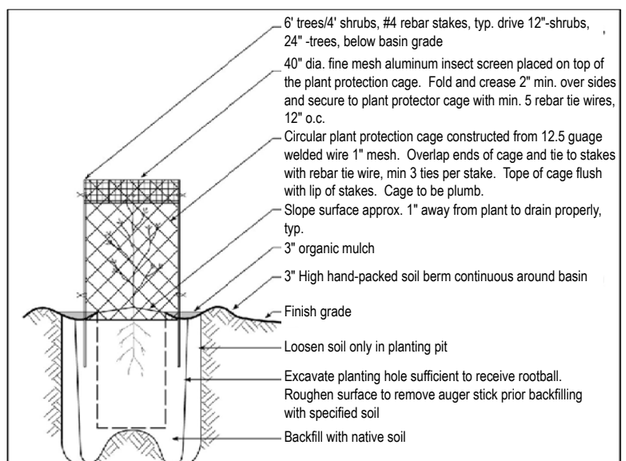
REVEGETATION AREA PLANTING LIST

| Common Name | Scientific Name | Spacing | Approximate Quantity | Plant Size |
|---|---|---|---|---|
| **Willow Riparian Revegetation Areas (0.13 Acre)** | | | | |
| Willow | Willow sp. | 6' o.c. | 193 | Dormant pole cutting installed along creek bank |
| **Mid and Upper Slope Riparian Revegetation Area (0.13 Acre)** | | | | |
| Brown Dogwood | Cornus glabrata | 20' o.c. | 27 | Tree pot |
| Blue Elderberry | Sambucus mexicana | 20' o.c. | 30 | Tree pot |
| Red-flowering Currant | Ribes sanguineum | 6' o.c. | 33 | 1 gallon |
| Mugwort | Artemisia douglasiana | 6' o.c. | 33 | Dee pot |
| California Rose | Rosa californica | 6' o.c. | 33 | Dee pot |
| California Blackberry | Rubus ursinus | 6' o.c. | 34 | Dee pot |
| ROCK SLOPE PROTECTION REVEGETATION AREAS (0.07 ACRE) | | | | |
| Willow | Willow sp. | 6' o.c. | 58 | Dormant pole cutting in rock slope protection |

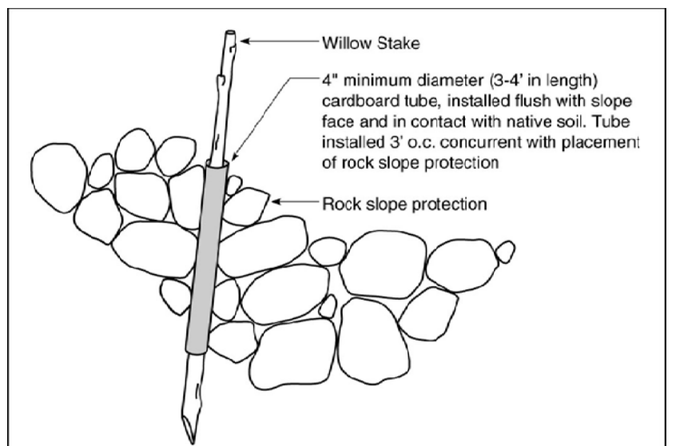
EROSION CONTROL SEEDING LIST

| Common Name | Scientific Name | Application Rate (lbs./acre) | Quantity (lbs.) for 0.26 Acre |
|---|---|---|---|
| Blue Wildrye | Elymus glaucus | 10 | 2.6 |
| California Brome | Bromus carinatus | 10 | 2.6 |
| Meadow Barley | Hordeum branchyantherum | 15 | 3.9 |
| California Brome | Bromus carinatus | 10 | 2.0 |
| Sky Lupine * | Lupinus nanus * | 6 | 1.5 |
| California Poppy | Eschscholtzia californica | 3 | 1.0 |
| Straw Mulch Blanket | N/A | N/A | Tbd |

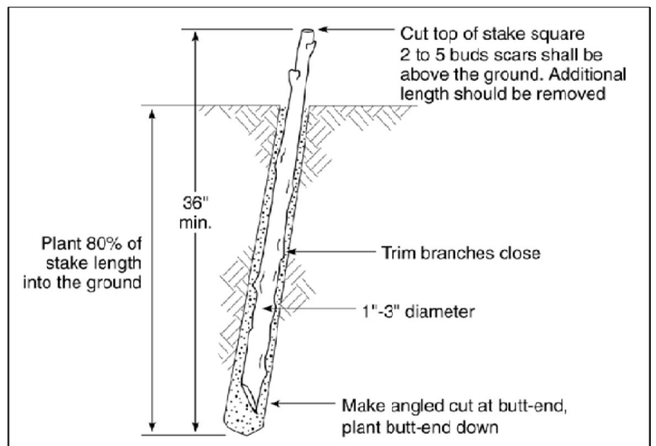
* Legume seed-pellet inoculated



TYPICAL CONTAINER STOCK INSTALLATION DETAIL



WILLOW STAKING DETAIL



WILLOW STAKE DETAIL

## PLANTING DETAILS
N.T.S.

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Figure K 4

PREPARED AT THE REQUEST OF
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JONES SITE
MAIN CHANNEL

CONCEPTUAL PLANTING PLAN

WATSONVILLE SLOUGHS

CONCEPTUAL STREAM STABILIZATION PLAN

Date 11/02
Scale AS SHOWN
Project 02-311

P1



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A. GENERAL REVEGETATION INFORMATION

The revegetation notes apply to the designated areas depicted on the Conceptual Revegetation Planting Plan. Plantings are specified for the following areas:
§Rock Slope Protection Riparian Revegetation Areas (approx. 0.07 acre)
§Toe of Slope Willow Riparian Revegetation Areas (approx. 0.13 acre)
§Mid to Upper Slope Riparian Revegetation Areas (approx. 0.13 acre)
§Erosion Control Revegetation Areas (approx. 0.26 acre)
Prior to plant material installation, planting locations shall be coordinated with the layout of both aboveground and underground utilities. The property owner and/or Landscape Contractor shall be familiar with the locations of existing and future underground services and improvements that may conflict with the work to be done. Landscape Contractor is responsible for verifying all locations of underground utilities prior to the start of work. The Landscape Contractor shall notify the Project Engineer immediately should conflicts arise.
The property owner and/or Landscape Contractor shall be responsible for maintaining the revegetation areas in a safe and clean condition. All revegetation work areas shall be fenced to preclude horse access.

B. PLANTING OPERATIONS

The property owner and/or Landscape Contractor shall be responsible for the following revegetation work items:
Installation of placeholder devices amid the rock slope protection revegetation areas; the property owner and/or Landscape Contractors shall be responsible for installing the placeholder devices amid the rock in coordination with the work of the other site contractors.
Installation of willow pole cuttings within the rock slope protection and natural soil areas; the willow pole cuttings within the rock slope protection shall be planted within designated placeholder devices. The collection and installation of all willow pole cuttings shall be conducted when the plants are dormant (i.e., between December 15 and January 15).
Installation of container stock along the mid-to-upper slope revegetation areas, including below and aboveground browse protection. Installation of container stock shall occur after rain has moistened the ground to a minimum depth of 8" and more rain is forecast (typically November through January).
Application of erosion control seed and mulch within designated revegetation areas. This work will be done prior to the installation of the container stock and prior to October 15 the work year. The property owner and/or Landscape Contractor shall minimize ground disturbances to hydroseeded areas during the installation of container stock plantings.
Irrigation of container planting stock (hand watering) for a 3-year period following planting. Irrigation shall typically be conducted during the months of May through September.
The locations of revegetation elements are for planning purposes only and may be adjusted in the field at the direction of the Project Engineer prior to installation. The property owner and/or Landscape Contractor shall take care to locate plant materials to provide optimum growth conditions and maximum aesthetics. Plant material shall not be installed to obstruct drainage patterns or harm existing plant material. The property owner and/or Landscape Contractor shall notify the Project Engineer should conflicts occur.
The placeholder tubes (for planting willow pole cuttings) shall be cardboard tubes, measuring approximately 4" in diameter, 0.20" wall thickness. The tubes shall be installed during placement of the rock slope protection at approximately 6' on-center. The tubes shall be inserted flush with the rock and suitable for subsequent insertion of willow pole cuttings by the property owner and/or Landscape Contractor. The tubes shall be installed with one end abutting the natural grade.
Prior to site work for the installation of the container stock, the property owner and/or Landscape Contractor shall layout the planting sites as flagged locations in the field. The Project Engineer shall review and approve all planting locations prior to site work.
The property owner and/or Landscape Contractor shall be responsible for supplying plants of the species and size specified and delivery of the plant material to the site. The Project Engineer shall review and approve all plant materials, prior to their installation The property owner and/or Landscape Contractor shall be responsible for any replacement of plant material if said material is in poor condition and rejected by the Project Engineer.
The property owner and/or Landscape Contractor shall ensure that all plants are true to name, with one plant in each bundle or lot tagged with the botanical name and plant size, in accordance to the standards of practice recommended by the American Association of Nurserymen.
All plants shall be the genus, species, and sizes shown on the plans. Under no conditions, will there be any substitution of plants or sizes, except with the express written consent of the Project Engineer. If the specified plant material is not available, the property owner and/or Landscape Contractor shall secure suitable substitution materials in a timely fashion to meet the project schedule.
Existing vegetation that is not within the limits of the project area shall not be cut, removed or otherwise disturbed, except for occurrences of invasive, non-native plant species as addressed in Item C.3.
Planting of container stock and live cuttings (i.e., willow pole stakes within rock slope protection and in natural soil area) shall occur after rain has moistened the ground to a minimum depth of 8" and more rain is forecast (typically November through January).
Dormant willow cuttings shall be installed within the designated placeholders amid the rock slope protection revegetation areas and in the willow riparian revegetation areas, as depicted on the Conceptual Planting Plan. Cuttings shall be installed approximately 6' o.c. in a zigzag pattern along to lower portion of the creek bank. These cuttings shall be installed when the plants are dormant (typically between December 15th and January 15th). The cuttings shall pierce the filter fabric, such that the pole cutting is deeply inserted into native soil. Soil can be jetted into the placeholder tubes if desired by the Project Engineer.
The willow pole cuttings shall be obtained during the dormant period. The property owner and/or Landscape Contractor shall be responsible for obtaining the required cuttings within 24 hours of placement. The property owner and/or Landscape Contractor shall collect cuttings from the surrounding work area or other areas as designated by the Project Engineer. The Landscape Contractor shall maintain all cuttings in water (fully immersed) prior to their placement amid the rock slope protection and natural soil areas.
Container stock plants shall be installed in areas designated for planting, as shown on the Conceptual Planting Plan. Plants shall be installed by excavating a planting hole into native soil and/or the erosion control fabric large enough to receive the belowground browse protection cage and the rootball. All planting holes shall be backfilled with native soil and tamped. Plantings shall be watered in such that the root crown is even with the surrounding grade. A 3" high hand-packed soil berm shall be constructed around the plant (or just along the downslope edge for creek bank plantings) to create a watering basin. If soil is not moist to 14" from natural rainfall, the plant shall be hand watered immediately following installation. After planting is complete, the property owner and/or Landscape Contractor shall furnish and spread shredded mulch in the planting basin, as shown on the detail.

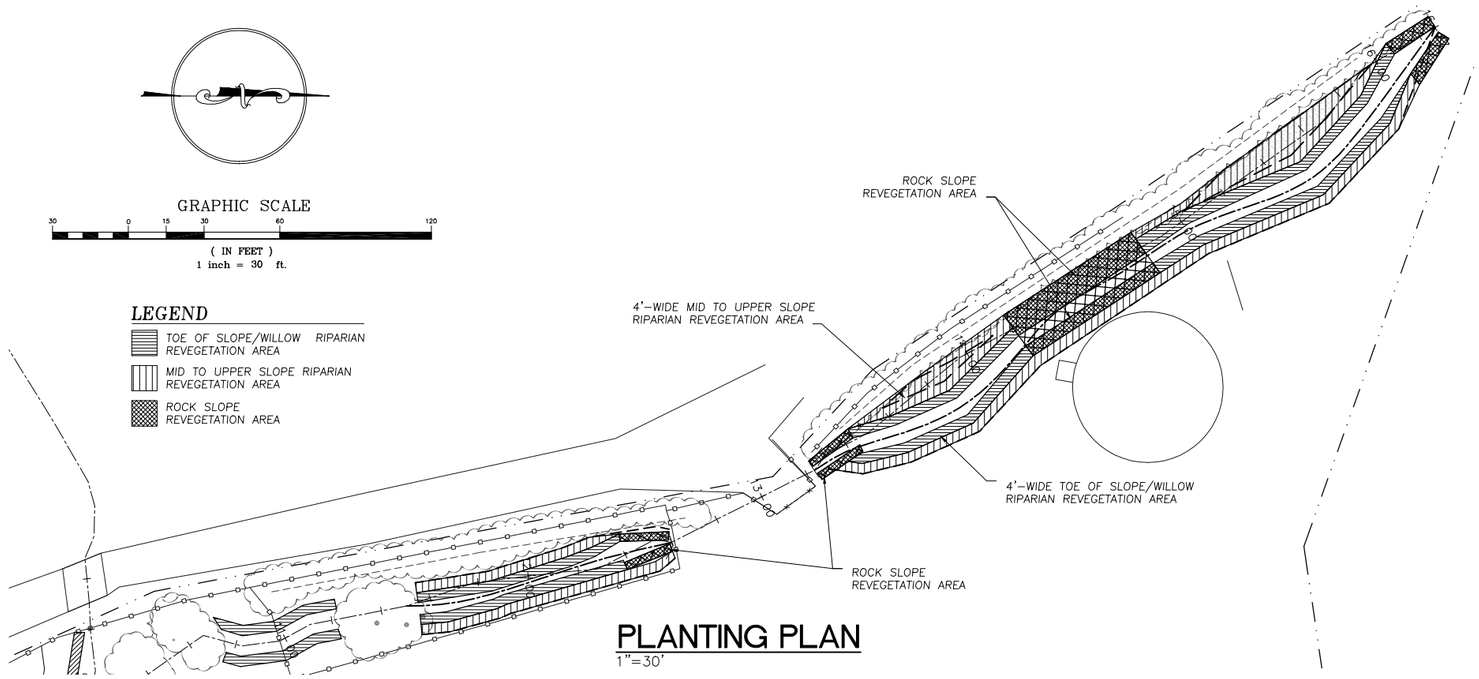
GRAPHIC SCALE

30 0 15 30 60 120

( IN FEET )
1 inch = 30 ft.

LEGEND

- TOE OF SLOPE/WILLOW RIPARIAN REVEGETATION AREA
- MID TO UPPER SLOPE RIPARIAN REVEGETATION AREA
- ROCK SLOPE REVEGETATION AREA




PLANTING PLAN
1"=30'

C. REVEGETATION AREA MAINTENANCE NOTES

Work shall include, but is not limited to, maintenance of installed plant materials, plant basins, plant protection devices, watering and weeding necessary to keep the plant materials in a healthy, growing conditions and keep the planting areas neat throughout the 3-year maintenance period. The property owner and/or Landscape Contractor shall not prune plant material unless otherwise directed by the Project Engineer.
All weeds shall be removed from the container stock planting basins throughout the 3-year maintenance period. The plants will be removed in order to reduce competition for available nutrients, moisture, and sunlight. Plants shall be hand-pulled. All weed control shall be done in a manner that protects the installed plants. Weeds that grow within the planting basins shall be controlled when they reach a height of 4" or cover 20% of the planting basin. Weeding shall consist of bagging and removal of weed plants from the project site. No pre-emergent herbicides shall be allowed.
If invasive, non-native plant species establish within the revegetation areas, controls shall be implemented to prevent the infestations from developing and to further enhance survival of the planted species. Invasive, non-native plant species that occur, or may establish on the site, include acacia ( Acacia spp.), periwinkle (Vinca major), cape ivy (Delaireia odorata) , giant reed (Arundo donax ), cocklebur (Xanthium spp.), yellow star thistle (Centaurea soltitialis ), Italian thistle (Carduus pycnocephalus ), bull thistle (Cirsium vulgare) , poison hemlock (Conium maculatum), and French broom (Genista monspessulana ). Hand removal shall be utilized to remove and control the occurrence of these species from the project work area. Individuals of these species shall be removed through hand hoeing and hand pulling, with all plant materials bagged and removed from the site. Hand hoeing shall sever the root a minimum of 4 inches below the ground surface. Hand pulling shall removal the root of the plant. Site maintenance visits shall be conducted in spring (March through May) and summer (June through August) of each maintenance year (for a period of three years) wherein non-native plant species shall be removed. The goal of the maintenance actions will be to remove all invasive plant species from the project area prior to their development of flowering heads and/or spreading into the revegetation areas.
The property owner and/or Landscape Contractor shall maintain the plant protection devices in functional and secure order throughout the 3-year maintenance period. Plant protection devices shall be removed by the property owner and/or Landscape Contractor and disposed off site either at 1) following the presence of leaves or branches of the plant materials at least 1" through the fencing, or 2) at the end of the 3-year maintenance period.
Supplemental watering shall be implemented for the container stock plantings. Plants shall be hand-watered no less than three times a month during May, June, July, August and September of Years 1, 2 and 3. Approximately 5 gallons of water shall be applied to each container stock planting at each watering event. Each watering shall be of such a quantity as to provide optimum growth conditions. This work shall include watering by hand from water truck. If drought stress or chlorosis is noted on any of the plantings, the quantity and interval of watering will be increased.
If an unusual drought occurs in other months (i.e., less that 70% of normal rainfall between October and April) such that soil moisture drops to a level where plant survival is compromised, supplemental irrigation shall be initiated. Supplemental irrigation shall be continued until natural rainfall levels replenish soil moisture.

D. MONITORING NOTES

The Project Engineer shall conduct monitoring of the revegetation areas for a period of three years after planting. In the summer of Years 1-3 (i.e., years following plant installation), all installed plants shall be counted and monitored for survival, health and vigor.
Photo-documentation shall be employed to record progress of the revegetation for a period of three years.
Data from the site visits shall be incorporated into a yearly Monitoring Report. The Project Engineer shall be responsible for submitting the report to the California Department of Fish and Game, U.S. Army Corps of Engineers and the County of Santa Cruz Planning Department in December of each year's monitoring. The report shall state whether the project revegetation has been successful and if any remedial measures are required.
The project shall be deemed successful if the project achieves:
80% survival of container stock at the end of Year 3.
60% survival of willow pole cuttings at the end of Year 3.
No evidence of erosion or rilling along the creek bank.
The property owner and/or Landscape Contractor shall be responsible for assuring the survival of a minimum of 80% of the container stock and 60% of willow pole cuttings within Years 1-3. If survival rates drop below this level, the property owner and/or Landscape Contractor shall replant the failed plantings during the next fall/winter season.

E. SEEDING NOTES

The property owner and/or Landscape Contractor shall be responsible for the application of seed and straw mulch blanket on disturbed soil areas, as depicted on the Conceptual Planting Plan.
The locations of the erosion seeding areas are for planning purposes only and may be adjusted in the field at the direction of the Project Engineer prior to installation. The property owner and/or Landscape Contractor shall take care to install seed and related materials to provide optimum growth conditions and maximum aesthetics. Seeded material shall not be installed to obstruct drainage patterns or harm existing plant material. The property owner and/or Landscape Contractor shall notify the Project Engineer should conflict occur.
Prior to site work, the property owner and/or Landscape Contractor shall flag the boundaries of the seeding areas, demarcating the application area. The Project Engineer shall review and approve all seeding locations prior to site work.
The property owner and/or Landscape Contractor shall be responsible for supplying all materials for the seed application and delivery of the materials to the site. The Project Engineer shall review and approve all materials, prior to their installation. The property owner and/or Landscape Contractor shall be responsible for replacement of any material if said material is not as specified and is rejected by the Engineer.
The property owner and/or Landscape Contractor shall ensure that all seed are true to name, with seed mixes identified with the botanical name, application rate, and that the seed and/or seed mix contains no noxious weeds.
All seeds shall be the genus and species shown on the plans. Under no conditions, will there be any substitution of species, except with the express written consent of the Project Engineer. If the specified material is not available, the property owner and/or Landscape Contractor shall secure suitable substitution materials in a timely fashion to meet the project schedule.
Existing vegetation that is not within the limits of the project area shall not be cut, removed or otherwise disturbed.
Seeding shall occur following all site work and when the seedbed has been prepared. Seeding shall occur in October, prior to October 15 and when rain is forecast.
yearsSeeding shall consist of a 2-step process, applied by the property owner and/or Landscape Contractor. Prior to seeding, the seed mixture will be mixed. The seed shall be hand broadcast onto the prepared seedbed and lightly raked in to provide good seed-to-soil contact. Seeded areas shall receive a top-dressing of a straw erosion control blanket (American Green S-150, or equivalent). The straw blanket shall be secured as specified by the manufacturer.

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Figure K 5

PREPARED AT THE REQUEST OF
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JONES SITE
SIDE CHANNEL

CONCEPTUAL
PLANTING PLAN

WATSONVILLE SLOUGHS

CONCEPTUAL STREAM
STABILIZATION PLAN

Date 11/02
Scale AS SHOWN
Project 02-311

P2

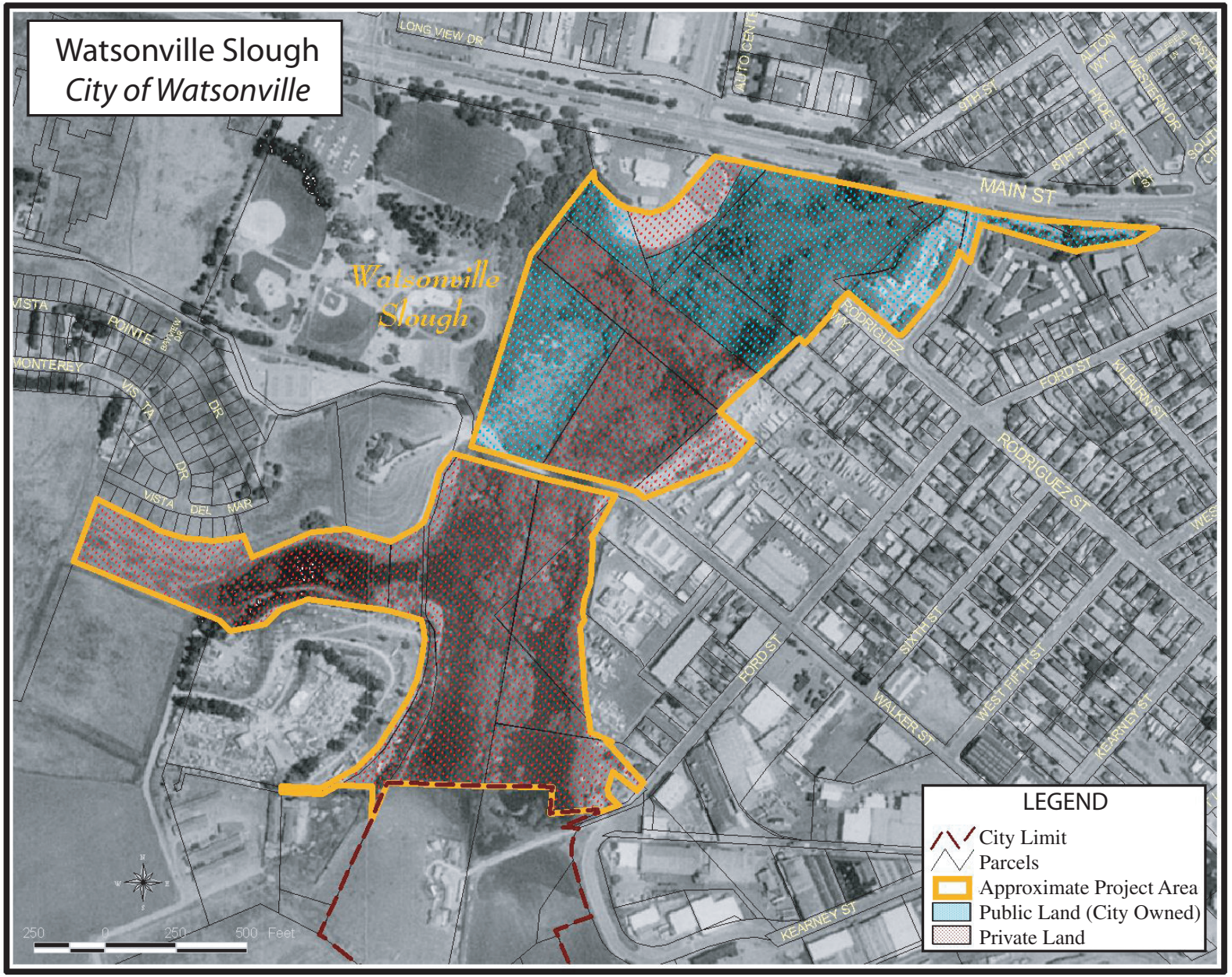


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**Figure L-1:** Project Location Map for proposed City of Watsonville wetlands restoration project.